

| Bialystok University of Technology                  |  |   |    |   |    |    |   |   |                             |
|---|--|---|----|---|----|----|---|---|-----------------------------|
| Faculty of Electrical Engineering                   |  |   |    |   |    |    |   |   |                             |
| Field of study                                      | Industry Digitization  |   |    |   |    |    |   | Degree level and programme type                           | full-time Bachelor's degree |
| Specialization / diploma path                       | common subject   |   |    |   |    |    |   | Study profile   | general academic            |
| Course name   | Robotization of industrial processes   |   |    |   |    |    |   | Course code   | CP1S06001                   |
|   |  |   |    |   |    |    |   | Course type   | obligatory                  |
| Forms and number of hours of educational activities | L  | C | LC | P | SW | FW | S | Semester  | 6                           |
|   | 15   |   |    |   | 30 |    |   | No. of ECTS credits                                       | 4                           |
| Entry requirements                                  | Fundamentals of robotics, Autonomous robots, Industrial robots   |   |    |   |    |    |   |   |                             |
| Course objectives                                   | Introduction to the use of robots and the structure and operation of robotic production systems. Acquainting with the procedures of designing robotic solutions based on the analysis of existing solutions. The use of CAD programs for the implementation of the technical design. The use of multimedia techniques to visualize the operation of a technical solution.  |   |    |   |    |    |   |   |                             |
| Course content                                      | <p>Lecture:</p> <p>Design of a robotic system. Production and service processes. Collection and commissioning of a new robotic system. End effectors: typical designs, drives, interface with a robot arm and their applications. Practical applications of robots: handling, assembly, painting, welding, cutting materials, dispensing sealants, foams and adhesives, testing and inspection, services, medicine. Possible applications of the robot; robot selection; products, scenarios and visions of robotic systems in industry and services. Robotic production systems. Non-technical aspects of robots application: economic and organizational, social, ethical. The robotic system, its components and configurations. Transport in close proximity to the robot. Robot system control.</p> <p>Specialistic workshop:</p> <p>Development of a robotic system concept with a selected service robot based on the analysis of existing solutions. Determining the requirements for major functions and relevant performance data. Description of the environment of use. Identification of key elements and market potential. Estimate design costs, development expenditure, and innovative aspects of bringing a solution to market in a CAD environment.</p> |   |    |   |    |    |   |   |                             |
| Teaching methods                                    | Informative-problem lecture; Specialization workshop;  |   |    |   |    |    |   |   |                             |
| Assessment method                                   | Lecture: one test<br>Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop  |   |    |   |    |    |   |   |                             |
| Symbol of learning outcome                          | Learning outcomes  |   |    |   |    |    |   | Reference to the learning outcomes for the field of study |                             |
|   | Knowledge: the graduate knows and understands  |   |    |   |    |    |   |   |                             |
| L01   | basic concepts of robotic production systems   |   |    |   |    |    |   | CP1 W03   |                             |
| L02   | configurations and design methods of robotic systems   |   |    |   |    |    |   | CP1 W05   |                             |

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| L02                        | configurations and design methods of robotic systems  |  |      |
| L03                        | structure and operating principles of basic end effectors and the way of their interfacing with a robot arm   | CP1_W12  |      |
|                            | <b>Skills: the graduate is able to</b>  |  |      |
| L04                        | use CAD software and selected multimedia tools to design a given technical system   | CP1_U04 CP1_U06 CP1_U09                              |      |
| L05                        | analyze existing technical solutions, identify technical problems and create guidelines for his/her own designs of robotic systems  | CP1_U06  |      |
|                            | <b>Social competences: the graduate is ready to</b>   |  |      |
| L07                        | think and act in a creative and enterprising way  | CP1_K04  |      |
| L08                        | self-education and improvement of qualifications, use of own knowledge and experts opinions in order to solve various problems  | CP1_K01  |      |
| Symbol of learning outcome | Methods of assessing the learning outcomes  | Type of tuition during which the outcome is assessed |      |
| L01                        | Lecture: one test;  | W  |      |
| L02                        | Lecture: one test;  | W  |      |
| L03                        | Lecture: one test;  | W  |      |
| L04                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | Ps   |      |
| L05                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | Ps   |      |
| L07                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | Ps   |      |
| L08                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | Ps   |      |
|                            | Student workload (in hours)   | No. of hours   |      |
| Calculation                | Lecture attendance  | 15   |      |
|                            | Workshop attendance   | 30   |      |
|                            | Preparation for lecture test(s)   | 19   |      |
|                            | Preparation for specialistic workshop   | 24   |      |
|                            | Preparation for workshop completion   | 7  |      |
|                            | Participation in teacher-student sessions related to the module subject   | 5  |      |
|                            | <b>TOTAL</b>  | <b>100</b>   |      |
|                            | Quantitative indicators   | Hours  | ECTS |
|                            | Student workload - activities that require direct teacher participation   | 50   | 2    |
|                            | Student workload - practical activities   | 66   | 2,6  |
| Basic references           | 1. Gawrysiak M., Wykłady Robotyzacja 2004, (dostępne w postaci plików pdf).<br>2. Zdanowicz R., Robotyzacja procesów wytwarzania. Wydawnictwo Politechniki Śląskiej, Gliwice 2007.<br>3. Zdanowicz R., Robotyzacja dyskretnych procesów produkcyjnych. Wydawnictwo Politechniki Śląskiej, Gliwice 2011. |  |      |

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|   | <p>4. Kost G., Łebkowski P., Węsierski Ł., Automatykacja i robotyzacja procesów produkcyjnych. Wydawnictwo PWE, 2013</p> <p>5. Kaczmarek W. Panasiuk J., Robotyzacja procesów produkcyjnych. Wydawnictwo Naukowe PWN, 2017.</p>   |                               |
| Supplementary references                  | <p>1. Bazy online czasopism naukowych i wydawnictw naukowych z Biblioteki Politechniki Białostockiej.</p> <p>2. Materiały z Internetu ze wskazaniem na biblioteki cyfrowe dotyczące najnowszych rozwiązań z dziedziny robotyki, robotyzacji, automatyki i mechatroniki, np. <a href="http://www.intechopen.com">www.intechopen.com</a>, bazy online czasopism naukowych z bibliotek internetowych Web of Science, IEEE, SCOPUS, GOOGLE SCHOLAR, GOOGLE PATENTS itp.</p> |                               |
| Organisational unit conducting the course | Department of Automatic Control and Robotics  | Date of issuing the programme |
| Author of the programme                   | dr inż. Roman Trochimczuk   | 2022-06-07                    |

| <b>Bialystok University of Technology</b>           |  |   |    |   |           |    |   |   |                                    |  |
|---|--|---|----|---|-----------|----|---|---|------------------------------------|--|
| <b>Faculty of Electrical Engineering</b>            |  |   |    |   |           |    |   |   |                                    |  |
| Field of study                                      | <b>Industry Digitization</b>   |   |    |   |           |    |   | Degree level and programme type                           | <b>full-time Bachelor's degree</b> |  |
| Specialization / diploma path                       | <b>common subject</b>  |   |    |   |           |    |   | Study profile   | <b>general academic</b>            |  |
| Course name   | <b>Algorithms of artificial intelligence 1</b>   |   |    |   |           |    |   | Course code   | <b>CP1S06002</b>                   |  |
|   |  |   |    |   |           |    |   | Course type   | <b>elective</b>                    |  |
| Forms and number of hours of educational activities | L  | C | LC | P | SW        | FW | S | Semester  | <b>6</b>                           |  |
|   | <b>15</b>  |   |    |   | <b>30</b> |    |   | No. of ECTS credits                                       | <b>4</b>                           |  |
| Entry requirements                                  | Digital signal processing, Python programming 1, Python programming 2  |   |    |   |           |    |   |   |                                    |  |
| Course objectives                                   | Getting to know the basic concepts of artificial intelligence. Characteristics, description and application of artificial neural networks. Familiarization with machine learning techniques. Acquiring knowledge of the performance characteristics and applications of genetic algorithms. Acquisition of skills in the field of design and teaching of neural networks. Implementation of selected genetic algorithms.   |   |    |   |           |    |   |   |                                    |  |
| Course content                                      | <p>Lecture:</p> <p>Introduction to artificial intelligence, historical outline, basic concepts, achievements and applications to date. Artificial neural networks: structure, division, basic models of neurons, learning algorithms. Evolutionary algorithms: principle of operation, stages of evolution, parameters of evolution, evolution problems. Searching large databases.</p> <p>Specialistic workshop:</p> <p>Implementation of a neural network for the identification of object states and calibration of measurement signals. A genetic algorithm applied to the search for the optimal design of a simple electric vehicle. Application of the genetic algorithm to realize the autonomous gait of the bioinspired mechanism.</p> |   |    |   |           |    |   |   |                                    |  |
| Teaching methods                                    | Informative-problem lecture; Specialization workshop;  |   |    |   |           |    |   |   |                                    |  |
| Assessment method                                   | Lecture: exam<br>Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop  |   |    |   |           |    |   |   |                                    |  |
| Symbol of learning outcome                          | Learning outcomes  |   |    |   |           |    |   | Reference to the learning outcomes for the field of study |                                    |  |
|   | <b>Knowledge: the graduate knows and understands</b>   |   |    |   |           |    |   |   |                                    |  |
| LO1   | basic artificial intelligence algorithms   |   |    |   |           |    |   | CP1_W01 CP1_W02 CP1_W08                                   |                                    |  |
| LO2   | structure and operating principles of artificial neural networks   |   |    |   |           |    |   | CP1_W01 CP1_W02 CP1_W08                                   |                                    |  |
| LO3   | evolutionary algorithms  |   |    |   |           |    |   | CP1_W08   |                                    |  |
|   | <b>Skills: the graduate is able to</b>   |   |    |   |           |    |   |   |                                    |  |
| LO4   | carry out calculations with the use of artificial intelligence algorithms  |   |    |   |           |    |   | CP1_U02 CP1_U10 CP1_U12                                   |                                    |  |

