Syllabus
Course Program

Mechanization and Automation of Technological Processes

Specialty
131 –
Applied Mechanics

Institute
Institute of Education and Science in Mechanical Engineering and Transport

Educational program
Applied Mechanics

Department
Department of Mechanical Engineering Technology and Metal-Cutting Machines (146)

Level of education
Bachelor's level

Course type
Free choice (professional), Selective

Semester
4

Language of instruction
English, Ukrainian

Lecturers and course developers

Maryna Ivanova

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Candidate of Technical Sciences. Associate Professor. Associate Professor of the Department of Mechanical Engineering Technology and Metal-Cutting Machines

Work experience - 12 years. Co-author of more than 50 scientific works, 1 monograph, and 2 training manuals. Leading lecturer in courses: Introduction to Speciality. Introductory Practice; Mechanization and automation of technological processes; Equipment and Transportation of Machining Shops, Technological Fundamentals of Machinebuilding.
More about the lecturer on the department's website

General information

Summary

The course "Mechanisation and automation of technological processes" is aimed at mastering the system of knowledge about the means of mechanisation and automation of technological processes, methods of organising automated control and monitoring of production. As a result of studying the discipline, the student must know the principles of operation of mechanised systems as part of a technological complex, SCADA control and monitoring systems for production infrastructure, types and characteristics of communication elements with the control object (sensors), methods of automation of actuators. Must be able to: choose the most rational option for process automation, calculate and adjust automatic and automated processing systems, assemble technological complexes with auxiliary automation devices depending on the size and shape of manufactured parts.

Course objectives and goals

Acquiring a system of knowledge about the means of mechanisation and automation of technological processes and ways of organising automated control and monitoring of production systems, as well as knowledge about building flexible automated systems while ensuring all the requirements for accuracy, quality and productivity of production of the appropriate scale.

Format of classes

Lectures, laboratory classes, practical training, self-study, consultations. The final control is an exam.

Competencies

GC01. Ability to think abstractly, analyze and synthesize.
GC02. Knowledge and understanding of the subject area and understanding of professional activities.
GC03. Ability to identify, pose and solve problems.
GC04. Ability to apply knowledge in practical situations.
GC07. Ability to learn and master modern knowledge.
GC09. Skills in the use of information and communication technologies.
GC12. Ability to search, process and analyze information from various sources.
GC13. Ability to evaluate and ensure the quality of work performed.
PC1. Ability to analyze materials, structures and processes based on the laws, theories and methods of mathematics, natural sciences and applied mechanics.
PC2. Ability to evaluate the performance parameters of materials, structures and machines in operating conditions and find appropriate solutions to ensure a given level of reliability of structures and processes, including in the presence of some uncertainty.
PC3. Ability to carry out technological and technical and economic assessment of the effectiveness of the use of new technologies and technical means.
PC4. Ability to make the optimal choice of technological equipment, complete set of technical complexes, have a basic understanding of the rules of their operation.
PC5. Ability to use analytical and numerical mathematical methods to solve problems of applied mechanics, in particular to carry out calculations for strength, endurance, stability, durability, stiffness in the process of static and dynamic loading in order to assess the reliability of parts and structures of machines.
PC6. Ability to perform technical measurements, obtain, analyze and critically evaluate measurement results.
PC7. Ability to apply computer-aided design (CAD), manufacturing (CAM), engineering research (CAE) and specialized application software to solve engineering problems in applied mechanics.

Learning outcomes

LO01. Select and apply suitable mathematical methods to solve problems of applied mechanics;
LO02. To use knowledge of the theoretical foundations of fluid and gas mechanics, heat engineering and electrical engineering to solve professional problems;
LO06. To create and theoretically justify the design of machines, mechanisms and their elements on the basis of methods of applied mechanics, general principles of design, the theory of interchangeability, standard methods of calculating machine parts;
LO10. To know the design, methods of selection and calculation, basics of maintenance and operation of drives of machine tools and robotic equipment;
LO11. Understand the principles of operation of automated control systems for technological equipment, in particular microprocessor-based, select and use the best automation tools;
LO13. Evaluate the technical and economic efficiency of production;
LO14. To make the optimal choice of equipment and complete technical complexes

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, laboratory classes - 32 hours, practical training - 16 hours, self-study - 70 hours.

