



## Subject card

|                                             |                                                                                                                                                                                                                                                                                                      |                                                          |                                                                                                                                                                                                                                                                                                                                                 |                                     |                                                                                                                                                                                                                                                           |            |     |
|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-----|
| Subject name and code                       | Kalman Filters and Stochastic Control, PG_00064517                                                                                                                                                                                                                                                   |                                                          |                                                                                                                                                                                                                                                                                                                                                 |                                     |                                                                                                                                                                                                                                                           |            |     |
| Field of study                              | Filtr Kalmana i sterowanie w warunkach losowych                                                                                                                                                                                                                                                      |                                                          |                                                                                                                                                                                                                                                                                                                                                 |                                     |                                                                                                                                                                                                                                                           |            |     |
| Date of commencement of studies             | February 2026                                                                                                                                                                                                                                                                                        |                                                          | Academic year of realisation of subject                                                                                                                                                                                                                                                                                                         |                                     | 2025/2026                                                                                                                                                                                                                                                 |            |     |
| Education level                             | second-cycle studies                                                                                                                                                                                                                                                                                 |                                                          | Subject group                                                                                                                                                                                                                                                                                                                                   |                                     | Optional subject group<br>Specialty subject group<br>Subject group related to scientific research in the field of study                                                                                                                                   |            |     |
| Mode of study                               | Full-time studies                                                                                                                                                                                                                                                                                    |                                                          | Mode of delivery                                                                                                                                                                                                                                                                                                                                |                                     | at the university                                                                                                                                                                                                                                         |            |     |
| Year of study                               | 1                                                                                                                                                                                                                                                                                                    |                                                          | Language of instruction                                                                                                                                                                                                                                                                                                                         |                                     | Polish                                                                                                                                                                                                                                                    |            |     |
| Semester of study                           | 1                                                                                                                                                                                                                                                                                                    |                                                          | ECTS credits                                                                                                                                                                                                                                                                                                                                    |                                     | 2.0                                                                                                                                                                                                                                                       |            |     |
| Learning profile                            | general academic profile                                                                                                                                                                                                                                                                             |                                                          | Assessment form                                                                                                                                                                                                                                                                                                                                 |                                     | assessment                                                                                                                                                                                                                                                |            |     |
| Conducting unit                             | Department of Signals and Systems -> Faculty of Electronics Telecommunications and Informatics -> Faculties of Gdańsk University of Technology                                                                                                                                                       |                                                          |                                                                                                                                                                                                                                                                                                                                                 |                                     |                                                                                                                                                                                                                                                           |            |     |
| Name and surname of lecturer (lecturers)    | Subject supervisor                                                                                                                                                                                                                                                                                   |                                                          | dr inż. Artur Gańcza                                                                                                                                                                                                                                                                                                                            |                                     |                                                                                                                                                                                                                                                           |            |     |
|                                             | Teachers                                                                                                                                                                                                                                                                                             |                                                          | dr inż. Artur Gańcza                                                                                                                                                                                                                                                                                                                            |                                     |                                                                                                                                                                                                                                                           |            |     |
| Lesson types                                | Lesson type                                                                                                                                                                                                                                                                                          | Lecture                                                  | Tutorial                                                                                                                                                                                                                                                                                                                                        | Laboratory                          | Project                                                                                                                                                                                                                                                   | Seminar    | SUM |
|                                             | Number of study hours                                                                                                                                                                                                                                                                                | 15.0                                                     | 0.0                                                                                                                                                                                                                                                                                                                                             | 0.0                                 | 15.0                                                                                                                                                                                                                                                      | 0.0        | 30  |
|                                             | 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                                                                                                                                                                                                                                                                                | 30                                                       |                                                                                                                                                                                                                                                                                                                                                 | 4.0                                 |                                                                                                                                                                                                                                                           | 16.0       | 50  |
| Subject objectives                          | Introducing design methods for regulation systems working in random conditions.                                                                                                                                                                                                                      |                                                          |                                                                                                                                                                                                                                                                                                                                                 |                                     |                                                                                                                                                                                                                                                           |            |     |
| Learning outcomes                           | Course outcome                                                                                                                                                                                                                                                                                       |                                                          | Subject outcome                                                                                                                                                                                                                                                                                                                                 |                                     | Method of verification                                                                                                                                                                                                                                    |            |     |
|                                             | [K7_W02] knows and understands, to an increased extent, selected laws of physics and physical phenomena, as well as methods and theories explaining the complex relationships between them, constituting advanced general knowledge in the field of technical sciences related to the field of study |                                                          | Students know basic kinds of random processes and Markow's decision problems. Students understand the principle of Bayesian reasoning.                                                                                                                                                                                                          |                                     | [SW1] Ocena wiedzy faktograficznej<br>[SU4] Ocena umiejętności korzystania z metod i narzędzi<br>[SU3] Ocena umiejętności wykorzystania wiedzy uzyskanej w ramach przedmiotu<br>[SK5] Ocena umiejętności rozwiązywania problemów występujących w praktyce |            |     |
|                                             | [K7_W01] knows and understands, to an increased extent, mathematics to the extent necessary to formulate and solve complex issues related to the field of study                                                                                                                                      |                                                          | Students understand the minimum-variance estimation, they understand the operating principle of Kalman filter and its selected modifications. Students understand the working principle of minimum-variance control and know its properties. Students understand how Bayesian reasoning can be used to combine results of different algorithms. |                                     | [SW1] Ocena wiedzy faktograficznej<br>[SW2] Ocena wiedzy zawartej w prezentacji                                                                                                                                                                           |            |     |

