

## SYLLABUS

### 1. Data about the program of study

|                                      |                                             |
|--------------------------------------|---------------------------------------------|
| 1.1 Institution                      | The Technical University of Cluj-Napoca     |
| 1.2 Faculty                          | Automation and Computer Science             |
| 1.3 Department                       | Computer Science                            |
| 1.4 Field of study                   | Computer Science and Information Technology |
| 1.5 Cycle of study                   | Bachelor of Science                         |
| 1.6 Program of study / Qualification | Computer Science / Engineer                 |
| 1.7 Form of education                | Full time                                   |

### 2. Data about the subject

|                                                           |                                                                                                                                                                                                          |              |   |                                                                     |          |
|-----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---|---------------------------------------------------------------------|----------|
| 2.1 Subject name                                          | <b>Linear Algebra and Analytical Geometry</b>                                                                                                                                                            |              |   | Subject code                                                        | <b>2</b> |
| 2.2 Course responsible / lecturer                         | Prof. dr. Peter Radu - <a href="mailto:radu.peter@math.utcluj.ro">radu.peter@math.utcluj.ro</a>                                                                                                          |              |   |                                                                     |          |
| 2.3 Teachers in charge of seminars / Laboratory / project | Prof. dr. Peter Radu - <a href="mailto:radu.peter@math.utcluj.ro">radu.peter@math.utcluj.ro</a><br>Lect. dr. Timbos Liana - <a href="mailto:Liana.Timbos@math.utcluj.ro">Liana.Timbos@math.utcluj.ro</a> |              |   |                                                                     |          |
| 2.4 Year of study                                         | I                                                                                                                                                                                                        | 2.5 Semester | 1 | 2.6 Type of assessment (E - exam, C - colloquium, V – verification) | E        |
| 2.7 Subject category                                      | Formative category: DF – fundamental, DS – speciality, DC – complementary                                                                                                                                |              |   |                                                                     | DF       |
|                                                           | Optionality: DOB – mandatory, DOP – optional (alternative), DFA – optional (free choice)                                                                                                                 |              |   |                                                                     | DOB      |

### 3. Estimated total time

|                                                                                     |     |           |        |    |              |    |
|-------------------------------------------------------------------------------------|-----|-----------|--------|----|--------------|----|
| 3.1 Number of hours per week                                                        | 4   | of which: | Course | 2  | applications | 2  |
| 3.2 Total hours in the teaching plan                                                | 104 | of which: | Course | 28 | applications | 28 |
| 3.3 Individual study                                                                |     |           |        |    |              |    |
| a) Manual, lecture material and notes, bibliography                                 |     |           |        |    |              | 20 |
| b) Supplementary study in the library, online, and in the field                     |     |           |        |    |              | 3  |
| c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays |     |           |        |    |              | 18 |
| d) Tutoring                                                                         |     |           |        |    |              | -  |
| e) Exams and tests                                                                  |     |           |        |    |              | 3  |
| f) Other activities                                                                 |     |           |        |    |              | -  |
| 3.4 Total hours of individual study                                                 | 44  |           |        |    |              |    |
| 3.5 Total hours per semester                                                        | 100 |           |        |    |              |    |
| 3.6 Number of credit points                                                         | 4   |           |        |    |              |    |

### 4. Pre-requisites (where appropriate)

|                |                                                                                                                                    |
|----------------|------------------------------------------------------------------------------------------------------------------------------------|
| 4.1 Curriculum | Basic knowledge of Linear Algebra and Analytic Geometry                                                                            |
| 4.2 Competence | Competences in elementary Linear Algebra and Analytic Geometry: matrices, determinants, linear systems, vectors and lines in plane |

### 5. Requirements (where appropriate)

|                          |                             |
|--------------------------|-----------------------------|
| 5.1 For the course       | Blackboard, video projector |
| 5.2 For the applications | Blackboard, video projector |

## 6. Specific competences

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6.1 Professional competences | <ul style="list-style-type: none"> <li>• C1.1. Professional communication using scientific concepts, theory and methods used in system engineering.</li> <li>• C1.2. Presentation and motivation of solution to problems from system engineering using techniques, concepts and principles from mathematics, physics, etc.</li> <li>• C1.3. solving usual problems in system engineering by identifying techniques, principles and methods from mathematics.</li> <li>• C1.4. Identifying the potential, advantages and disadvantages of methods from system engineering, documentation of projects and using mathematical methods.</li> <li>• C1.5. Use of mathematical methods in projects in system engineering.</li> </ul> |
| 6.2 Cross competences        | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