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| L05   | design the control law with the use of a selected method of artificial intelligence  | CP1_U03 CP1_U06 CP1_U10                              |
| Social competences: the graduate is ready to                            |  |  |
| L07   | keep to principles of professional ethics while using artificial intelligence in engineering tasks   | CP1_K02  |
| Symbol of learning outcome  | Methods of assessing the learning outcomes   | Type of tuition during which the outcome is assessed |
| L01   | Lecture: exam;   | W  |
| L02   | Lecture: exam;   | W  |
| L03   | Lecture: exam;   | W  |
| L04   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |
| L05   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |
| L07   | Lecture: exam; Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | W Ps   |
| Student workload (in hours)   |  | No. of hours   |
| Calculation   | Lecture attendance   | 15   |
|   | Workshop attendance  | 30   |
|   | Preparation for the lecture exam; participation in the exam  | 20   |
|   | Preparation for specialistic workshop  | 23   |
|   | Preparation for workshop completion  | 7  |
|   | Participation in teacher-student sessions related to the module subject  | 5  |
|   | TOTAL  | 100  |
| Quantitative indicators   |  | Hours ECTS   |
| Student workload - activities that require direct teacher participation |  | 52 2,1   |
| Student workload - practical activities                                 |  | 65 2,6   |
| Basic references  | 1. Rudkowski L., Metody i techniki sztucznej inteligencji. Inteligencja obliczeniowa. PWN Warszawa 2005.<br>2. Osowski S., Sieci neuronowe do przetwarzania informacji. Oficyna Wydawnicza Politechniki Warszawskiej 2013.<br>3. Conway D., White M. J., Uczenie maszynowe dla programistów. Gliwice, Helion, 2015.      |  |
| Supplementary references  | 1. Russell S. J., Norvig P., Artificial intelligence - a modern approach (2nd Ed.), Prentice-Hall, 2001.<br>2. Krawiec K., Stefanowski J., Uczenie maszynowe i sieci neuronowe, Oficyna Wydawnicza Politechniki Poznańskiej, 2004.<br>3. Cichosz P., Systemy uczące się. Wydawnictwa Naukowo-Techniczne, Warszawa, 2000. |  |
| Organisational unit conducting the course                               | Department of Automatic Control and Robotics   | Date of issuing the programme                        |
| Author of the programme   | dr inż. Sławomir Romaniuk  | 2022-06-07   |

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|---|--|---|----|---|----|----|---|---|-----------------------------|
| Faculty of Electrical Engineering                   |  |   |    |   |    |    |   |   |                             |
| Field of study                                      | Industry Digitization  |   |    |   |    |    |   | Degree level and programme type                           | full-time Bachelor's degree |
| Specialization / diploma path                       | common subject   |   |    |   |    |    |   | Study profile   | general academic            |
| Course name   | Algorithms of intelligent controllers  |   |    |   |    |    |   | Course code   | CP1S06003                   |
|   |  |   |    |   |    |    |   | Course type   | elective                    |
| Forms and number of hours of educational activities | L  | C | LC | P | SW | FW | S | Semester  | 6                           |
|   | 15   |   |    |   | 30 |    |   | No. of ECTS credits                                       | 4                           |
| Entry requirements                                  | Digital signal processing, Python programming 1, Python programming 2  |   |    |   |    |    |   |   |                             |
| Course objectives                                   | Knowing and understanding the operation of intelligent controllers. Description, definition, characteristics and application of intelligent control systems. Defining and systematizing machine learning for use in intelligent control systems. Acquisition of skills in the use of artificial neural networks in the implementation of control of linear and non-linear objects. Application of fuzzy logic to control automation systems. The use of genetic algorithms for the implementation of control algorithms.   |   |    |   |    |    |   |   |                             |
| Course content                                      | <p>Lecture:</p> <p>heoretical introduction in the field of intelligent controllers, historical outline, basic concepts, achievements to date, current applications and development direction. Machine learning: artificial intelligence in the implementation of control tasks - basic concepts, systematizing the division. Examples of the use of machine learning in industry. Fuzzy algorithms: fuzzy logic, fuzzy control. Application of artificial intelligence methods in controlling linear and non-linear objects as well as objects with parametric characteristics variable in time. Examples of difficult to describe objects.</p> <p>Specialistic workshop:</p> <p>ANN implementation for the control of a non-linear object. Application of the genetic algorithm for the automatic selection of the PID controller settings and for the optimization of the parameters of the object control law. Implementation of the law of controlling an object that changes in time with the use of fuzzy logic.</p> |   |    |   |    |    |   |   |                             |
| Teaching methods                                    | Informative-problem lecture; Specialization workshop;  |   |    |   |    |    |   |   |                             |
| Assessment method                                   | Lecture: exam<br>Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop  |   |    |   |    |    |   |   |                             |
| Symbol of learning outcome                          | Learning outcomes  |   |    |   |    |    |   | Reference to the learning outcomes for the field of study |                             |
|   | Knowledge: the graduate knows and understands  |   |    |   |    |    |   |   |                             |
| L01   | basic algorithms of intelligent controllers  |   |    |   |    |    |   | CP1 W01 CP1 W02 CP1 W08                                   |                             |
| L02   | applications of artificial neural networks in control systems  |   |    |   |    |    |   | CP1 W01 CP1 W02 CP1 W08                                   |                             |
| L03   | methods of fuzzy control implementation  |   |    |   |    |    |   | CP1 W02 CP1 W08   |                             |

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| LO3                                       | methods of fuzzy control implementation   |  |      |
|   | <b>Skills: the graduate is able to</b>  |  |      |
| LO4                                       | develop control algorithm an intelligent controller   | CP1_U02 CP1_U07 CP1_U08                              |      |
| LO5                                       | design the control law with the use of a selected method of artificial intelligence   | CP1_U02 CP1_U07                                      |      |
|   | <b>Social competences: the graduate is ready to</b>   |  |      |
| LO7                                       | keep to principles of professional ethics while programming algorithms of intelligent controllers   | CP1_K02  |      |
| Symbol of learning outcome                | Methods of assessing the learning outcomes  | Type of tuition during which the outcome is assessed |      |
| LO1                                       | Lecture: exam;  | W  |      |
| LO2                                       | Lecture: exam;  | W  |      |
| LO3                                       | Lecture: exam; Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | W  | Ps   |
| LO4                                       | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   |  | Ps   |
| LO5                                       | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   |  | Ps   |
| LO7                                       | Lecture: exam; Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | W  | Ps   |
|   | Student workload (in hours)   | No. of hours   |      |
| Calculation                               | Lecture attendance  | 15   |      |
|   | Workshop attendance   | 30   |      |
|   | Preparation for the lecture exam; participation in the exam   | 20   |      |
|   | Preparation for specialistic workshop   | 23   |      |
|   | Preparation for workshop completion   | 7  |      |
|   | Participation in teacher-student sessions related to the module subject   | 5  |      |
|   | TOTAL   | 100  |      |
|   | Quantitative indicators   | Hours  | ECTS |
|   | Student workload - activities that require direct teacher participation   | 52   | 2,1  |
|   | Student workload - practical activities   | 65   | 2,6  |
| Basic references                          | 1. Rudkowski L., Metody i techniki sztucznej inteligencji. Inteligencja obliczeniowa. PWN Warszawa 2005.<br>2. Osowski S., Sieci neuronowe do przetwarzania informacji. Oficyna Wydawnicza Politechniki Warszawskiej 2013.<br>3. Conway D., White M. J., Uczenie maszynowe dla programistów. Gliwice, Helion, 2015. |  |      |
| Supplementary references                  | 1. Krawiec K., Stefanowski J., Uczenie maszynowe i sieci neuronowe, Oficyna Wydawnicza Politechniki Poznańskiej, 2004.<br>2. Cichosz P., Systemy uczące się. Wydawnictwa Naukowo-Techniczne, Warszawa, 2000.  |  |      |
| Organisational unit conducting the course | Department of Automatic Control and Robotics  | Date of issuing the programme                        |      |

