

## Subject card

|                                             |                                                                                                                                                                                                                                                                                                                           |                                                          |                                                                                                                                                                                                                                                                              |                                     |         |                                                                                                                      |     |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------|-----|
| Subject name and code                       | Linear Algebra II, PG_00189370                                                                                                                                                                                                                                                                                            |                                                          |                                                                                                                                                                                                                                                                              |                                     |         |                                                                                                                      |     |
| Field of study                              | Mathematical Modeling and Data Analysis                                                                                                                                                                                                                                                                                   |                                                          |                                                                                                                                                                                                                                                                              |                                     |         |                                                                                                                      |     |
| Date of commencement of studies             | October 2026                                                                                                                                                                                                                                                                                                              |                                                          | Academic year of realisation of subject                                                                                                                                                                                                                                      |                                     |         | 2026/2027                                                                                                            |     |
| Education level                             | Bachelor's studies                                                                                                                                                                                                                                                                                                        |                                                          | Subject group                                                                                                                                                                                                                                                                |                                     |         | Obligatory subject group in the field of study<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                           | 2                                                                                                                                                                                                                                                                                                                         |                                                          | ECTS credits                                                                                                                                                                                                                                                                 |                                     |         | 5.0                                                                                                                  |     |
| Learning profile                            | academic                                                                                                                                                                                                                                                                                                                  |                                                          | Assessment form                                                                                                                                                                                                                                                              |                                     |         | exam                                                                                                                 |     |
| Conducting unit                             |                                                                                                                                                                                                                                                                                                                           |                                                          |                                                                                                                                                                                                                                                                              |                                     |         |                                                                                                                      |     |
| Name and surname of lecturer (lecturers)    | Subject supervisor                                                                                                                                                                                                                                                                                                        |                                                          | dr hab. Błażej Szebietowski, prof. UG                                                                                                                                                                                                                                        |                                     |         |                                                                                                                      |     |
|                                             | Teachers                                                                                                                                                                                                                                                                                                                  |                                                          |                                                                                                                                                                                                                                                                              |                                     |         |                                                                                                                      |     |
| Lesson types                                | Lesson type                                                                                                                                                                                                                                                                                                               | Lecture                                                  | Tutorial                                                                                                                                                                                                                                                                     | Laboratory                          | Project | Seminar                                                                                                              | SUM |
|                                             | Number of study hours                                                                                                                                                                                                                                                                                                     | 30.0                                                     | 30.0                                                                                                                                                                                                                                                                         | 0.0                                 | 0.0     | 0.0                                                                                                                  | 60  |
|                                             | 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                                                                                                                                                                                                                                                                                                     | 60                                                       |                                                                                                                                                                                                                                                                              | 3.0                                 |         | 62.0                                                                                                                 | 125 |
| Subject objectives                          | The aim of the course is to familiarize students with the methods and theorems of linear algebra and with selected concepts of general algebra.                                                                                                                                                                           |                                                          |                                                                                                                                                                                                                                                                              |                                     |         |                                                                                                                      |     |
| Learning outcomes                           | Course outcome                                                                                                                                                                                                                                                                                                            |                                                          | Subject outcome                                                                                                                                                                                                                                                              |                                     |         | Method of verification                                                                                               |     |
|                                             | [MMiADL3_W06] knows and understands the role and importance of proof in mathematics, as well as the concept of the importance of assumptions                                                                                                                                                                              |                                                          | The student understands the role and significance of mathematical proof, can analyse its logical structure, and can recognise the importance of assumptions in theorems used in algebra and geometry.                                                                        |                                     |         | [SW4] test/exam - oral or written                                                                                    |     |
|                                             | [MMiADL3_W03] knows and understands selected concepts, methods and theorems of linear algebra and analytic geometry, as well as basic examples both illustrating specific concepts in this field and allowing to refute false hypotheses or invalid reasoning; knows and understands selected concepts of general algebra |                                                          | The student knows and understands the fundamental concepts, methods, and theorems of linear algebra, analytic geometry, and general algebra; is familiar with basic examples illustrating these notions and can identify counterexamples that disprove incorrect hypotheses. |                                     |         | [SW4] test/exam - oral or written                                                                                    |     |
|                                             | [MMiADL3_U03] is able to correctly use the concepts of linear algebra and analytic geometry, is able to apply the theorems and methods of these fields and is able to interpret the obtained results; correctly uses the learned concepts of general algebra                                                              |                                                          | The student is able to correctly use the concepts and methods of linear algebra, analytic geometry, and general algebra; can apply relevant theorems to solve computational and theoretical problems, and can properly interpret the obtained results.                       |                                     |         | [SU5] implementation of a problem task                                                                               |     |

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|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Subject contents                                               | <p>1. Linear mappings. Examples of linear maps, kernel, image, structure of linear maps. Matrices of linear maps. Transition matrices.</p> <p>2. Eigenvalues and eigenvectors. Characteristic polynomial.</p> <p>3. Bilinear mappings and scalar products. Symmetrical bilinear mappings and their associated quadratic forms. Form matrices. Determinacy of the quadratic form.</p> <p>4. Elements of geometry in Euclidean spaces - angle between vectors, orthogonality, norm, distance. Euclidean, normed, metric spaces. Gram-Schmidt orthogonalization.</p> <p>5. Basics of general algebra: binary operation on a set, associativity, commutativity, neutral and inverse elements.</p> <p>6. Groups. Definitions and examples, order of an element, cyclic groups, subgroup, order of a subgroup, Lagrange's theorem.</p> <p>7. English nomenclature of the course</p> |                                                                                                                                                                            |                               |
| Prerequisites and co-requisites                                | Linear algebra I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                            |                               |
| Assessment methods and criteria                                | Subject passing criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Passing threshold                                                                                                                                                          | Percentage of the final grade |
|                                                                | egzamin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 51.0%                                                                                                                                                                      | 40.0%                         |
|                                                                | short tests                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 51.0%                                                                                                                                                                      | 30.0%                         |
|                                                                | tests                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 51.0%                                                                                                                                                                      | 30.0%                         |
| Recommended reading                                            | Basic literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"><li>J. Topp, Algebra liniowa, Wyd. PG, Gdańsk 2005</li><li>J. Rutkowski, Algebra liniowa w zadaniach, PWN , 2008.</li></ul>              |                               |
|                                                                | Supplementary literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <ul style="list-style-type: none"><li>B. Gleichgewicht, Algebra, Oficyna Wydawnicza GiS, Wrocław 2002;</li><li>A. Białynicki-Birula, Algebra, PWN Warszawa 2014;</li></ul> |                               |
|                                                                | eResources addresses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                            |                               |
| Example issues/<br>example questions/<br>tasks being completed | <ol style="list-style-type: none"><li>Determine the matrix of a given linear transformation in the specified bases.</li><li>Determine the kernel and image of a given linear transformation.</li><li>Determine the eigenvalues and eigenvectors of a given linear transformation.</li><li>Check whether a given quadratic form is positively or negatively definite.</li><li>Perform orthogonalization of a given basis.</li><li>Check whether a given set with an operation forms a group.</li><li>Prove that a linear transformation is bijective if and only if its kernel is trivial.</li><li>Prove that eigenvectors corresponding to different eigenvalues are linearly independent.</li><li>Formulate and prove the orthogonalization theorem.</li></ol>                                                                                                               |                                                                                                                                                                            |                               |
| Work placement                                                 | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                            |                               |

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