|                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                |                               |
|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|-------------------------------|
| Subject contents                                               | Course content – lecture                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                |                               |
|                                                                | <div>1. Principles of minimum variance (MV) control</div> <div>2. MV regulators for ARMAX systems</div> <div>3. Stability of MV regulators</div> <div>4. Diophantine equations and their solutions</div> <div>5. MV tracking of a reference signal</div> <div>6. Limitations and drawbacks of MV control</div> <div>7. Moving average (MA) control</div> <div>8. Linear quadratic (LQ) control principles</div> <div>9. Design of LQ regulators</div> <div>10. Principles of minimum variance estimation</div> <div>11. Introduction to Kalman filtering conditional densities of Gaussian variables</div> <div>12. Prediction, filtration and smoothing of stochastic signals</div> <div>13. Kalman predictor and Kalman filter</div> <div>14. Properties of Kalman filter</div> <div>15. Stationary Kalman filter Wiener filter</div> <div>16. Kalman filter as an optimal state observer</div> <div>17. Application of Kalman filter to airplane tracking</div> <div>18. Numerical safeguards used in Kalman filtering</div> <div>19. Extended Kalman filter (EKF)</div> <div>20. Application of EKF to localization of an autonomous guided vehicle</div> <div>21. LQ regulators in state space</div> <div>22. Separation theorem</div> <div>23. Robustness of LQ regulators</div> <div>24. Markov chains</div> <div>25. Multiple models estimation methods</div> |                                                                                                |                               |
|                                                                | Course content – project                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                |                               |
|                                                                | <div>1. Kalman filter in state estimation of a stationary object.</div> <div>2. Kalman filter in state estimation of a stationary nonlinear object.</div> <div>3. Combining estimation results of multiple Kalman filters.</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                |                               |
| Prerequisites and co-requisites                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                |                               |
| Assessment methods and criteria                                | Subject passing criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Passing threshold                                                                              | Percentage of the final grade |
|                                                                | Midterm colloquium                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 52.0%                                                                                          | 100.0%                        |
| Recommended reading                                            | Basic literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | B. D. O. Anderson & Moore J. B., "Optimal Filtering", Dover Publications, 2005                 |                               |
|                                                                | Supplementary literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Blackman S. & Poppoli R., "Design and Analysis of Modern Tracking Systems", Artech House, 1999 |                               |
|                                                                | eResources addresses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                |                               |
| Example issues/<br>example questions/<br>tasks being completed |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                |                               |
| Practical activities within the subject                        | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                |                               |

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