## 7. Expected learning outcomes

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Knowledge                    | The student/graduate identifies and describes basic concepts, principles and methods in mathematics, physics, chemistry, technical drawing, economics and computer science.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Skills                       | <p>The student/graduate operates with basic concepts, principles and methods from mathematics, physics, chemistry, technical drawing, economics and computer science.</p> <p>The student/graduate solves problems in mathematics, physics and chemistry with applicability in engineering and validates the solution obtained.</p> <p>The student/graduate performs engineering and economic calculations of medium complexity and associates them with graphical representations or specific computer-aided design.</p> <p>The student/graduate describes physico-chemical and economic phenomena and processes.</p>                                                 |
| Responsibility and autonomy: | <p>The student/graduate applies the values of ethics and deontology of the engineering profession.</p> <p>The student/graduate practices logical reasoning, evaluation and self-evaluation in decision-making.</p> <p>The student/graduate communicates effectively about engineering activities with a wide range of audiences.</p> <p>The student/graduate is engaged in lifelong learning to acquire and implement knowledge, as needed, using appropriate learning strategies.</p> <p>The student/graduate promotes dialogue, cooperation, respect for others and interculturality.</p> <p>The student/graduate works effectively as a team member or leader.</p> |

## 8. Discipline objectives (as results from the *key competences gained*)

|                         |                                                                                                                                                                                                                                                                                  |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8.1 General objective   | A presentation of the concepts, notions, methods and fundamental techniques used in linear algebra and analytic geometry and their use in automation.                                                                                                                            |
| 8.2 Specific objectives | <p>Use of the matrix calculus (in the general context of linear algebra) in order to solve problems in engineering.</p> <p>Use of the vectorial calculus (in the general context of analytic geometry) in modelling and solving practical problems concerning spatial forms.</p> |

## 9. Contents

| 9.1. Lecture (syllabus)                                                                                                     | Teaching methods                                                         | Notes |
|-----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------|
| Vectors in plane and space.                                                                                                 | Explanation<br>Demonstration<br>Collaboration<br>Interactive activities. |       |
| Lines and planes.                                                                                                           |                                                                          |       |
| Vector spaces: definition, examples, subspaces, sums of subspaces.                                                          |                                                                          |       |
| Basis and dimensions. Linear independence. Change of basis.                                                                 |                                                                          |       |
| Inner product spaces (I): definition, examples, computations, orthonormal basis, Schwarz inequality, orthogonal complement. |                                                                          |       |
| Inner product spaces (II): Gram-Schmidt orthogonalization process, Gram determinants. Linear manifolds, distances.          |                                                                          |       |
| Linear maps (I): definition, kernel, image, injective and surjective maps.                                                  |                                                                          |       |
| Linear maps (II): the matrix of a linear map.                                                                               |                                                                          |       |

