Ministry of Education and Science of Ukraine
Dnipro University of Technology

Department of Electric Drive

«APPROVED»
Head of Department
Khudolii S.S. _____
«30» August 2022

WORK PROGRAM OF THE ACADEMIC DISCIPLINE
«Mechatronics and Robotics»

Field of study	14 Electrical engineering
Specialty	141 Electrical energetics, electrical engineering and electromechanics
Academic level	first (bachelor)
Status	elective
Total workload	4 ECTS credits (120 hours)
Type of summative assessment	differentiated test
Period of study	7 semester (13, 14 terms)
Language of study.....	English

Instructor: Prof. Beshta O.S.

Prolonged: on: 20__/20__ a.y. _____(_____) «__»___ 20__y.
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(sign, name, data)

Dnipro
DNIPROTECH
2022

Work program of the academic discipline «Mechatronics and Robotics» for bachelors of the specialty 141 Electrical energetics, electrical engineering and electromechanics / Dnipro University of Technology, Department of Electric Drive. – D.: DNIPROTECH, 2022 – 13 p.

Author:

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The work program regulates:

- the aim of the discipline;
- the disciplinary learning outcomes;
- basic disciplines (if any);
- volume and distribution by forms of organization of the educational process and types of classes;
- discipline program (thematic plan by types of training);
- algorithm for assessing the level of achievement of disciplinary learning outcomes (scales, tools, procedures and assessment criteria);
- tools, equipment and software;
- recommended sources of information.

The work program is designed to implement a competency approach in planning an education process, delivery of the academic discipline, preparing students for control activities, controlling the implementation of educational activities, internal and external quality assurance in higher education, accreditation of degree programs.

CONTENTS

1 AIM OF THE DISCIPLINE

The aim of the discipline 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.

2 INTENDED DISCIPLINARY LEARNING OUTCOMES

Disciplinarylearning outcomes (DLO)	
code DLO	**contents**
DLO–01	Know what a technological process is, understand the organization of the mechatronic module and its control system
DLO–02	Understand the principles of designing automated technological processes
DLO–03	Understand the principles of designing mechatronic devices of various types, understand and analyze functional and basic control schemes
DLO–04	Be able to algorithmize the technological process
DLO–05	Understand the principles of controlling mechatronic systems using a programmable logic controller (PLC)
DLO–06	Be able to program a PLC, create projects in the software environment
DLO–07	Understand the principles of designing a robot and a robotic complex (RC), be able to design a robot trajectory in the RC

3 BASIC DISCIPLINES

Title of the discipline	**Achieved learning outcomes**
Б1 «Higher Mathematics»	PLO08 To select and apply suitable methods for analysis and synthesis of electromechanical and electric power systems with specified parameters
Б5 «Theoretical foundations of electrical engineering»	PLO05 To know the basics of the theory of the electromagnetic field, methods of calculating electric circuits and be able to use them to solve practical prob-lems in professional activities
Ф3 «Fundamentals of metrology and electrical measurements»	PLO02 To know and understand the theoretical foundations of metrology and electrical measurements, the principles of automatic control devices, relay protection and automation, have the skills to perform appropriate measurements and use these devices to solve professional problems
Ф4 «Fundamentals of Electric Drives»	PLO03 To know the principles of operation of electric machines, devices and automated electric drives and be able to use them to solve practical problems in professional activities
Ф7 «Electronics, microprocessor technology and automation tools»	PLO06 To apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities

4 WORKLOAD DISTRIBUTION BY THE FORM OF EDUCATIONAL PROCESS ORGANIZATION AND TYPES OF CLASSES

Types of classes	Workload, *hours*	Distribution by forms of education, *hours*					
		Full-time		Part-time		Extramural	
		Lecture classes	individual work	Lecture classes	individual work	Lecture classes	individual work
lectures	75	26	49	-	-	6	69
practical	-	-	-	-	-	-	-
laboratory	45	26	19	-	-	4	41
seminars	-	-	-	-	-	-	-
TOTAL	120	52	68	-	-	10	110

