Syllabus
Course Program

Dynamics of Mechatronic and Robotic Systems

Specialty
141 Electric Power Engineering, Electrical Engineering and Electromechanics

Institute
Institute of Power Engineering, Electronics and Electromechanics

Educational program
Electric Drive, Mechatronics and Robotics

Department
Automated Electromechanical Systems (129)

Level of education
Master's level

Course type
Optional

Semester
2

Language of instruction
English

Lecturers and course developers

Oleksii Semikov

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Candidate of technical sciences, senior lecturer at the Department of “AEMS”.

Experience is 8 years. An author is over 20 scientific works.
More about the lecturer on the department's website

General information

Summary

The discipline aims to master the methods of constructing mechatronic systems and industrial robots, studying their kinematics and dynamics, principles of constructing electric drives, control systems, mathematical and computer modeling, programming.

Course objectives and goals

To develop practical skills in students regarding the modeling of mechatronic and robotic systems using modeling tools in a computer environment.

Format of classes

Lectures, practical studies, consultations, self-study. Final control in the form of an exam.

Competencies

Ability for abstract thinking, analysis, and synthesis. Proficiency in using a foreign language for professional, scientific, and technical activities and communication. Capability to search, process, and analyze information from various sources. Proficiency in using information and communication technologies. Ability to apply knowledge in practical situations, work independently and in a team. Awareness of the necessity to constantly expand one's knowledge about new technologies in electrical engineering, electronics, and electromechanics. Knowledge and understanding of modern technological processes and systems of technological production preparation, technical characteristics, design features, purpose, and operating rules of electrical, electrical engineering, and electromechanical equipment and machinery. Ability to apply acquired theoretical knowledge, scientific and technical methods, and appropriate software to solve scientific and technical problems and conduct scientific research in the field

of electrical engineering, electronics, and electromechanics. Ability to apply existing and develop new methods, techniques, technologies, and procedures to solve engineering tasks, including in the design and operation of electrical engineering, electronics, and electromechanical objects. Ability to apply analytical methods of analysis, mathematical modeling, and perform physical, mathematical, and computational experiments to solve engineering tasks and conduct scientific research. Ability to apply information and communication technologies and programming skills to solve typical engineering and scientific tasks in electrical engineering, electronics, and electromechanics. Ability to analyze the current state and determine the trends in the development of electric drive systems and automatic control theory, numerical control systems of mechatronic systems, metal-cutting machines, industrial, and mobile robots. Ability to use modern methods of mathematical apparatus in the design of electromechanical and mechatronic systems and microprocessor control systems for electric drives. Ability to develop and design schemes of electrical installations for various purposes, determine the composition of their equipment, and calculate their operating modes. Ability to apply modern means of computer technology, communication, and communication in conducting technical calculations of automation facilities of enterprises and designing mechatronic systems and modules. Ability to use modern methods of designing and calculating individual mechatronic systems and modules and methods of mathematical and computer modeling.

Learning outcomes

Reproducing processes in electrical power, electrical engineering, and electromechanical systems during their computer modeling. Mastering new versions or new software designed for computer modeling of objects and processes in electrical power, electrical engineering, and electromechanical systems. Analyzing processes in electrical power, electrical engineering, and electromechanical equipment and corresponding complexes and systems. Proficiency in methods of mathematical and physical modeling of objects and processes in electrical power, electrical engineering, and electromechanical systems. Searching for sources of resource support for additional learning, scientific, and innovative activities. Adhering to principles and rules of academic integrity in educational and scientific activities. Effective oral and written communication in both native and foreign languages on modern scientific and technical issues in electrical power engineering, electrical engineering, and electromechanics. Numerical software control of mechatronic systems. Reconstructing existing electrical networks, stations, and substations, electrical and electromechanical complexes and systems to improve their reliability, operational efficiency, and lifespan extension. Solving professional tasks related to the design, installation, and operation of electrical power, electrical engineering, and electromechanical complexes and systems. Dynamics of mechatronic and robotic systems. Mastering new methods of synthesis of electrical power, electrical engineering, and electromechanical installations and systems with specified indicators. Analyzing the current state and determining trends in the development of electric drive systems and automatic control theory, numerical control systems of mechatronic systems, metal-cutting machines, mobile, and industrial robots. Utilizing modern methods of mathematical apparatus in designing electromechanical systems, microprocessor control systems for electric drives of mechatronic systems. Applying modern means of computer technology, communication, and connectivity in conducting technical calculations for enterprise automation and designing mechatronic systems and modules. Using modern methods of designing and calculating individual mechatronic systems and modules and methods of mathematical and computer modeling to investigate the dynamic characteristics of mechatronic and robotic systems.

Student workload

The total volume of the course is 90 hours (3 ECTS credits): lectures - 32 hours, practical studies - 16 hours, self-study - 42 hours.