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| Author of the programme | dr inż. Sławomir Romaniuk | 2022-06-07 |
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| <b>Bialystok University of Technology</b>           |  |   |    |   |           |    |   |   |                                    |  |
|---|--|---|----|---|-----------|----|---|---|------------------------------------|--|
| <b>Faculty of Electrical Engineering</b>            |  |   |    |   |           |    |   |   |                                    |  |
| Field of study                                      | <b>Industry Digitization</b>   |   |    |   |           |    |   | Degree level and programme type                           | <b>full-time Bachelor's degree</b> |  |
| Specialization / diploma path                       | <b>common subject</b>  |   |    |   |           |    |   | Study profile   | <b>general academic</b>            |  |
| Course name   | <b>Image processing algorithms</b>   |   |    |   |           |    |   | Course code   | <b>CP1S06004</b>                   |  |
|   |  |   |    |   |           |    |   | Course type   | <b>elective</b>                    |  |
| Forms and number of hours of educational activities | L  | C | LC | P | SW        | FW | S | Semester  | <b>6</b>                           |  |
|   | <b>30</b>  |   |    |   | <b>30</b> |    |   | No. of ECTS credits                                       | <b>6</b>                           |  |
| Entry requirements                                  | Digital signal processing  |   |    |   |           |    |   |   |                                    |  |
| Course objectives                                   | Provide basic information on image processing and compression. Acquisition of the skills of image content analysis, extracting the desired image features, forming the appropriate image form depending on possible applications.  |   |    |   |           |    |   |   |                                    |  |
| Course content                                      | <p>Lecture:<br/>Image formation and image perception by humans, context-free operations and changing image parameters (brightness, saturation, contrast), image processing in frequency domain (spatial FFT transformation) and digital image filtering, mathematical morphology, image reduction, re-sampling and change of image resolution, reduction of correlated and uncorrelated noise, object recognition, image compression.</p> <p>Specialistic workshop:<br/>Contextless and contextual operations on images, morphological operations, image transformations, image resolution change, noise reduction procedures, object recognition, image compression and coding.</p> |   |    |   |           |    |   |   |                                    |  |
| Teaching methods                                    | Informative-problem lecture; Specialization workshop;  |   |    |   |           |    |   |   |                                    |  |
| Assessment method                                   | Lecture: exam<br>Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop  |   |    |   |           |    |   |   |                                    |  |
| Symbol of learning outcome                          | Learning outcomes  |   |    |   |           |    |   | Reference to the learning outcomes for the field of study |                                    |  |
|   | <b>Knowledge: the graduate knows and understands</b>   |   |    |   |           |    |   |   |                                    |  |
| L01   | selected methods of signal/image analysis/processing   |   |    |   |           |    |   | CP1_W09   |                                    |  |
|   | <b>Skills: the graduate is able to</b>   |   |    |   |           |    |   |   |                                    |  |
| L04   | acquire knowledge from literature, databases and other sources, also in a foreign language; integrate the obtained information, interpret it, draw conclusions and formulate and justify opinions  |   |    |   |           |    |   | CP1_U01   |                                    |  |
| L05   | use knowledge from various fields of science to analyze, formulate   |   |    |   |           |    |   | CP1_U02   |                                    |  |

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| LO3   | and solve complex technical problems  |  |
| LO6   | plan his/her own development; work individually and in a team; estimate the time needed to complete the task; develop a work schedule and carry out this schedule while meeting the adopted deadlines | CP1_U03  |
|   | <b>Social competences: the graduate is ready to</b>   |  |
| LO7   | critical assessment of knowledge, self-education and improvement of qualifications, use of own knowledge and experts opinions in order to solve various problems                                      | CP1_K01  |
| Symbol of learning outcome  | Methods of assessing the learning outcomes  | Type of tuition during which the outcome is assessed |
| LO1   | Lecture: exam;  | W  |
| LO4   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | Ps   |
| LO5   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | Ps   |
| LO6   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | Ps   |
| LO7   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;   | Ps   |
| Student workload (in hours)   |   | No. of hours   |
| Calculation   | Lecture attendance  | 30   |
|   | Workshop attendance   | 30   |
|   | Preparation for the lecture exam; participation in the exam   | 33   |
|   | Preparation for specialistic workshop   | 40   |
|   | Preparation for workshop completion   | 12   |
|   | Participation in teacher-student sessions related to the module subject   | 5  |
|   | <b>TOTAL</b>  | <b>150</b>   |
| Quantitative indicators   |   | Hours  |
| Student workload - activities that require direct teacher participation |   | 67   |
| Student workload - practical activities                                 |   | 87   |
| Basic references  | 1. Doros M., Przetwarzanie obrazów. Skrypt WSISIZ, Warszawa 2005.   |  |
|   | 2. Malina W., Smiatacz M., Cyfrowe przetwarzanie obrazów. Akademicka Oficyna Wydawnicza EXIT, Warszawa 2012.  |  |
|   | 3. Mokrzycki W. S., Wprowadzenie do przetwarzania informacji wizualnej I: Percepcja, akwizycja, wizualizacja. Akademicka Oficyna Wydawnicza Exit, Warszawa 2010.                                      |  |
|   | 4. Mokrzycki W. S., Wprowadzenie do przetwarzania informacji wizualnej II: Dyskretyzacja, operacje pikselowe, morfologiczne i przekształcenia obrazowe. Oficyna Wydawnicza EXIT, Warszawa 2012.       |  |
|   | 5. Wróbel Z., Koprowski R., Praktyka przetwarzania obrazów w programie Matlab. Oficyna Wydawnicza EXIT, Warszawa 2004.  |  |
|   | 1. Gonzalez R. C., Woods R. E., Digital image processing. Prentice Hall, 2008.  |  |

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|---|---|-------------------------------|
| Supplementary references                  | <p>2. Tadeusiewicz R., Korohoda P., Komputerowa analiza i przetwarzanie obrazów. Społeczeństwo globalnej informacji. Wydawnictwo Fundacji Postępu Telekomunikacji, Kraków 1997.</p> <p>3. Domański M., Obraz cyfrowy. WKŁ, Warszawa 2010.</p> <p>4. Rafajłowicz E., Rafajłowicz W., Wstęp do przetwarzania obrazów przemysłowych. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2014.</p> |                               |
| Organisational unit conducting the course | Department of Photonics, Electronics and Light Technology   | Date of issuing the programme |
| Author of the programme                   | dr hab. inż. Ewa Świercz, prof. PB  | 2022-06-07                    |

