



## Subject card

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| Subject name and code                       | Control System Structures, PG_00016960                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                          |                                                                                                                                                                                                                                                                         |                                     |                                                                                                                                 |            |     |
| Field of study                              | Automation, Robotics and Control Systems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                          |                                                                                                                                                                                                                                                                         |                                     |                                                                                                                                 |            |     |
| Date of commencement of studies             | February 2026                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                          | Academic year of realisation of subject                                                                                                                                                                                                                                 |                                     | 2026/2027                                                                                                                       |            |     |
| Education level                             | second-cycle studies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                          | Subject group                                                                                                                                                                                                                                                           |                                     |                                                                                                                                 |            |     |
| Mode of study                               | Full-time studies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                          | Mode of delivery                                                                                                                                                                                                                                                        |                                     | at the university                                                                                                               |            |     |
| Year of study                               | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                          | Language of instruction                                                                                                                                                                                                                                                 |                                     | Polish                                                                                                                          |            |     |
| Semester of study                           | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                          | ECTS credits                                                                                                                                                                                                                                                            |                                     | 4.0                                                                                                                             |            |     |
| Learning profile                            | general academic profile                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                          | Assessment form                                                                                                                                                                                                                                                         |                                     | exam                                                                                                                            |            |     |
| Conducting unit                             | Department of Electric Drives and Energy Conversion -> Faculty of Electrical and Control Engineering -> Faculties of Gdańsk University of Technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                          |                                                                                                                                                                                                                                                                         |                                     |                                                                                                                                 |            |     |
| Name and surname of lecturer (lecturers)    | Subject supervisor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                          | dr hab. inż. Marek Adamowicz                                                                                                                                                                                                                                            |                                     |                                                                                                                                 |            |     |
|                                             | Teachers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                          | dr hab. inż. Marek Adamowicz                                                                                                                                                                                                                                            |                                     |                                                                                                                                 |            |     |
| Lesson types                                | Lesson type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Lecture                                                  | Tutorial                                                                                                                                                                                                                                                                | Laboratory                          | Project                                                                                                                         | Seminar    | SUM |
|                                             | Number of study hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 30.0                                                     | 0.0                                                                                                                                                                                                                                                                     | 15.0                                | 0.0                                                                                                                             | 0.0        | 45  |
|                                             | E-learning hours included: 0.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                          |                                                                                                                                                                                                                                                                         |                                     |                                                                                                                                 |            |     |
| Learning activity and number of study hours | Learning activity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Participation in didactic classes included in study plan |                                                                                                                                                                                                                                                                         | Participation in consultation hours |                                                                                                                                 | Self-study | SUM |
|                                             | Number of study hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 45                                                       |                                                                                                                                                                                                                                                                         | 10.0                                |                                                                                                                                 | 45.0       | 100 |
| Subject objectives                          | The aim of the course is to equip students with the knowledge and skills to create control system structures for various types of control systems. Students will learn the principles of selecting the appropriate control system structure for a control system. Furthermore, students will acquire knowledge on defining the control purpose and control quality requirements, as well as knowledge on the design and modeling of control systems, and the study of control system characteristics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                          |                                                                                                                                                                                                                                                                         |                                     |                                                                                                                                 |            |     |
| Learning outcomes                           | Course outcome                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                          | Subject outcome                                                                                                                                                                                                                                                         |                                     | Method of verification                                                                                                          |            |     |
|                                             | [K7_K06] is aware of the impact of engineering activities on the quality of applied solutions and the environment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                          | Based on the acquired theoretical knowledge and simulation studies, it assesses the quality of the control system, compliance with requirements and the possibility of implementation on a physical object.                                                             |                                     | [SK5] Assessment of ability to solve problems that arise in practice                                                            |            |     |
|                                             | [K7_W14] has knowledge of mathematical modelling, identification, optimisation, decision support decision-making and control, knows methods of implementing advanced control algorithms in industrial equipment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                          | Builds a model of a given control object in the form of a transfer function or a system of differential equations, builds a simulation model and implements the given structure of a complex control system, taking into account constraints and parametric uncertainty |                                     | [SW2] Assessment of knowledge contained in presentation<br>[SW3] Assessment of knowledge contained in written work and projects |            |     |
| Subject contents                            | <div>Course content – lecture</div> <ul style="list-style-type: none"><li>• Feed-forward control.</li><li>• Cascade control system with trajectory generator and disturbance compensation.</li><li>• Delayed object control (Smith predictor).</li><li>• State-feedback control.</li><li>• Vibration damping methods.</li><li>• Adaptive control (MRAS).</li><li>• Sliding-mode control of a nonlinear object.</li><li>• Nonlinear control, nonlinear transformation of variables, and feedback linearization.</li><li>• Modal control.</li></ul> <div>Course content – laboratory</div> <ul style="list-style-type: none"><li>• Eliminating vibrations in poorly damped systems using an input shaping filter.</li><li>• A state-feedback control system.</li><li>• Using the Smith predictor to control an object with a delay.</li><li>• A model-based adaptive control system (MRAS, MRAC).</li><li>• Investigating a cascaded control system using a servo mechanism as an example.</li><li>• Robust servo control using sliding mode control.</li></ul> |                                                          |                                                                                                                                                                                                                                                                         |                                     |                                                                                                                                 |            |     |