Course prerequisites

To successfully pass the course, it's required to have knowledge and practical skills in the following courses: "Higher Mathematics", "Physics", "Chemistry", "Theoretical Mechanics", "Theory of Mechanisms and Machines", "Introduction to the speciality", "Informatics", " Fundamentals of Theory of Materials Cutting and Cutting Tools ", "Information Technology in Mechanical Engineering", " CAD Fundamentals "

Features of the course, teaching and learning methods, and technologies

Lectures are held in an interactive form using multimedia technologies. In practical classes, a project approach to learning is used, attention is focused on the independent solution of individual tasks, and the use of video materials on methods of processing parts in mechanical engineering. Laboratory classes are planned to be performed in the laboratory of the department according to an individual assignment for a group of students. Study materials are available to students through the teacher's corporate disk.

Program of the course

Topics of the lectures

Topic 1. Mechanization and automation in manufacturing.

Production Systems: Facilities and Manufacturing Support Systems. Automation in Production Systems. Automated Manufacturing Systems. Computerized Manufacturing Support Systems. Reasons for Automating. Manual Labor in Production Systems. Manual Labor in Factory Operations. Labor in Manufacturing Support Systems. Automation Principles and Strategies. The USA Principle. Ten Strategies for Automation and Process Improvement. Automation Migration Strategy.

Topic 2. Manufacturing Industries and Products

Manufacturing Operations: Processing and Assembly Operations. Other Factory Operations. Low Production. Medium Production. High Production. Product/Production Relationships: Production Quantity and Product Variety. Product and Part Complexity. Limitations and Capabilities of a Manufacturing Plant.

Topic 3. Manufacturing Metrics and Economics

Cycle Time and Production Rate. Production Capacity and Utilization. Manufacturing Lead Time and Work-in-Process Manufacturing Costs. Fixed and Variable Costs. Direct Labor, Material, and Overhead. Cost of Equipment Usage. Cost of a Manufactured Part.

Topic 4. Basics of Automation

Basic Elements of an Automated System. Power to Accomplish the Automated Process. Program of Instructions. Control System. Advanced Automation Functions. Safety Monitoring. Maintenance and Repair Diagnostics. Error Detection and Recovery. Levels of Automation.

Topic 5. Industrial Control Systems

Process Industries Versus Discrete Manufacturing Industries. Levels of Automation in the Two Industries. Variables and Parameters in the Two Industries. Continuous Versus Discrete Control. Continuous Control Systems. Discrete Control Systems. Computer Process Control. Control Requirements. Capabilities of Computer Control. Forms of Computer Process Control.

Topic 6. Hardware Components for Automation and Process Control

Sensors. Actuators. Analog-to-Digital Converters. Digital-to-Analog Converters. Input/Output Devices for Discrete Data. Contact Input/Output Interfaces. Pulse Counters and Generators.

Topic 7. Computer Numerical Control

Basic Components of an NC System. NC Coordinate Systems. Motion Control Systems. The CNC Machine Control Unit. CNC Software. Distributed Numerical Control. Machine Tool Applications of NC. Other NC Applications. Advantages and Disadvantages of NC. Analysis of Positioning Systems. Open-Loop Positioning Systems. Closed-Loop Positioning Systems. Precision in Positioning Systems. NC Part Programming. Manual Part Programming. Computer-Assisted Part Programming. CAD/CAM Part Programming. Manual Data Input.

Topic 8. Industrial Robotics

Robot Anatomy and Related Attributes. Joints and Links. Common Robot Configurations. Joint Drive Systems. Sensors in Robotics. Robot Control Systems. End Effectors. Grippers. Tools. Applications of Industrial Robots. Material Handling Applications. Processing Operations. Assembly and Inspection. Economic Justification of Industrial Robots. Robot Programming. Leadthrough Programming. Robot Programming Languages. Simulation and Off-Line Programming. Robot Accuracy and Repeatability.