| <b>Bialystok University of Technology</b>           |   |   |    |   |           |    |   |   |                                    |  |
|---|---|---|----|---|-----------|----|---|---|------------------------------------|--|
| <b>Faculty of Electrical Engineering</b>            |   |   |    |   |           |    |   |   |                                    |  |
| Field of study                                      | <b>Industry Digitization</b>  |   |    |   |           |    |   | Degree level and programme type                           | <b>full-time Bachelor's degree</b> |  |
| Specialization / diploma path                       | <b>common subject</b>   |   |    |   |           |    |   | Study profile   | <b>general academic</b>            |  |
| Course name   | <b>Objects recognition in industrial processes</b>  |   |    |   |           |    |   | Course code   | <b>CP1S06005</b>                   |  |
|   |   |   |    |   |           |    |   | Course type   | <b>elective</b>                    |  |
| Forms and number of hours of educational activities | L   | C | LC | P | SW        | FW | S | Semester  | <b>6</b>                           |  |
|   | <b>30</b>   |   |    |   | <b>30</b> |    |   | No. of ECTS credits                                       | <b>6</b>                           |  |
| Entry requirements                                  | Digital signal processing   |   |    |   |           |    |   |   |                                    |  |
| Course objectives                                   | Providing basic information on the recognition of industrial objects using imaging techniques. Understanding the methods of image acquisition, image correction, detection and identification of objects or defects based on a group of pixels. Acquiring the ability to analyze the image content, extract the desired image features that allow the assessment of objects in the images, classification of objects based on features, estimation of the location of the object using the system of vision cameras.  |   |    |   |           |    |   |   |                                    |  |
| Course content                                      | <p>Lecture:</p> <p>Image acquisition by camera and vision systems, human image perception, context-free operations and image parameter change (brightness, saturation, contrast), object detection and identification using segmentation, contour finding, image enhancement (spatial filtering, mathematical morphology), resampling and change of image resolution, noise reduction, detection and identification of objects or defects based on a group of pixels, classification of objects in an image, object position estimation.</p> <p>Specialistic workshop:</p> <p>Image analysis methods: context-free operations on images, contextual operations on images, image transformations improving the quality, changing image resolution. Morphological operations and their role in recognizing image objects. Selected transformations of feature extraction (SIFT, SURF and others) in the tasks of classification and recognition of objects in images.</p> |   |    |   |           |    |   |   |                                    |  |
| Teaching methods                                    | Informative-problem lecture; Specialization workshop;   |   |    |   |           |    |   |   |                                    |  |
| Assessment method                                   | Lecture: exam<br>Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop   |   |    |   |           |    |   |   |                                    |  |
| Symbol of learning outcome                          | Learning outcomes   |   |    |   |           |    |   | Reference to the learning outcomes for the field of study |                                    |  |
|   | <b>Knowledge: the graduate knows and understands</b>  |   |    |   |           |    |   |   |                                    |  |
| LO1   | selected methods of signal/image analysis/processing  |   |    |   |           |    |   | CP1_W09   |                                    |  |
|   | <b>Skills: the graduate is able to</b>  |   |    |   |           |    |   |   |                                    |  |
| LO4   | acquire knowledge from literature, databases and other sources, also in a foreign language; integrate the obtained information, interpret it  |   |    |   |           |    |   | CP1_U01   |                                    |  |

|   |  |  |
|---|--|--|
| L04   | in a foreign language, integrate the obtained information, interpret it, draw conclusions and formulate and justify opinions   |  |
| L05   | use knowledge from various fields of science to analyze, formulate and solve complex technical problems  | CP1_U02  |
| L06   | plan his/her own development; work individually and in a team; estimate the time needed to complete the task; develop a work schedule and carry out this schedule while meeting the adopted deadlines  | CP1_U03  |
| <b>Social competences: the graduate is ready to</b>                     |  |  |
| L07   | critical assessment of knowledge, self-education and improvement of qualifications, use of own knowledge and experts opinions in order to solve various problems   | CP1_K01  |
| Symbol of learning outcome  | Methods of assessing the learning outcomes   | Type of tuition during which the outcome is assessed |
| L01   | Lecture: exam;   | W  |
| L04   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |
| L05   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |
| L06   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |
| L07   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |
| Student workload (in hours)   |  | No. of hours   |
| Calculation   | Lecture attendance   | 30   |
|   | Workshop attendance  | 30   |
|   | Preparation for the lecture exam; participation in the exam  | 33   |
|   | Preparation for specialistic workshop  | 40   |
|   | Preparation for workshop completion  | 12   |
|   | Participation in teacher-student sessions related to the module subject  | 5  |
|   | <b>TOTAL</b>   | <b>150</b>   |
| Quantitative indicators   |  | Hours      ECTS                                      |
| Student workload - activities that require direct teacher participation |  | 67      2,7  |
| Student workload - practical activities                                 |  | 87      3,5  |
| Basic references  | 1. Doros M., Przetwarzanie obrazów. Skrypt WSISIZ, Warszawa 2005.<br>2. Malina W., Smiatacz M., Cyfrowe przetwarzanie obrazów. Akademicka Oficyna Wydawnicza EXIT, Warszawa 2012.<br>3. Mokrzycki W. S., Wprowadzenie do przetwarzania informacji wizualnej I: Percepcja, akwizycja, wizualizacja. Akademicka Oficyna Wydawnicza Exit, Warszawa 2010.<br>4. Mokrzycki W. S., Wprowadzenie do przetwarzania informacji wizualnej II: Dyskretyzacja, operacje pikselowe, morfologiczne i przekształcenia obrazowe. Oficyna Wydawnicza EXIT, Warszawa 2012. |  |

|   |   |                               |
|---|---|-------------------------------|
|   | 5. Wróbel Z., Koprowski R., Praktyka przetwarzania obrazów w programie Matlab. Oficyna Wydawnicza EXIT, Warszawa 2004.  |                               |
| Supplementary references                  | 1. Gonzalez R. C., Woods R. E., Digital image processing, Prentice Hall, 2008.<br>2. Tadeusiewicz R., Korohoda P., Komputerowa analiza i przetwarzanie obrazów. Społeczeństwo globalnej informacji. Wydawnictwo Fundacji Postępu Telekomunikacji, Kraków 1997.<br>3. Domański M., Obraz cyfrowy. WKŁ, Warszawa 2010.<br>4. Rafajłowicz E., Rafajłowicz W., Wstęp do przetwarzania obrazów przemysłowych. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2014.<br>5. Kwiatkowski W.: Metody automatycznego rozpoznawania wzorców, BEL Studio, 2007. |                               |
| Organisational unit conducting the course | Department of Photonics, Electronics and Light Technology   | Date of issuing the programme |
| Author of the programme                   | dr hab. inż. Ewa Świercz, prof. PB  | 2022-06-07                    |

| <b>Bialystok University of Technology</b>           |   |   |    |           |    |    |   |   |                                    |  |
|---|---|---|----|-----------|----|----|---|---|------------------------------------|--|
| <b>Faculty of Electrical Engineering</b>            |   |   |    |           |    |    |   |   |                                    |  |
| Field of study                                      | <b>Industry Digitization</b>  |   |    |           |    |    |   | Degree level and programme type                           | <b>full-time Bachelor's degree</b> |  |
| Specialization / diploma path                       | <b>common subject</b>   |   |    |           |    |    |   | Study profile   | <b>general academic</b>            |  |
| Course name   | <b>Interim team project</b>   |   |    |           |    |    |   | Course code   | <b>CP1S06006</b>                   |  |
|   |   |   |    |           |    |    |   | Course type   | <b>elective</b>                    |  |
| Forms and number of hours of educational activities | L   | C | LC | P         | SW | FW | S | Semester  | <b>6</b>                           |  |
|   |   |   |    | <b>30</b> |    |    |   | No. of ECTS credits                                       | <b>3</b>                           |  |
| Entry requirements                                  | -   |   |    |           |    |    |   |   |                                    |  |
| Course objectives                                   | Expanding knowledge in the field of digitization of industrial processes through independent study of specialist literature. Acquisition of the ability to solve complex technical problems, consisting in the digitization of selected industrial processes using methods and tools learned during studies and acquired through independent analysis of application examples and studying literature. Developing teamwork skills in solving a given engineering problem.   |   |    |           |    |    |   |   |                                    |  |
| Course content                                      | <p>Project classes:</p> <p>Development of a project for the digitization of a selected industrial process. The division of tasks and the definition of rules of cooperation between the members of the project team. Analysis of the literature in terms of technologies and solutions known and used in a given process. Description of the process, determination of the required production resources, measurement and control signals, material and energy flows. Process virtualization: developing a digital twin. Cloud processing of measurement and control data: selection of network technology and data transmission security, design of a cloud database, processing algorithms for large data sets. Selection and programming of robots and cooperating manipulators. Estimating the impact of the proposed solution on the social and economic environment. Presentation, discussion and defense of the completed project in the forum of the student group.</p> |   |    |           |    |    |   |   |                                    |  |
| Teaching methods                                    | Project classes;  |   |    |           |    |    |   |   |                                    |  |
| Assessment method                                   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes   |   |    |           |    |    |   |   |                                    |  |
| Symbol of learning outcome                          | Learning outcomes   |   |    |           |    |    |   | Reference to the learning outcomes for the field of study |                                    |  |
|   | <b>Knowledge: the graduate knows and understands</b>  |   |    |           |    |    |   |   |                                    |  |
| L01   | selected industrial processes as the basis for their digitization   |   |    |           |    |    |   | CP1_W03   |                                    |  |
| L02   | principles, methods and tools used in digitization of industrial processes  |   |    |           |    |    |   | CP1_W04 CP1_W05 CP1_W08<br>CP1_W09                        |                                    |  |
| L03   | non-technical aspects of engineering activity   |   |    |           |    |    |   | CP1_W11   |                                    |  |