5 DISCIPLINE PROGRAM BY TYPES OF CLASSES

code DLO	Types and topics of classes	Volume of components, *hours*
	LECTURES	**75**
DLO–1	**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	3
DLO–2	**2. Didactic complex of FESTO company.** Elements of the complex. Portal robot station MPS Handling (H1)	10
	MPS Joining Station (J)	
	MPS Sorting Station (S)	
DLO–3	**3. Electropneumomechatronic devices:** symbols of elements; air preparation system; executive cylinders; distributors; control circuits of the executive cylinder	10
	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	
DLO–4	**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	4
DLO–5	**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	12
DLO–6	**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	12
DLO–6	**7. Project creation and device configuration in the TIA Portal environment**	10

DLO–7	**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	14
	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	**45**
DLO–1, DLO–2, DLO–3	1. Study of the functionality of the portal robot MPS Handling Station (H1) using the SimuBox simulation console	4
DLO–1, DLO–2, DLO–3	2. Study of the functionality of the MPS Joining Station (J) using the SimuBox simulation console	5
DLO–1, DLO–2, DLO–3	3. Study of the functionality of the MPS Sorting Station (S) using the SimuBox simulation console	5
DLO–4, DLO–5	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
DLO–4	5. GRAFCET specification language. Introduction to the construction of functional diagrams for solving problems of workflow management	4
DLO–6	6. Automation of algorithms of functioning of the portal robot MPS Handling Station (H1) by means of a Siemens programmable logic controller	6
DLO–6	7. Automation of algorithms of operation of MPS Joining Station (J) by means of a Siemens programmable logic controller	6
DLO–6	8. Automation of algorithms of operation of the portal robot MPS Sorting Station (S), by means of a Siemens programmable logic controller	6
DLO–7	9. Programming the movement of a FischerTechnik 3-D robot along a designed path	4
	TOTAL	**120**

For the implementation of the hybrid form of teaching students, the electronic resource of the e-learning in the discipline is used at the following address: **https://do.nmu.org.ua/course/view.php?id=3411**

6 KNOWLEDGE PROGRESS TESTING

Certification of student achievement is accomplished through transparent procedures based on objective criteria in accordance with the University Regulations "On Evaluation of Higher Education Applicants' Learning Outcomes".

The level of competencies achieved in relation to the expectations, identified during the control activities, reflects the real result of the student's study of the discipline.

6.1 Grading scales

Assessment of academic achievements of higher education applicants of the DNIPROTECH is carried out based on a rating (100-point) and institutional grading scales. The latter is necessary (in the official absence of a national scale) to convert (transfer) grades for mobile applicants.

The scales of assessment of learning outcomes of the DNIPROTECH students

Rating	Institutional
90 ... 100	відмінно / Excellent
74 ... 89	добре / Good
60 ... 73	задовільно / Satisfactory
0 ... 59	незадовільно / Fail

Discipline credits are scored if the applicant has a final grade of at least 60 points. A lower grade is considered to be an academic debt that is subject to liquidation in accordance with the Regulations on the Organization of the Educational Process of DNIPROTECH.

6.2 Tools and procedures

The content of diagnostic tools is aimed at controlling the level of knowledge, proficiency/skills, communication, autonomy, and responsibility of the applicant according to the requirements of the National Qualifications Framework (NQF) up to the 6^{th} qualification level during the demonstration of the learning outcomes regulated by the work program.

During the control activities, the applicant should perform tasks focused solely on the demonstration of disciplinary learning outcomes (Section 2).

Diagnostic tools provided to applicants at the control activities in the form of tasks for the formative and summative knowledge progress testing are formed by specifying the initial data and a way of demonstrating disciplinary learning outcomes.

Diagnostic tools (control tasks) for the formative and summative knowledge progress testing are approved by the department.

Types of diagnostic tools and procedures for evaluating the formative and summative knowledge progress testing are given below.

