Ministry of Education and Science of Ukraine
Dnipro University of Technology

Department of Electric Drive

"APPROVED"
Head of Department

Khudoliy SS. _____

"31" august 2021

CURRICULUM
"Mechatronics and robotics"

Field of knowledge……. 14	Electrical engineering
Specialty …… ... 141	Electric Power Engineering, Electrical Engineering and Electromechanics
Educational level	First (bachelor's)
Educational program ……. Electric power, electrical engineering and electromechanics	Electric Power Engineering, Electrical Engineering and Electromechanics
Status ……	selective
Total volume ..…….	7 ECTS credits (210 hours)
Form of final control	test
Term of teaching	7th semester
Language of instruction	English

Teacher Beshta O.S.

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

on 20__/20__ н.р. _____(_____) «__»___ 20__p.
(sign, name, data)

Dnipro
DUT
2021

Working program of the discipline "Mechatronics and Robotics" for bachelors majoring in 141 "Power Engineering, Electrical Engineering and Electromechanics" / Dnipro University of Technology, dept. electric drive. - D.: DUT. 2021. – 13 p.

Developer - prof. Beshta O.S.

The work program regulates:

- the purpose of the discipline;

- disciplinary learning outcomes formed on the basis of the transformation of the expected learning outcomes of the educational program;

- basic disciplines;

- volume and distribution by forms of organization of the educational process and types of training sessions;

- program of the discipline (thematic plan by types of classes);

- 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-based approach to planning the educational process, teaching the discipline, preparing students for control activities, monitoring the implementation of educational activities, internal and external quality control of higher education, accreditation of educational programs within the specialty.

Approved by the decision of the Scientific-Methodical Commission of specialty 141 «Electric Power Engineering, Electrical Engineering and Electromechanics» (protocol HMK 21/22-01 of 30.08.2021).

CONTENT

1 PURPOSE OF THE COURSE

In the educational-professional program of the specialty 141 Electrical Power Engineering, Electrical Engineering and Electromechanics (admission 2018) the following learning outcomes are included in the discipline C2.14 "Mechatronics and Robotics":

BP2.13	Carry out the selection of mechatronic units, their installation, adjustment and maintenance
BP2.14	Choose the layout of the industrial robot and the configuration of the robotic complex
BP2.15	To program systems of automatic control of mechatronic systems, robots and robotic complexes

The purpose of the discipline - the formation of competencies and acquaintance with existing mechatronic systems and robots, robotic systems and their management; acquisition by students of theoretical knowledge and practical skills for the analysis of kinematics, dynamics, synthesis of mechanisms of robots taking into account optimization of algorithms of their management.

Achieving the goal requires the transformation of program learning outcomes into disciplinary and adequate selection of the content of the discipline according to this criterion.

2 EXPECTED DISCIPLINARY LEARNING OUTCOMES

Theory of electric drive

Disciplinary learning outcomes (DLO)	
шифр ДРН	**зміст**
DLO1	Know what is a technological process, understand the organization of the mechatronic module and its control system.
DLO2	Understand the principles of building automated technological processes
DLO3	Understand the principles of construction of mechatronic devices of different types, understand and analyze the functional and basic control schemes.
DLO4	Be able to algorithmize the technological process
DLO5	Understand the principles of control of mechatronic systems using a programmable logic controller (PLC)
DLO6	Be able to program PLCs, create projects in a software environment
DLO7	Understand the principles of robot construction and robotic complex (RC), be able to design the trajectory of the robot in the RC.