| L03   |  | non-technical aspects of engineering activity        |      |  |
|---|--|--|------|--|
|   |  | Skills: the graduate is able to                      |      |  |
| L04   | select appropriate tools and methods to digitize a given industrial process  | CP1_U06 CP1_U07 CP1_U08<br>CP1_U09 CP1_U10           |      |  |
| L05   | obtain information from various sources, integrate and interpret them, draw conclusions and apply in his/her engineering practice        | CP1_U01  |      |  |
| L06   | work in a team during the implementation of an engineering project; prepare and present a short presentation on the results of this work | CP1_U03 CP1_U04                                      |      |  |
|   |  | Social competences: the graduate is ready to         |      |  |
| L07   | creative approach to the implementation of the design task   | CP1_K04  |      |  |
| L08   | use the acquired own knowledge and the knowledge of people with greater engineering experience to solve complex technical problems       | CP1_K01  |      |  |
| Symbol of learning outcome  | Methods of assessing the learning outcomes   | Type of tuition during which the outcome is assessed |      |  |
| L01   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes;           | P  |      |  |
| L02   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes;           | P  |      |  |
| L03   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes;           | P  |      |  |
| L04   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes;           | P  |      |  |
| L05   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes;           | P  |      |  |
| L06   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes;           | P  |      |  |
| L07   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes;           | P  |      |  |
| L08   | Project: evaluation of project completion, current progress in project completion, discussion and activity during the classes;           | P  |      |  |
| Student workload (in hours)   |  | No. of hours   |      |  |
| Calculation   | Project attendance   | 30   |      |  |
|   | Preparation for project classes  | 21   |      |  |
|   | Working on projects (including preparation of presentations)   | 12   |      |  |
|   | Preparation for projects completion  | 7  |      |  |
|   | Participation in teacher-student sessions related to the module subject  | 5  |      |  |
|   | TOTAL  | 75   |      |  |
| Quantitative indicators   |  | Hours  | ECTS |  |
| Student workload - activities that require direct teacher participation |  | 35   | 1,4  |  |

|   |  |                               |   |
|---|--|-------------------------------|---|
| Student workload - practical activities   |  | 75                            | 3 |
| Basic references                          | 1. Rudawska A., Student's team project experiences and their attitudes towards teamwork. Journal of Management and Business Administration. Central Europe, 25(1), 2017, 78-97.<br>2. Literatura techniczna z zakresu tematyki realizowanego projektu. |                               |   |
| Supplementary references                  | 1. Smith K. A., Project management and teamwork. McGraw Hill, 2000.<br>2. Zarządzanie zespołem. PARP, Wschód Biznesu, 2014. <a href="https://www.wschodzimy.pl">https://www.wschodzimy.pl</a>  |                               |   |
| Organisational unit conducting the course | Department of Automatic Control and Robotics   | Date of issuing the programme |   |
| Author of the programme                   | dr hab. inż. Zbigniew Kulesza, prof. PB  | 2022-06-07                    |   |

| <b>Bialystok University of Technology</b>           |   |   |    |   |           |    |   |   |                                    |  |
|---|---|---|----|---|-----------|----|---|---|------------------------------------|--|
| <b>Faculty of Electrical Engineering</b>            |   |   |    |   |           |    |   |   |                                    |  |
| Field of study                                      | <b>Industry Digitization</b>  |   |    |   |           |    |   | Degree level and programme type                           | <b>full-time Bachelor's degree</b> |  |
| Specialization / diploma path                       | <b>common subject</b>   |   |    |   |           |    |   | Study profile   | <b>general academic</b>            |  |
| Course name   | <b>Cloud databases</b>  |   |    |   |           |    |   | Course code   | <b>CP1S06007</b>                   |  |
|   |   |   |    |   |           |    |   | Course type   | <b>obligatory</b>                  |  |
| Forms and number of hours of educational activities | L   | C | LC | P | SW        | FW | S | Semester  | <b>6</b>                           |  |
|   | <b>15</b>   |   |    |   | <b>30</b> |    |   | No. of ECTS credits                                       | <b>3</b>                           |  |
| Entry requirements                                  | Database systems, Computer networks and wireless systems  |   |    |   |           |    |   |   |                                    |  |
| Course objectives                                   | Acquainting with cloud databases. Acquisition of skills of their establishment, configuration and maintenance.  |   |    |   |           |    |   |   |                                    |  |
| Course content                                      | <p>Lecture:</p> <p>Cloud databases, introduction, cloud database solutions, elements that should run in the cloud, services and applications. Distributed databases. Cloud programming - cloud computing. Cloud services available, IaaS, SaaS, PaaS, artificial intelligence algorithms. Connection of a cloud database with IoT systems. Communication protocols used for connectivity with the cloud. Virtual machines. Models of implementing cloud databases, traditional model, DBaaS model. Advantages and disadvantages of a cloud database. Cloud database management methods. Autonomous cloud databases. Types of cloud databases and the transition to a multi-model database. Data security, system reliability, scalability. Moving a local database to the cloud.</p> <p>Specialistic workshop:</p> <p>Establishment and configuration of the IaaS platform. Virtual machine configuration, scaling. Maintaining the cloud database. Writing C language software for communication with cloud applications. Creation and configuration of a cloud database on an assumed virtual machine. Connection of the sensor system working in the Internet of Things model to the cloud database. Deploy system security components. Communication with the created cloud from stationary and mobile devices. Programming of applications in the cloud for data processing and analysis. Data visualization carried out directly in the cloud, on a stationary device and on a mobile device. Configuration of alarm algorithms. Establishing a distributed database.</p> |   |    |   |           |    |   |   |                                    |  |
| Teaching methods                                    | Informative-problem lecture; Specialization workshop;   |   |    |   |           |    |   |   |                                    |  |
| Assessment method                                   | Lecture: one test<br>Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop   |   |    |   |           |    |   |   |                                    |  |
| Symbol of learning outcome                          | Learning outcomes   |   |    |   |           |    |   | Reference to the learning outcomes for the field of study |                                    |  |

|   |  | Knowledge: the graduate knows and understands        |      |
|---|--|--|------|
| L01   | selected concepts of cloud databases and cloud services  | CP1_W01  |      |
| L02   | architecture, functions, programming and applications of microprocessor systems used in the Internet of Things associated with cloud databases | CP1_W06  |      |
| L03   | artificial intelligence algorithms used in cloud databases   | CP1_W08  |      |
|   |  | Skills: the graduate is able to                      |      |
| L04   | design a cloud database  | CP1_U08  |      |
| L05   | use IT tools in the field of visualization and virtualization of technical processes   | CP1_U09  |      |
| L06   | use various database technologies related to cloud computing   | CP1_U10  |      |
|   |  | Social competences: the graduate is ready to         |      |
| L07   | self-education in order to learn about new trends in cloud technologies  | CP1_K01  |      |
| L08   | take actions in a planned manner and take responsibility for the results of cloud computing  | CP1_K03  |      |
| Symbol of learning outcome  | Methods of assessing the learning outcomes   | Type of tuition during which the outcome is assessed |      |
| L01   | Lecture: one test;   | W  |      |
| L02   | Lecture: one test;   | W  |      |
| L03   | Lecture: one test;   | W  |      |
| L04   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |      |
| L05   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |      |
| L06   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |      |
| L07   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |      |
| L08   | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps   |      |
| Student workload (in hours)   |  | No. of hours   |      |
| Calculation   | Lecture attendance   | 15   |      |
|   | Workshop attendance  | 30   |      |
|   | Preparation for lecture test(s)  | 9  |      |
|   | Preparation for specialistic workshop  | 12   |      |
|   | Preparation for workshop completion  | 4  |      |
|   | Participation in teacher-student sessions related to the module subject  | 5  |      |
|   | TOTAL  | 75   |      |
| Quantitative indicators   |  | Hours  | ECTS |
| Student workload - activities that require direct teacher participation |  | 50   | 2    |

|   |   |                               |   |
|---|---|-------------------------------|---|
| Student workload - practical activities   |   | 51                            | 2 |
| Basic references                          | <ol style="list-style-type: none"> <li>1. Dotson C., Bezpieczeństwo w chmurze. Przewodnik po projektowaniu i wdrażaniu zabezpieczeń. PWN, 2020.</li> <li>2. Toroman M., Chmura Azure. Praktyczne wprowadzenie dla administratora. Helion, 2020.</li> <li>3. Toroman M., Azure Networking Cookbook. Packt Publishing, 2020.</li> <li>4. Marinescu D. C., Cloud Computing Theory and Practice. Elsevier 2013.</li> </ol>                                    |                               |   |
| Supplementary references                  | <ol style="list-style-type: none"> <li>1. Costa F., Rethinking the Internet of Things, A Scalable Approach to Connecting Everything. Apress, 2014.</li> <li>2. Dunko G., Misra J., Robertson J., Snyder T., A Reference Guide to the Internet of Things. Bridgera LLC, 2017.</li> <li>3. Soldatos J., Building Blocks for IoT Analytics. River Publishers, 2017.</li> <li>4. Lewis D., Database systems: Volume 1. University of London, 2016.</li> </ol> |                               |   |
| Organisational unit conducting the course | Department of Automatic Control and Robotics  | Date of issuing the programme |   |
| Author of the programme                   | dr inż. Wojciech Wojtkowski   | 2022-06-07                    |   |