Diagnostic and assessment procedures

FORMATIVE ASSESSMENT			SUMMATIVE ASSESSMENT	
training sessions	**diagnostic tools**	**procedures**	**diagnostic tools**	**procedures**
lectures	control tasks for each topic	performing the task during lectures	complex control work (CCW)	determination of the weighted average result of formative assessments; performing CCW during the differentiated test at the request of the student
laboratory	verification and defense	performance of laboratory works		

During the formative assessment, lecture classes are evaluated by determining the quality of performance of specific control tasks. Laboratory classes are evaluated by the quality of performance and defense of laboratory works.

If the content of a certain type of classes is subordinated to several components of the description of the qualification level according to the NQF, the integral value of the grade can be determined taking into account the weighting coefficients set by the lecturer.

Provided that the level of results of the formative assessments of all types of training at least 60 points, the summative assessment can be carried out without the participation of the applicant by determining the weighted average value of the obtained grades.

Regardless of the results of the formative assessments, every applicant during the summative knowledge progress testing has the right to perform the CCW, which contains tasks covering key disciplinary learning outcomes.

The number of specific tasks of the CCW should be consistent with the allotted time for completion. The number of CCW options should ensure that the task is individualized.

The value of the mark for the implementation of the CCW is determined by the average evaluation of the components (specific tasks) and is final.

The integral value of the assessment of the implementation of the CCW can be determined taking into account the weighting coefficients established by the department for each component of the description of the qualification level of the NQF.

6.3 Criteria

The actual learning outcomes of the applicant are identified and measured against the expected ones during the control activities using criteria that describe the actions of the applicant to demonstrate the achievement of learning outcomes.

To assess the performance of control tasks during the formative assessment on lectures and laboratory classes the coefficient of mastery is used as a criterion, which automatically adapts the assessment indicator to the rating scale:

$$O_i = 100\ a/m,$$

where *a* is a number of correct answers or significant operations performed in accordance with the solution standard; *m* is the total number of questions or significant operations of the standard.

Individual tasks and complex control works are assessed expertly using criteria that characterize the ratio of requirements to the level of competencies and indicators of assessment on a rating scale.

The content of the criteria is based on the competency characteristics defined by the NQF for the bachelor's level of higher education (given below).

General criteria for achieving learning outcomes for the 6th qualification level of NQF (bachelor)

Description of qualification level	**Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility**	**Indicator evaluation**
Knowleges		
Conceptual scientific and practical knowledge, critical understanding of theories, principles, methods and concepts in the field of professional activity and / or training	The answer is excellent - correct, reasonable, meaningful. Characterizes the presence of: - conceptual knowledge; - high degree of knowledge of the state of the art; - critical understanding of the basic theories, principles, methods and concepts in education and professional activity	95-100
	The answer contains minor errors or omissions	90-94
	The answer is correct, but has some inaccuracies	85-89
	The answer is correct, but has some inaccuracies and is insufficiently substantiated	80-84
	The answer is correct, but has some inaccuracies, insufficiently substantiated and meaningful	74-79
	The answer is fragmentary	70-73
	The answer shows the student's vague ideas about the object of study	65-69
	The level of knowledge is minimally satisfactory	60-64
	The level of knowledge is unsatisfactory	<60
Proficiency/Skills		
In-depth cognitive and practical skills, mastery and innovation at the level required to solve complex specialized tasks and practical problems in the field of professional activity or training	The answer characterizes the ability to: - identify problems; - formulate hypotheses; - solve problems; - choose appropriate methods and tools; - collect and interpret information logically and clearly; - use innovative approaches to solving problems	95-100
	The answer characterizes the ability to apply knowledge in practice with minor errors	90-94
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of one requirement	85-89
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the two requirements	80-84