3 БАЗОВІ ДИСЦИПЛІНИ

Назва дисципліни	**Здобуті результати навчання**
Б1 Higher mathematics	СР4 Solving professional tasks on design and operation of electric power, electrotechnical, electromechanical complexes and systems

Назва дисципліни	Здобуті результати навчання
Б5 Theoretical foundations of electrical engineering	СР1 To determine the principles of construction and functioning of elements of electric power, electrotechnical electromechanical complexes and systems.
Ф4 Fundamentals of electric drive	СР7 To have methods of synthesis of electromechanical and electric power systems with the set indicators

4 SCOPE AND DISTRIBUTION BY FORMS OF ORGANIZATION OF THE EDUCATIONAL PROCESS AND TYPES OF EDUCATIONAL CLASSES

Type of training sessions	Volume, hours	Distribution by forms of study, hours					
		daily		evening		correspondence	
		Lecture classes	individual work	Lecture classes	individual work	Lecture classes	individual work
lectures	120	49	71	-	-	-	-
practical	-	-	-	-	-	-	-
laboratory	90	19	71	-	-	-	-
seminars	-	-	-	-	-	-	-
TOGETHER	210	68	142	-	-	-	-

5 DISCIPLINE PROGRAM BY TYPES OF EDUCATIONAL CLASSES

Ciphers DLO	Types and topics of training sessions	Volume of components, hours
	LECTURES	**120**
DLO1	**Properties of industrial production, the level of process automation. Technological process**. Symbols of automated operations. **Basic terms of mechatronics.** Organization of mechatronic module. Mechatronic modules by types of converted energy. The structure of the automated control system	8
DLO2	**Didactic complex of FESTO company.** Elements of the complex Portal robot station MPS Handling (H1)	18
	MPS Joining Station (J)	
	MPS Sorting Station (S)	
DLO3	**Electropneumomechatronic devices:** symbols of elements; air preparation system; executive cylinders; distributors; control circuits of the executive cylinder	16
	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	
DLO4	**GRAFCET specification language.** Introduction to the construction of functional diagrams for solving problems of workflow management. Algorithms for the operation of FESTO stations	6
DLO5	**Control of mechatronic systems.** Programmable logic controllers (PLCs). Familiarity with the external and internal structure of the PLC, memory area, data types, addressing and wiring diagrams.	16

	Review of PLC S7-1200 on the example of CPU 1212C: how the CPU 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.	
DLO6	**LAD programming language.** **Simatic Siemens 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	16
DLO6	**Project creation and device configuration in the TIA Portal environment**	20
DLO7	**Robotics**: general questions; functional parts of the robot; industrial works 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	20
	Composition and classification of robotic complex (RC). **Movement work within the RC.** Composition and classification of robotic complex. Samples of location, layout of robotic complexes. The trajectories of the robot manipulator in the robotic complex Features of using several robots in one robotic complex Robotic maintenance strategies Trajectories between machines as a function of the number of grips and the organization of the production platform (stag**e)**	
	Design work on the example of 3D -work. Determining the degree of mobility of a 3D robot. Determination of the working area 3D-robot, calculation of positioning coordinates Sample movement of the manipulator on two axes: -axis Z -polyharmonic trajectory; -is the X -linear motion at a constant speed	
	LABORATORY WORKS	90
DLO1, DLO 2, DLO 3	Study the functionality of the portal robot handling station (H1) using the SimuBox simulation panel.	10
DLO 1, DLO 2, DLO 3	Study the functionality of the MPS Joining station (J) using the SimuBox simulation console.	10
DLO 1, DLO 2, DLO 3	Explore the functionality of the MPS Sorting (S) station using the SimuBox simulation console	10
DLO 4, DLO 5	Study of number systems used in computer technology, the rules of translation of numbers from one number system to another, the principles of programmable logic controllers.	10
DLO 4	GRAFCET specification language. Introduction to the construction of functional diagrams for solving problems of workflow management.	10
DLO 6	Automation of algorithms of functioning of station of portal robot MPS Handling (H1) by means of the programmable Siemens logic controller.	10

DLO 6	Automation of algorithms of operation of MPS Joining station (J) by means of the programmable logic controller Siemens.	10
DLO 6	Automation of algorithms of operation of station of portal robot Sorting (S), by means of the software logic controller Siemens.	10
DLO 7	FischerTechnic 3-D motion programming works on the designed trajectory	10
	Together:	**210**

6 EVALUATION OF LEARNING OUTCOMES

Certification of student achievement is carried out through transparent procedures based on objective criteria in accordance with the Regulations of the University "On the evaluation of learning outcomes of higher education."