| <b>Bialystok University of Technology</b>           |   |   |    |   |           |    |   |                                 |                                    |  |
|---|---|---|----|---|-----------|----|---|---------------------------------|------------------------------------|--|
| <b>Faculty of Electrical Engineering</b>            |   |   |    |   |           |    |   |                                 |                                    |  |
| Field of study                                      | <b>Industry Digitization</b>  |   |    |   |           |    |   | Degree level and programme type | <b>full-time Bachelor's degree</b> |  |
| Specialization / diploma path                       | <b>common subject</b>   |   |    |   |           |    |   | Study profile                   | <b>general academic</b>            |  |
| Course name   | <b>Systems virtualization</b>   |   |    |   |           |    |   | Course code                     | <b>CP1S06008</b>                   |  |
|   |   |   |    |   |           |    |   | Course type                     | <b>elective</b>                    |  |
| Forms and number of hours of educational activities | L   | C | LC | P | SW        | FW | S | Semester                        | <b>6</b>                           |  |
|   | <b>15</b>   |   |    |   | <b>30</b> |    |   | No. of ECTS credits             | <b>4</b>                           |  |
| Entry requirements                                  | Process visualization, PLC programming, Industrial networks 1   |   |    |   |           |    |   |                                 |                                    |  |
| Course objectives                                   | Acquisition of knowledge and skills in the field of design and programming of virtual models of machines, devices and industrial automation systems. Designing and programming models of production lines and conducting their simulations in real time. Support for cooperation of industrial manipulators.  |   |    |   |           |    |   |                                 |                                    |  |
| Course content                                      | <p>Lecture:</p> <p>Basic aspects of virtual reality elements in industrial automation systems. Designing, modeling and programming models of virtual elements of machines, devices and entire industrial automation systems. Support for PLCSIM and PLCSIM Advanced simulators. Programming models of machines, devices and systems in the SIMIT and Factory I/O environment. Conducting real-time simulations. Running hardware simulation. Building and servicing of virtual communication/distributed systems models. OPC UA interfaces for the SCADA system. Web-server support for remote access to process data and management. System integration with the data cloud. API programming. S7 communication. Designing control logic for the operation of models of electromechanical, hydraulic, pneumatic and drive systems. Virtual models of cooperation of industrial manipulators.</p> <p>Specialistic workshop:</p> <p>Solving problem tasks in the field of programming and testing control logic for the operation of models of electromechanical, hydraulic, pneumatic and drive systems, eg in TIA portal and SIMIT. Construction of production line models in Factory I/O. Programming cooperation of industrial manipulators. Testing the work of models. Conducting simulations of the operation of virtual models in PLCSIM and PLCSIM Advanced simulators. Programming of models of machines, devices and systems in the SIMIT environment. Conducting real-time simulations. Running hardware simulation. Programming and configuration of OPC UA communication interfaces in PLC and web-server devices. PLC integration, data logging and data processing to the data cloud.</p> |   |    |   |           |    |   |                                 |                                    |  |
| Teaching methods                                    | Informative-problem lecture; Specialization workshop;   |   |    |   |           |    |   |                                 |                                    |  |
| Assessment method                                   | Lecture: one test<br>Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop   |   |    |   |           |    |   |                                 |                                    |  |

| Symbol of learning outcome | Learning outcomes  | Reference to the learning outcomes for the field of study |
|----------------------------|--|---|
|                            | <b>Knowledge: the graduate knows and understands</b>   |   |
| L01                        | basics of designing and programming models of virtual machines, devices and industrial automation systems  | CP1_W01 CP1_W02 CP1_W03<br>CP1_W05 CP1_W07                |
| L02                        | basics of design and programming of production line models and cooperation of industrial manipulators  | CP1_W02 CP1_W03 CP1_W05<br>CP1_W07                        |
| L03                        | programming environments and simulators of industrial automation devices and systems for testing virtual models in real time                     | CP1_W02 CP1_W03 CP1_W05<br>CP1_W07                        |
|                            | <b>Skills: the graduate is able to</b>   |   |
| L04                        | design and program models of virtual machines, devices and industrial automation systems   | CP1_U07 CP1_U08 CP1_U09<br>CP1_U10                        |
| L05                        | design and program production line models and cooperation of industrial manipulators   | CP1_U07 CP1_U08 CP1_U09<br>CP1_U10                        |
| L06                        | simulate the operation of virtual models of industrial automation systems in real time   | CP1_U07 CP1_U08 CP1_U09<br>CP1_U10                        |
|                            | <b>Social competences: the graduate is ready to</b>  |   |
| L07                        | critical assessment of knowledge in the field of designing and programming virtual models of machines, devices and industrial automation systems | CP1_K01   |
| Symbol of learning outcome | Methods of assessing the learning outcomes   | Type of tuition during which the outcome is assessed      |
| L01                        | Lecture: one test;   | W   |
| L02                        | Lecture: one test;   | W   |
| L03                        | Lecture: one test;   | W   |
| L04                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps  |
| L05                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps  |
| L06                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps  |
| L07                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps  |
|                            | <b>Student workload (in hours)</b>   | <b>No. of hours</b>                                       |
| Calculation                | Lecture attendance   | 15  |
|                            | Workshop attendance  | 30  |
|                            | Preparation for lecture test(s)  | 19  |
|                            | Preparation for specialistic workshop  | 24  |
|                            | Preparation for workshop completion  | 7   |
|                            | Participation in teacher-student sessions related to the module subject  | 5   |

|   |   | TOTAL                         | 100  |
|---|---|-------------------------------|------|
| Quantitative indicators   |   | Hours                         | ECTS |
| Student workload - activities that require direct teacher participation |   | 50                            | 2    |
| Student workload - practical activities                                 |   | 66                            | 2,6  |
| Basic references  | 1. <a href="https://support.industry.siemens.com/cs/products?mfn=ps&amp;lc=en-PT">https://support.industry.siemens.com/cs/products?mfn=ps&amp;lc=en-PT</a><br>2. Krzyżanowski R., SIMATIC Motion Control - sterowanie serwonapędami, Helion, 2022.<br>3. <a href="https://www.biblioteka.siemens.academy/materials">https://www.biblioteka.siemens.academy/materials</a><br>4. <a href="http://www.profibus.com">www.profibus.com</a> , <a href="http://www.profibus.org.pl">www.profibus.org.pl</a> (PNO), <a href="http://www.multiprojekt.pl/">http://www.multiprojekt.pl/</a> ; Kanał youtube-#Pro_Tuto - komunikacja PLC i symulacja komunikacji<br>5. Tematy szkoleniowe: PLC SIM Advanced, Komunikacja OPC UA w sterownikach SIMATIC, programy do symulacji układów automatyki, platforma symulacyjna SIMIT. |                               |      |
| Supplementary references  | 1. Serwisy internetowe: <a href="https://automatykab2b.pl/">https://automatykab2b.pl/</a> , <a href="https://iautomatyka.pl/">https://iautomatyka.pl/</a> , <a href="https://strefainzyniera.pl/">https://strefainzyniera.pl/</a> ; <a href="https://www.multiprojekt.pl/">https://www.multiprojekt.pl/</a><br>2. Przemysł 4.0 w akcji – przykłady zastosowań - <a href="https://www.multiprojekt.pl/przemysl-4-0-w-akcji-przyklady-zastosowan-2/">https://www.multiprojekt.pl/przemysl-4-0-w-akcji-przyklady-zastosowan-2/</a><br>3. <a href="https://factoryio.com">https://factoryio.com</a>   |                               |      |
| Organisational unit conducting the course                               | Department of Automatic Control and Robotics  | Date of issuing the programme |      |
| Author of the programme   | dr hab. inż. Arkadiusz Mystkowski, prof.<br>PB  | 2022-06-07                    |      |