|                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                          |       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------|
| Eigenvectors and eigenvalues of operators (and associated matrix). Characteristic polynomial. Cayley-Hamilton theorem. Diagonal form. Diagonalizable operators.                                                                                                                                                                                                                                    |                                                                          |       |
| The Jordan canonical form for operators (and associated matrix). Jordan basis, the Jordan matrix.                                                                                                                                                                                                                                                                                                  |                                                                          |       |
| Functions of a matrix. The n-th power of a matrix. Elementary functions of a matrix.                                                                                                                                                                                                                                                                                                               |                                                                          |       |
| The adjoint operator. Definition, properties, examples.                                                                                                                                                                                                                                                                                                                                            |                                                                          |       |
| Special operators, Properties of eigenvalues and eigenvectors.                                                                                                                                                                                                                                                                                                                                     |                                                                          |       |
| Bilinear forms, quadratic forms. The associated matrix.                                                                                                                                                                                                                                                                                                                                            |                                                                          |       |
| Conics and quadrics. Reduction to a canonical form. Geometric properties.                                                                                                                                                                                                                                                                                                                          |                                                                          |       |
| Bibliography:<br>1. Ioan Radu Peter, Szilard Laszlo, Adrian Viorel , Elements of Linear Algebra, Mediamira 2014, <a href="https://algappl.utcluj.ro/">https://algappl.utcluj.ro/</a><br>2. D. Cimpean, D. Inoan, I. Rasa, An invitation to Linear Algebra and Analytic Geometry, Ed. Mediamira, 2012<br>3. V. Pop, I. Rasa, Linear Algebra with Applications to Markov Chains, Ed. Mediamira, 2005 |                                                                          |       |
| 9.2. Applications (Seminars)                                                                                                                                                                                                                                                                                                                                                                       | Teaching methods                                                         | Notes |
| Linear systems, matrices, determinants.                                                                                                                                                                                                                                                                                                                                                            | Explanation<br>Demonstration<br>Collaboration<br>Interactive activities. |       |
| Vectorial geometry. Determinants. Exercises.                                                                                                                                                                                                                                                                                                                                                       |                                                                          |       |
| Problems in analytical geometry: lines and planes. Applications.                                                                                                                                                                                                                                                                                                                                   |                                                                          |       |
| Linear spaces, basis, dimension, direct sums.                                                                                                                                                                                                                                                                                                                                                      |                                                                          |       |
| Linear independence, basis, dimensions.                                                                                                                                                                                                                                                                                                                                                            |                                                                          |       |
| Inner product spaces (I): definition, examples, computations, orthonormal basis, Schwarz inequality, orthogonal complement.                                                                                                                                                                                                                                                                        |                                                                          |       |
| Inner product spaces (II): Gram-Schmidt orthogonalization process, Gram determinants. Linear manifolds, distances.                                                                                                                                                                                                                                                                                 |                                                                          |       |
| Linear maps (I): definition, kernel, image, injective and surjective maps.                                                                                                                                                                                                                                                                                                                         |                                                                          |       |
| Linear maps (II): the matrix of a linear map. Applications.                                                                                                                                                                                                                                                                                                                                        |                                                                          |       |
| Eigenvalues and eigenvectors. Diagonalizable linear maps.                                                                                                                                                                                                                                                                                                                                          |                                                                          |       |
| Jordan canonical form I. Applications.                                                                                                                                                                                                                                                                                                                                                             |                                                                          |       |
| Jordan canonical form II, Jordan basis. Special operators.                                                                                                                                                                                                                                                                                                                                         |                                                                          |       |
| Bilinear forms, quadratic forms. Applications.                                                                                                                                                                                                                                                                                                                                                     |                                                                          |       |
| Conics and quadrics, reduction to a canonical form. Recapitulative problems.                                                                                                                                                                                                                                                                                                                       |                                                                          |       |
| Bibliography:<br>1. Ioan Radu Peter, Szilard Laszlo, Adrian Viorel , Elements of Linear Algebra, Mediamira 2014, <a href="https://algappl.utcluj.ro/">https://algappl.utcluj.ro/</a><br>2. D. Cimpean, D. Inoan, I. Rasa, An invitation to Linear Algebra and Analytic Geometry, Ed. Mediamira, 2012<br>3. V. Pop, I. Corovei, Algebra pentru ingineri. Culegere de probleme, Ed. Mediamira, 2003. |                                                                          |       |

### 9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

Collaboration with engineers in order to identify and solve problems raised by the market.

### 10. Evaluation

| Activity type                                                                                     | Assessment criteria                                                     | Assessment methods  | Weight in the final grade |
|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------|---------------------------|
| Course                                                                                            | Abilities of understanding and using creatively the concepts and proofs | Written examination | 20%                       |
| Applications                                                                                      | Abilities of solving problems and applying algorithms                   | Written examination | 80%                       |
| Minimum standard of performance:                                                                  |                                                                         |                     |                           |
| Ability to present coherently a theoretical subject and to solve problems with practical content. |                                                                         |                     |                           |

|                                  |              |                             |           |
|----------------------------------|--------------|-----------------------------|-----------|
| Date of filling in<br>28.04.2026 | Responsible  | Title, First name Last name | Signature |
|                                  | Course       | Prof.dr. Ioan-Radu PETER    |           |
|                                  | Applications | Prof.dr. Ioan-Radu PETER    |           |
|                                  |              | Lect. Liana TIMBOS          |           |

|                                         |                                                            |
|-----------------------------------------|------------------------------------------------------------|
| Date of approval in the department      | Head of Department of Mathematics,<br>Prof.dr. Dorian Popa |
| Date of approval by the Faculty Council | Dean,<br>Prof.dr.eng. Vlad Mureșan                         |