The achieved level of competencies relative to the expected ones, which is identified during the control activities, reflects the real result of the student's study in the discipline.

6.1 Scales

Assessment of academic achievements of students of NTU "DP" is carried out on a rating (100-point) and institutional scales. The latter is necessary (in the official absence of a national scale) for the conversion (translation) of higher education students' grades of various institutions.***Шкали оцінювання навчальних досягнень студентів НТУ «ДП»***

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

Credits of the discipline are credited if the student received a final grade of at least 60 points. The 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 NTU "DP".

6.2 Means and procedures

The content of diagnostic tools is aimed at controlling the level of knowledge, skills, communication, autonomy and responsibility of the student according to the requirements of the NQF to the 8th qualification level during the demonstration of learning outcomes regulated by the work program.

The student in the control activities must perform tasks focused solely on the demonstration of disciplinary learning outcomes (Section 2).

Diagnostic tools provided to students at control activities in the form of tasks for current and final control, are formed by specifying the initial data and the method

of demonstrating disciplinary learning outcomes.

Diagnostic tools (control tasks) for the current and final control of the discipline are approved by the department.

The types of diagnostic tools and assessment procedures for the current and final control of the discipline are given below.

Diagnostic tools and assessment procedures

CURRENT CONTROL			**FINAL CONTROL**	
training session	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 current controls; performing CCW during the exam at the request of the student
Laboratory	control tasks for each topic or individual task	performing tasks during independent work		

During the current control, lectures are evaluated by determining the quality of control specific tasks. Practical classes are assessed by the quality of the control or individual task.

If the content of a certain type of classes is subject to several descriptors, the integral value of the assessment can be determined taking into account the weights set by the teacher.

If the level of results of current controls in all types of classes is not less than 60 points, the final control is carried out without the participation of the student by determining the weighted average of current grades.

Regardless of the results of the current control, each student during the exam has the right to perform KKR, which contains tasks that cover key disciplinary learning outcomes.

The number of specified tasks of the RCC should correspond to the allotted time for execution. The number of RCC options should provide individualization of the task.

The value of the assessment for the implementation of the RCC is determined by the average assessment of the components (specified tasks) and is final.

The integral value of the assessment of the implementation of the RCC can be determined taking into account the weights set by the department for each descriptor of the NQF.

6.3 Criteria

Actual student learning outcomes are identified and measured relative to what is expected during the control activities using criteria that describe the student's actions to demonstrate the achievement of learning outcomes.

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

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

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

Individual tasks and complex tests 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 master's level of higher education (below).

General criteria for achieving learning outcomes for the 6th qualification level for NRC

NRC descriptors	**Requirements for knowledge, 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: - specialized conceptual knowledge at the level of the latest achievements; - critical comprehension of problems in education and / or professional activity and at the border of subject branches	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

NRC descriptors	Requirements for knowledge, skills, communication, autonomy and responsibility	Indicator evaluation
	The answer is correct, but has some inaccuracies, insufficiently substantiated and meaningful	75-79
	The answer is fragmentary	70-74
	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
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; - update knowledge; - integrate knowledge; - to carry out innovative activity; - to carry out scientific activity	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
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the three requirements	75-79
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the four requirements	70-74
	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	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;	95-100