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|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Prerequisites and co-requisites                                | Basic knowledge of automation, including the elementary structures of P, I, PI, and PD controllers. Knowledge of the Laplace Transform and the definition of the transfer function.                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                               |
| Assessment methods and criteria                                | Subject passing criteria                                                                                                                                                                                                                                                                                                                                                                           | Passing threshold                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Percentage of the final grade |
|                                                                | Exam                                                                                                                                                                                                                                                                                                                                                                                               | 50.0%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 50.0%                         |
|                                                                | Laboratory reports                                                                                                                                                                                                                                                                                                                                                                                 | 60.0%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 50.0%                         |
| Recommended reading                                            | Basic literature                                                                                                                                                                                                                                                                                                                                                                                   | 1. Kaczorek T., Dzieliński, Dąbrowski, Łopatka: Podstawy teorii sterowania, PWN 2009.<br>2. Tatjewski P.: Sterowanie zaawansowane obiektów przemysłowych. Struktury i Algorytmy. Warszawa.<br>3. Bubnicki: Teoria i algorytmy sterowania, PWN, 2005.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                               |
|                                                                | Supplementary literature                                                                                                                                                                                                                                                                                                                                                                           | 1. Åström, Wittenmark , H. Butler, Model-Reference Adaptive Control- From Theory to Practice, Prentice-Hall, 1992,<br>2. Bodgan Wilamowski; J. David Irwin: Control and mechatronics, CRC Press, Taylor&Francis Group, 2011.<br>3. Bogdan M. Wilamowski; J. David Irwin: Intelligent systems, CRC Press, Taylor&Francis Group, 2011.<br>4. Brok S.: Struktury odpornego sterowania elektrycznego napędu bezpośredniego z wykorzystaniem koncepcji sterowania ślizgowego, Politechnika Poznańska, Rozprawy nr 497, Poznań, 2013.<br>5. Ellis G.: Comparison of position control for industrial Applications, Danaher Motion, 2002.<br>6. Franklin G., Powell J. D., Emami-Naeini A.: Feedback Control of Dynamic Systems, Prentice Hall, 4 edition, 2002.<br>7. Malek. K, Makys P., Sturlajter M.: Feed Forward Control of Electrical Drives Rules and Limits, Power Engineering and Electrical Engineering, vol.9, no 1/2011 |                               |
|                                                                | eResources addresses                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                               |
| Example issues/<br>example questions/<br>tasks being completed | 1. Discuss the properties of a cascaded control systema servomechanism: response to trapezoidal and sinusoidal setpoints, Bode plot.<br><br>2. Explain the structure of a MRAS and list the methods for parameter adaptation.<br><br>3. To what class of objects is sliding mode control applied? 4. Describe the principles of constructing a setpoint signal in open systems with input shaping. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                               |
| Practical activites within the subject                         | Not applicable                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                               |

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