| <b>Bialystok University of Technology</b>           |  |   |    |   |           |    |   |                                 |                                    |  |
|---|--|---|----|---|-----------|----|---|---------------------------------|------------------------------------|--|
| <b>Faculty of Electrical Engineering</b>            |  |   |    |   |           |    |   |                                 |                                    |  |
| Field of study                                      | <b>Industry Digitization</b>   |   |    |   |           |    |   | Degree level and programme type | <b>full-time Bachelor's degree</b> |  |
| Specialization / diploma path                       | <b>common subject</b>  |   |    |   |           |    |   | Study profile                   | <b>general academic</b>            |  |
| Course name   | <b>Cyberphysical systems</b>   |   |    |   |           |    |   | Course code                     | <b>CP1S06009</b>                   |  |
|   |  |   |    |   |           |    |   | Course type                     | <b>elective</b>                    |  |
| Forms and number of hours of educational activities | L  | C | LC | P | SW        | FW | S | Semester                        | <b>6</b>                           |  |
|   | <b>15</b>  |   |    |   | <b>30</b> |    |   | No. of ECTS credits             | <b>4</b>                           |  |
| Entry requirements                                  | Process visualization, PLC programming, Industrial networks 1  |   |    |   |           |    |   |                                 |                                    |  |
| Course objectives                                   | Acquisition of knowledge and skills in the field of active connection of devices, machines (including industrial robots) working autonomously equipped with integrated communication systems with their virtual models. Basics of connecting components of simulation models of machines and devices with mechanical and electronic parts of real machines and devices.  |   |    |   |           |    |   |                                 |                                    |  |
| Course content                                      | <p>Lecture:</p> <p>Structure of a cyber-physical system with a high degree of complexity. Designing and programming models of machines and devices and their integration in communication networks with their real counterparts working in industrial automation. Support for PLCSIM and PLCSIM Advanced simulators, SIMIT environment and NX MCD/Plant Simulation software. Running hardware simulation. Conducting simulations of the operation of cyber-physical systems in real time. Support for cooperation of industrial manipulators and elements of production lines with their virtual counterparts, the so-called digital machine twins. Design and programming of cyber physical systems. IT systems. Support for communication interfaces of machines and models. Building and servicing of virtual communication/distributed systems models. Design of control logic for the work of digital twins of machines and systems.</p> <p>Specialistic workshop:</p> <p>Implementation of problem projects in the field of design and programming of cyber-physical systems in the NC MCD/Plant Simulation environment. Conducting simulations of cyber-physical systems using API interfaces and the SIMIT environment. Building models of machines and devices in the Plant Simulation and SIMIT environment. Integration of models of virtual machines and devices with mechanical and electronic elements of real equivalents (machine twins). Programming of logic for controlling cyber physical systems in the TIA portal environment. Conducting simulations of the operation of cyber-physical systems in SIMIT, PLCSIM and PLCSIM Advanced simulators. Conducting real-time simulations. Running hardware simulation.</p> |   |    |   |           |    |   |                                 |                                    |  |
| Teaching methods                                    | Informative-problem lecture; Specialization workshop;  |   |    |   |           |    |   |                                 |                                    |  |
| Assessment  | Lecture: one test  |   |    |   |           |    |   |                                 |                                    |  |

| method                     | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop   |   |
|----------------------------|--|---|
| Symbol of learning outcome | Learning outcomes  | Reference to the learning outcomes for the field of study |
|                            | <b>Knowledge: the graduate knows and understands</b>   |   |
| LO1                        | basics of construction and principles of operation of devices and machines (including industrial robots) as cyber-physical systems                       | CP1_W01 CP1_W02 CP1_W03<br>CP1_W05 CP1_W07                |
| LO2                        | basic principles of connecting components of simulation models of machines and devices with mechanical and electronic parts of real machines and devices | CP1_W02 CP1_W03 CP1_W05<br>CP1_W07                        |
| LO3                        | tools for the design, modeling and simulation of cyber physical systems  | CP1_W02 CP1_W03 CP1_W05<br>CP1_W07                        |
|                            | <b>Skills: the graduate is able to</b>   |   |
| LO4                        | design and model virtual models of devices and machines (including industrial robots) as cyber-physical systems  | CP1_U07 CP1_U08 CP1_U09<br>CP1_U10                        |
| LO5                        | make active joining of components of simulation models of machines and devices with mechanical and electronic parts of real machines and devices         | CP1_U07 CP1_U08 CP1_U09<br>CP1_U10                        |
| LO6                        | use tools for designing, modeling and simulating cyber-physical systems  | CP1_U07 CP1_U08 CP1_U09<br>CP1_U10                        |
|                            | <b>Social competences: the graduate is ready to</b>  |   |
| LO7                        | critical assessment of knowledge in the field of designing and programming virtual models of machines, devices and industrial automation systems         | CP1_K01   |
| Symbol of learning outcome | Methods of assessing the learning outcomes   | Type of tuition during which the outcome is assessed      |
| LO1                        | Lecture: one test;   | W   |
| LO2                        | Lecture: one test;   | W   |
| LO3                        | Lecture: one test;   | W   |
| LO4                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps  |
| LO5                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps  |
| LO6                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps  |
| LO7                        | Specialistic workshop: evaluation of reports, individual progress, discussion and activity at workshop;  | Ps  |
|                            | Student workload (in hours)  | No. of hours  |
|                            | Lecture attendance   | 15  |
|                            | Workshop attendance  | 30  |
|                            | Preparation for lecture test(s)  | 19  |

|   |   |                               |      |
|---|---|-------------------------------|------|
| Calculation   | Preparation for specialistic workshop   | 24                            |      |
|   | Preparation for workshop completion   | 7                             |      |
|   | Participation in teacher-student sessions related to the module subject   | 5                             |      |
|   | TOTAL   | 100                           |      |
| Quantitative indicators   |   | Hours                         | ECTS |
| Student workload - activities that require direct teacher participation |   | 50                            | 2    |
| Student workload - practical activities                                 |   | 66                            | 2,6  |
| Basic references  | <ol style="list-style-type: none"> <li>1. <a href="https://support.industry.siemens.com/cs/products?mfn=ps&amp;lc=en-PT">https://support.industry.siemens.com/cs/products?mfn=ps&amp;lc=en-PT</a></li> <li>2. Krzyżanowski R., SIMATIC Motion Control - sterowanie serwonapędami, Helion, 2022.</li> <li>3. <a href="https://www.biblioteka.siemens.academy/materials">https://www.biblioteka.siemens.academy/materials</a></li> <li>4. <a href="http://www.profibus.com">www.profibus.com</a>, <a href="http://www.profibus.org.pl">www.profibus.org.pl</a> (PNO), <a href="http://www.multiprojekt.pl/">http://www.multiprojekt.pl/</a>; Kanał youtube-#Pro_Tuto - komunikacja PLC i symulacja komunikacji</li> <li>5. Tematy szkoleniowe: PLC SIM Advanced, Komunikacja OPC UA w sterownikach SIMATIC, programy do symulacji układów automatyki, platforma symulacyjna SIMIT.</li> </ol> |                               |      |
| Supplementary references  | <ol style="list-style-type: none"> <li>1. Serwisy internetowe: <a href="https://automatykab2b.pl/">https://automatykab2b.pl/</a>, <a href="https://iautomatyka.pl/">https://iautomatyka.pl/</a>, <a href="https://strefainzyniera.pl/">https://strefainzyniera.pl/</a></li> <li>2. Przemysł 4.0 w akcji – przykłady zastosowań - <a href="https://www.multiprojekt.pl/przemysl-4-0-w-akcji-przyklady-zastosowan-2/">https://www.multiprojekt.pl/przemysl-4-0-w-akcji-przyklady-zastosowan-2/</a></li> <li>3. <a href="https://factoryio.com">https://factoryio.com</a></li> </ol>   |                               |      |
| Organisational unit conducting the course                               | Department of Automatic Control and Robotics  | Date of issuing the programme |      |
| Author of the programme   | dr hab. inż. Arkadiusz Mystkowski, prof.<br>PB  | 2022-06-07                    |      |

COURSE DESCRIPTION CARD

|   |   |  |                                     |
|---|---|--|-------------------------------------|
| <b>BIALYSTOK UNIVERSITY OF TECHNOLOGY</b> |   | <b>Faculty of Electrical Engineering</b> |                                     |
| <b>Field of study</b>                     | Industry Digitization   | <b>Level and form of study</b>           | Full-time first-cycle (BSc) studies |
| <b>A group of modules /specialty</b>      | Common subject  | <b>Education profile</b>                 | General                             |
| <b>Course name</b>                        | Industrial Networks 2   | <b>Course code</b>                       | CP1S06010                           |
|   |   | <b>Course type</b>                       | Mandatory                           |
| <b>Course form(s) and number of hours</b> | <b>L</b> <b>C</b> <b>LC</b> <b>P</b> <b>SW</b> <b>FW</b> <b>S</b> | <b>Semester</b>                          | <b>6</b>                            |
|   | 15 45   | <b>ECTS credits</b>                      | <b>6</b>                            |
| <b>The programme is valid from</b>        | 2025/2026   |  |                                     |
| <b>Introductory courses</b>               | CP1S05010   |  |                                     |

**Course objectives**

Introduction to Ethernet-based communication systems in networked industrial automation using high-level protocols such as TCP/IP, IRT, RT and PROFINET. Practical operation of PROFINET IO, ISO on TCP, MQTT, OPC UA and Modbus TCP communication. Principles of designing, commissioning, servicing and diagnosing PLC industrial networks and peripheral devices in DCS systems.