NRC descriptors	Requirements for knowledge, skills, communication, autonomy and responsibility	Indicator evaluation
issues, including in a foreign language, orally and in writing	- correct structure of the answer (report); - correct answers to questions; - appropriate technique for answering questions; - ability to draw conclusions and formulate proposals; - use of foreign languages in professional activities	
	Sufficient clarity of the answer (report) and appropriate communication strategy with minor flaws	90-94
	Good clarity of the answer (report) and appropriate communication strategy (three requirements in total are not realized)	85-89
	Good clarity of response (report) and appropriate communication strategy (four requirements not implemented in total)	80-84
	Good clarity of response (report) and appropriate communication strategy (five requirements not implemented in total)	75-79
	Satisfactory comprehensibility of the answer (report) and appropriate communication strategy (a total of seven requirements have not been implemented)	70-74
	Satisfactory comprehensibility of the answer (report) and communication strategy with errors (a total of nine requirements are not implemented)	65-69
	Satisfactory comprehensibility 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	Excellent competence: - use of principles and methods of organizing team activities; - effective distribution of powers in the team structure; - maintaining a balanced relationship with team members (responsibility for the relationship); - stress resistance; - self-regulation; - work activity in extreme situations; - high level of personal attitude to the case; - mastery of all types of educational activities; - appropriate level of fundamental knowledge; - - the appropriate level of formation of general educational skills and abilities	95-100
	Confident mastery of the competencies of autonomy and responsibility with minor flaws	90-94
	Good mastery of autonomy and responsibility competencies (two requirements not met)	85-89
	Good mastery of autonomy and responsibility competencies (three requirements not met)	80-84
	Good mastery of autonomy and responsibility competencies (four requirements not met)	75-79

NRC descriptors	Requirements for knowledge, skills, communication, autonomy and responsibility	Indicator evaluation
individuals and groups • ability to continue studies with a significant degree of autonomy	Satisfactory mastery of autonomy and responsibility competencies (five requirements not met)	70-74
	Satisfactory mastery of autonomy and responsibility competencies (six requirements not met)	65-69
	Satisfactory mastery of autonomy and responsibility competencies (fragmentary level)	60-64
	The level of autonomy and responsibility is unsatisfactory	<60

7 TOOLS, EQUIPMENT AND SOFTWARE

Technical training.
Remote platform MOODLE, MS Teams.
During the laboratory works the didactic equipment of FESTO and FischerTechnik companies, software packages for programming of controllers of Siemens and FischerTechnik companies are used.

8 RECOMMENDED SOURCES OF INFORMATION

Basic:

- Ловейкін В.С., Ромасевич Ю.О., Човнюк Ю.В. Мехатроніка. Навчальний посібник. – К., 2012. - 357 с.
- Введение в мехатронику: уч. пособие/ А.И. Грабченко, В.Б. Клепиков, В.Л. Доброскок и др. – Х.: НТУ«ХПИ», 2014. – 264 с.

Additional:

1. Егоров О.Д. Конструирование механизмов роботов. Учебник / О.Д. Егоров. М.: Абрис, 2012. — 444 с.
- Егоров О.Д., Подураев Ю.В., Буйнов М.А. Робототехнические мехатронные системы: учебник / О.Д. Егоров, Ю.В. Подураев, М.А. Буйнов. — ФГБОУ ВПО МГТУ «СТАНКИН», 2015. — 326с.
- Егоров О.Д., Подураев Ю.В. Мехатронные модули. Расчет и конструирование: Учебное пособие. М.: МГТУ «СТАНКИН», 2004, — 360с.)
- Егоров О.Д. Прикладная механика мехатронных устройств: учебное пособие. – М.: ФГБОУ ВПО МГТУ “СТАНКИН”, 2013. – 229 с.
- Подураев Ю.В. Мехатроника: основы, методы, применение: учеб, пособие для студентов вузов. - 2-е изд., стер. - М.: Машиностроение, 2007. - 256 с.

9 INFORMATION RESOURCES:

- Пономарев, С.В. Компоненты приводов мехатронных устройств [Электронный ресурс]: учебное пособие / С.В. Пономарев [и др.]. – Тамбов: Изд-во ФГБОУ ВПО «ТГТУ», 2014. — 269 с.

Literature on the website of the Department of Electric Drive:
http://elprivod.nmu.org.ua/ua/books/converters.php

Навчальне видання

РОБОЧА ПРОГРАМА НАВЧАЛЬНОЇ ДИСЦИПЛІНИ
«Мехатроніка та робототехніка» для бакалаврів
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