Topic 9. Discrete Control and Programmable Logic Controllers

Discrete Process Control. Logic Control. Sequence Control. Ladder Logic Diagrams. Programmable Logic Controllers. Components of the PLC. PLC Operating Cycle. Programming the PLC. Personal Computers and Programmable Automation Controllers. Personal Computers for Industrial Control. Programmable Automation Controllers.

Topic 10. Material Handling and Identification

Material Handling Equipment. Material Transport Equipment: Industrial Trucks, Automated Guided Vehicles, Rail-Guided Vehicles, Conveyors. Cranes and Hoists. Analysis of Material Transport Systems. Conventional Storage Methods and Equipment. Automated Storage Systems: Fixed-Aisle Automated Storage/Retrieval Systems. Carousel Storage Systems. Automatic Identification and Data Capture

Topic 11. Manufacturing Systems

Single-Station Manufacturing Cells. Manual Assembly Lines. Automated Production Lines. Automated Assembly Systems. Group Technology. and Cellular Manufacturing. Flexible Manufacturing Cells and Systems

Topic 12. Quality Control Systems

Traditional and Modern Quality Control. Traditional Quality Control. The Modern View of Quality Control. Process Variability and Process Capability. Process Variations. Process Capability and Tolerances. Statistical Process Control. Control Charts. Other SPC Tools. Implementing SPC. Six Sigma. Taguchi Methods in Quality Engineering. ISO 9000

Topic 13. Manufacturing Support Systems

Product Design and CAD/CAM in the Production System. Process Planning and Concurrent Engineering. Just-In-Time and Lean Production

Topics of the workshops

Topic 1. Solving the problems of the production system
Topic 2.Determination of Cycle Time and Production Rate. Production Capacity and Utilization
Topic 3. Determination of . Cost of a Manufactured Part for different types of production
Topic 4. Training the Successive Approximation Method to encode the signals
Topic 5. Zero-Order and First-Order Data Holds in Analog–Digital Conversion
Topic 6. Analysis of Open-Loop Positioning Systems
Topic 7. Analysis of Closed-Loop Positioning Systems
Topic 8. Precision of Positioning Systems
Topic 9: Calculation of the productivity of the vibrating hopper

Topics of the laboratory classes

Topic 1: Study of typical designs and applications of Temperature Sensors
Topic 2. Study of typical designs and applications of Pressure Sensors
Topic 3: Sensor Calibration
Topic 4. Study of typical design and applications of Servo Motor
Topic 5. Study of typical design and applications of Stepper Motor
Topic 6. Study of typical designs and applications of linear motor
Topic 7. Study of typical designs and applications of Relay System
Topic 8: Study of a typical SCADA system
Topic 9: NC Manual Part Programming (machining of holes). Point-to-Point Drilling
Topic 10. NC Manual Part Programming (profile milling). Two-Axis Milling
Topic 11. Robot Programming
Topic 12: Analysis of Vehicle-Based Systems
Topic 13: Analysis of Storage Systems
Theme 14: Study of the design and operation of the vibrating hopper

Self-study

The course involves performing an individual calculation task to analyze the manufacturability of a part and design a route for machining the surface of a part. Practical classes also require individual tasks to calculate cutting conditions, workpiece location, and fill in process documents. All calculation results are documented in a written report. Students are also recommended additional materials (videos, web-resources) for independent study and analysis

Course materials and recommended reading

Main references

1. Mikell P. Groover. Automation, Production Systems, and Computer-Integrated Manufacturing, 4th Edition. 2015

2. A. K. Gupta, S. K. Arora, J. R. Westcott. Industrial Automation and Robotics. 2017.

Additional references
1. Zongwei Luo. Robotics, Automation, and Control in Industrial and Service Settings. 2015
2. Beno Benhabib. Manufacturing: Design, Production, Automation, and Integration (Manufacturing Engineering and Materials Processing). 2003

Assessment and grading

Criteria for assessment of student performance, and the final score structure

Description of the final score structure, course requirements, and necessary steps to earn points, especially paying attention to self-study and individual assignments.

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	Date, signature	Head of the department Oleksandr PERMYAKOV
	Date, signature	Guarantor of the educational program Mykola PROKOPENKO