**Framework programme content**

Ethernet protocol structure. OSI model. Profile/architecture of TCP/IP, RT and IRT protocols. Physical and application layers of PROFINET IO. Operation in RT, IRT and non-RT modes. Design of PROFINET IO using PLCs. Principles for configuring and operating devices in a PROFINET IO network. Safety categories for devices controlled via an industrial network. Design of redundant networked systems. Communication functions in PROFINET IO using PLCs. Cyclic and acyclic communication. Network and peripheral diagnostics. Modbus TCP. Programming functions for MQTT and ISO on TCP communication. Implementing DCS communication tasks over Ethernet/PROFINET IO. Use of the MQTT protocol. Hardware and software handling of PLCs and peripherals. Programming cyclic/acyclic process-data communication in TCP/IP/RT/IRT modes. Building network topology. Performing diagnostics of the physical and application layers. Asynchronous communication with peripheral devices. A PROFINET IO network design for an example Safety system. Redundant network design under PROFINET IO. Decentralized safety system design using PROFINET IO. Design and simulation of a system with OPC UA/API communication and a web server. Synchronous master-slave communication with handling of selected system interrupts.

**Other information about the course**

content of the course refers to the principles of sustainable development  
the course is related to the scientific activity conducted at the University

|                     | Student workload related to:                     | Total number of hours | including contact | including practical |
|---------------------|--|-----------------------|-------------------|---------------------|
|                     |  |                       |                   |                     |
| <b>Calculation:</b> | participation in lectures                        | 15                    | 15                |                     |
|                     | participation in other forms of activities       | 45                    | 45                | 45                  |
|                     | participation in an examination                  | 3                     | 3                 | 2,3                 |
|                     | completion of professional training              | 0                     |                   | 0                   |
|                     | preparation for passing a lecture/an examination | 5                     |                   |                     |
|                     | preparation for practical classes                | 82                    |                   | 82                  |
|                     |  |                       | 0                 | 0                   |
|                     |  |                       |                   | 0                   |
|                     |  |                       |                   | 0                   |
|                     |  |                       |                   | 0                   |
|                     | <b>Total number of hours:</b>                    | <b>150</b>            | <b>63</b>         | <b>129</b>          |
|                     | <b>Total number of ECTS credits:</b>             | <b>6</b>              | <b>2,5</b>        | <b>5,2</b>          |

| <b>Expected discipline learning outcomes</b> | Knowledge | Skills | Social competence |
|--|-----------|--------|-------------------|
|  |           |        |                   |

**Objectives and framework content prepared by** Arkadiusz Mystkowski, DSc. PhD Eng. Assoc. Prof. **Date:** 3.09.2025

**Implementation in the academic year** 2025/2026

| <b>Programme content</b> | <b>Lecture</b>    |   |
|--------------------------|-------------------|---|
|                          |                   |   |
|                          | 1                 | Ethernet protocol structure. OSI model.   |
|                          | 2                 | Profile and architecture of TCP/IP, RT and IRT protocols.                               |
|                          | 3                 | PROFINET IO – physical and application layers.  |
|                          | 4                 | Operation in RT, IRT and non-RT modes.  |
|                          | 5                 | Design of PROFINET IO using PLCs.   |
|                          | 6                 | Configuring and operating devices in a PROFINET IO network.                             |
|                          | 7                 | Safety categories for devices controlled via an industrial network.                     |
|                          | 8                 | Design of redundant networked systems.  |
|                          | 9                 | Communication functions in PROFINET IO using PLCs.                                      |
|                          | 10                | Cyclic and acyclic communication.   |
|                          | 11                | Diagnostics of networks and peripheral devices.   |
|                          | 12                | Handling the Modbus TCP protocol.   |
|                          | 13                | Programming functions for MQTT communication.   |
|                          | 14                | OPC communication (web server).   |
|                          | 15                | S7 and ISO on TCP communication.  |
|                          | <b>Laboratory</b> |   |
|                          | 1                 | Communication with a SIPART S22 industrial controller and HMI panel using PROFINET I/O. |
|                          | 2                 | Familiarization with PLC SIM Advanced software.   |
|                          | 3                 | Communication with a Profisafe system over PROFINET I/O.                                |
|                          | 4                 | Communication with a signal tower via IO-Link.  |
|                          | 5                 | Handling a vision system over PROFINET I/O.   |

|  |    |  |
|--|----|--|
|  | 6  | MQTT communication.  |
|  | 7  | OPC communication (web server).  |
|  | 8  | S7 communication, PUT/GET functions.   |
|  | 9  | Synchronous IRT communication in a PROFINET I/O network  |
|  | 10 | ISO on TCP communication.  |
| <b>Teaching methods</b>                  | L  | Informative/problem-based lecture, discussion.   |
|  | LC | laboratory exercises   |
| <b>Teaching methods (online classes)</b> | -  |  |
| <b>Forms of crediting</b>                | L  | Written exam, two midterm tests, and an extra optional homeworks to increase the mark.   |
|  | LC | Evaluation of entry quizzes, reports, discussions and in-class activity  |
| <b>Conditions of crediting</b>           | L  | Written exam pass/grade scale: ( $\leq 49\%$ ) 2.0 (fail); (50%–60%) 3.0; (61%–70%) 3.5; (71%–80%) 4.0; (81%–90%) 4.5; (91%–100%) 5.0. |
|  | LC | The final assessment depends on the completeness of the individual lab tasks, homework tasks, report preparation and its presentation. |

**Outcome symbols** -

| Knowledge: the student knows and understands      | Expected learning outcomes   | Expected learning outcomes defined for the field of study |         |                   |
|---|--|---|---------|-------------------|
|   |  | owlegde   | Skills  | Social competence |
| <b>E1</b>   | the operating principles of Ethernet, TCP/IP, IRT, RT, and PROFI-safe network protocols.   | CP1_W10   |         |                   |
| <b>E2</b>   | functions for decentralized data exchange in industrial communication systems.   | CP1_W10   |         |                   |
| <b>E3</b>   | methods for diagnosing industrial networks and peripheral devices.   | CP1_W10   |         |                   |
| <b>Skills: the student can</b>                    |  |   |         |                   |
| <b>E4</b>   | configure, commission, and test communication connections in PROFI-safe, PROFINET IO networks, and redundant systems.  |   | CP1_U07 |                   |
| <b>E5</b>   | program functions for real-time data exchange in industrial networks.  |   | CP1_U07 |                   |
| <b>E6</b>   | apply selected methods for diagnosing industrial networks at the physical and application layers.  |   | CP1_U07 |                   |
| <b>Social competence: the student is ready to</b> |  |   |         |                   |
| <b>E7</b>   | critically evaluate one's own knowledge and skills in the design and operation of networked automation systems, while adhering to the principles of professional ethics. |   |         | CP1_K01           |

**Outcome symbols**

|           | Methods of verification of learning outcomes   | Course form subject to verification |
|-----------|--|-------------------------------------|
| <b>E1</b> | Written exam; completion of laboratory reports | W, LC                               |
| <b>E2</b> | Written exam; completion of laboratory reports | W, LC                               |
| <b>E3</b> | Written exam; completion of laboratory reports | W, LC                               |
| <b>E4</b> | Written exam; completion of laboratory reports | LC                                  |
| <b>E5</b> | Written exam; completion of laboratory reports | LC                                  |
| <b>E6</b> | Written exam; completion of laboratory reports | LC                                  |
| <b>E7</b> | Written exam; completion of laboratory reports | W, LC                               |

**Basic references**

- IEC 61784-1; IEC 61784-2; IEC 61784-5; IEC 61158-4, IEC 61158-5, IEC61784.
- Pigan R., Metter M., Automating with PROFINET: Industrial communication based on industrial Ethernet. 2nd Edition, 2015.
- Ethernet, 2nd ed., Siemens, 2006.
- Popp M., Weber K., The rapid way to PROFINET, PNO, 2004.

**Supplementary references**

- Teacher's materials, projects and instructions.
- <https://support.industry.siemens.com>, [www.profibus.com](http://www.profibus.com)

**Course coordinator**

Arkadiusz Mystkowski, DSc. PhD Eng. Assoc. Prof.

**Date:**

3.09.2025