Description of qualification level	Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility	Indicator evaluation
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the three requirements	74-79
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the four requirements	70-73
	The answer characterizes the ability to apply knowledge in practice when performing tasks on the model	65-69
	The answer characterizes the ability to apply knowledge in performing tasks on the model, but with inaccuracies	60-64
	The level of skills is unsatisfactory	<60
Communication		
♦ reporting to specialists and non-specialists information, ideas, problems, solutions, own experience and argumentation ♦ data collection, interpretation and application ♦ communication on professional issues, including in a foreign language, orally and in writing	Fluency in industry issues. Clarity of the answer (report). Language: - correct; - clean; - clear; - accurate; - logical; - expressive; - concise. Communication strategy: - consistent and consistent development of thought; - the presence of logical own judgments; - appropriate reasoning and its compliance with the defended provisions; - correct structure of the answer (report); - correct answers to questions; - appropriate technique for answering questions; - ability to draw conclusions and formulate proposals;	95-100
	Sufficient knowledge of industry issues with minor flaws. Sufficient clarity of the answer (report) with minor flaws. Relevant communication strategy with minor flaws.	90-94
	Good knowledge of industry issues. Good clarity of the answer (report) and appropriate communication strategy (three requirements in total are not realized)	85-89
	Good knowledge of industry issues. Good clarity of the answer (report) and appropriate communication strategy (four requirements not implemented in total)	80-84
	Good knowledge of industry issues. Good clarity of the answer (report) and appropriate communication strategy (five requirements not implemented in total)	74-79
	Satisfactory knowledge of industry issues.	70-73

Description of qualification level	Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility	Indicator evaluation
	Satisfactory clarity of the answer (report) and appropriate communication strategy (a total of seven requirements have not been implemented)	
	Partial knowledge of industry issues. Satisfactory clarity of the answer (report) and communication strategy with errors (a total of nine requirements are not implemented)	65-69
	Partial knowledge of industry issues. Satisfactory clarity of the answer (report) and communication strategy with errors (a total of 10 requirements are not implemented)	60-64
	The level of communication is unsatisfactory	<60
	Autonomy and responsibility	
♦ managing complex technical or professional activities or projects ♦ ability to take responsibility for making and making decisions in unpredictable work and / or learning contexts ♦ formation of judgments that take into account social, scientific and ethical aspects ♦ organization and management of professional development of individuals and groups ♦ ability to continue studies with a significant degree of autonomy	Excellent command of personal management competencies focused on: 1) management of complex projects, which involves: - research nature of educational activities, marked by the ability to independently assess various life situations, phenomena, facts, identify and defend a personal position; - ability to work in a team; - control of own actions; 2) responsibility for decision-making in unpredictable conditions, including: - justification of own decisions by the provisions of the regulatory framework of the industry and state levels; - independence in the performance of tasks; - initiative in discussing problems; - responsibility for relationships; 3) responsibility for the professional development of individuals and/or groups of individuals, which involves - use of professionally oriented skills; - use of evidence with independent and correct argumentation; - mastery of all types of learning activities; 4) the ability to continue learning with a high level of autonomy, which includes - the degree of mastery of fundamental knowledge; - independence of evaluative judgments; - a high level of general learning skills; - - independent search and analysis of information sources	95-100
	Good mastery of personality management competencies (two requirements not met)	90-94
	Good mastery of personality management competencies (three requirements not met)	85-89
	Good mastery of personality management competencies (four requirements not met)	80-84
	Good mastery of personality management competencies (six requirements not met)	74-79

Description of qualification level	Requirements for knowledge, proficiency/skills, communication, autonomy and responsibility	Indicator evaluation
	Satisfactory mastery of personality management competencies (seven requirements not met)	70-73
	Satisfactory mastery of personality management competencies (eight requirements not met)	65-69
	The level of responsibility and autonomy is fragmentary	60-64
	The level of autonomy and responsibility is unsatisfactory	<60

7 TOOLS, EQUIPMENT AND SOFTWARE

Technical means of training.

E-learning platform MOODLE, MS Teams.

During laboratory work, 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.

8 RECOMMENDED SOURCES OF INFORMATION

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

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Editorial by the author

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