Course prerequisites

To successfully complete the course, it is necessary to have a qualification of the 1st (bachelor's) level in the educational programs of the specialty "Electric Power Engineering, Electrical Engineering and Electromechanics.". Also previous courses (that are necessary for successful course completion) are: Fundamentals of scientific research, Computer Numerical Control of Mechatronic Systems p. 1, Mobile Mechatronic and Robotic Systems, Design of Mechatronic Systems.

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

Lectures are conducted interactively using multimedia technologies. Distributed lecture texts are utilized during lectures. Practical studies involve the use a project method with the application of physical and simulation models in a computer environment.

Program of the course

Topics of the lectures

Topic 1. Introduction. History of Robotics Development. Classification of Mechatronic and Robotic Systems.
Topic 2. Kinematics of Industrial Robot Manipulators. Concept of Kinematic Pair.
Topic 3. Coordinate Systems. Generalized Coordinates. Rotation and Translation Matrices.
Topic 4. Kinematics Equations of Manipulators. Forward and Inverse Kinematics Problems.
Topic 5. Kinetic and Potential Energy of Manipulators. Equations of Motion.
Topic 6. Methods for Describing Manipulator Dynamics. Dynamics Equations Based on Lagrange's Equations of the Second Kind.
Topic 7. Trajectory Planning for Manipulator Motion.
Topic 8. Control Systems of Industrial Robots. Transmission Functions of Connections.
Topic 9. Structural Schemes of Robot Electric Drives. Classification of Electric Drives. Features of Servo Systems.
Topic 10. Robot Perception. Methods of Measurement in the Far and Near Zones. Inductive, Capacitive, Ultrasonic, Tactile Sensors.
Topic 11. Mathematical and Computer Modeling of Manipulator Motion.

Topics of the workshops

Topic 1. Determining the Coordinates (X, Y, Z) of the End Effector of a Two-Link Manipulator Based on its Kinematic Scheme and Given Link Orientations.
Topic 2. Finding the Generalized Coordinates (Q1, Q2) of the End Effector of a Two-Link Manipulator for a Given Position.
Topic 3. Determining the Generalized Accelerations (a1, a2) Based on Given Forces and Moments Acting on the End Effector of a Two-Link Manipulator.
Topic 4. Finding the Forces and Moments Acting on the Joints of a Two-Link Manipulator.
Topic 5. Creating a Model of a Manipulator with 2, 3, 4 Links.
Topic 6. Visualization of the Execution of a Specified Motion Law.

Topics of the laboratory classes

Laboratory classes are not included in the curriculum.

Self-study

Processing of lecture materials. Preparation for practical studies. Independent study of topics and questions not covered in lectures. Creating of the calculated task.

Course materials and recommended reading

1. Wilhelm Lehmann. Die Elektrotechnik und die elektrischen Antriebe Lehr- und Nachschlagebuch für Studierende und Ingenieure. — 6th ed. — Springer-Verlag, 1962. — 433 p. — ISBN: 978-3-662-00241-4.
2. Aizerman M. A. Theory of Automatic Control. — Pergamon, 1963. — 519 p. — ISBN: 978-3-642-97648-3.
3. Koziol R., Sawicki J., Szklarski L. Digital Control of Electric Drives. — Elsevier, 1992. — 206 p. — ISBN: 0-444-41713-3.
4. Marlin, T.E., Process Control: Designing Processes and Control Systems for Dynamic Performance, McGraw-Hill, 1995. — 1056 p. — ISBN: 978-0070393622.
5. Beaty H.W., Kirtley J. Electric Motor Handbook. — McGraw Hill, 1998. — 398 p. —

ISBN: 978-0070359710.
6. Leonhard W. Control of Electrical Drives. — 2nd ed. — Springer, 1996. — 680 p. — ISBN: 978-3540418207.
7. Krishnan R. Electric Motor Drives. Modeling, Analysis, and Control. — Pearson, 2001. — 650 p. — ISBN: 978-0130910141.
8. Frank L.Lewis, Darren M.Dawson, Chaouki T.Abdallah. Robot Manipulator Control Theory and Practice. — 2nd ed. — New York, CRC Press, 2003. — 638 p. — ISBN: 978-1845426590.
9. Austin Hughes. Electric Motors and Drives. — 3rd ed. — Newnes, 2006. — 410 p. — ISBN: 978-0750647182.
10. Stan Gibilisco. Electricity and Electronics. — 4th ed. — McGraw-Hill/TAB Electronics, 2006. — 699 p. — ISBN: 978-0071459334.
11. John M. Miller. Propulsion Systems for Hybrid Vehicles. — IET, London, 2008. — 455 p. — ISBN: 978-0863413360.
12. Robert H. Bishop. Mechatronic System Control, Logic, and Data Acquisition. — Boca Raton: CRC Press, 2008. — 755 p. — ISBN: 978-1420009026.

Assessment and grading

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

The final grade consists of the results of the evaluation of individual control task (30%), calculated task (30%), and exam (30%).

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 Bohdan VOROBIOV
	Date, signature	Guarantor of the educational program Vira SHAMARDINA