# Syllabus

## 1. Data about the program of study

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| 1.1 Institution | Technical University of Cluj-Napoca |
| 1.2 Faculty | Automation and Computer Science |
| 1.3 Departament | Automation |
| 1.4 Field of study | Systems Engineering |
| 1.5 Cycle of study | Bachelor of Science |
| 1.6 Program of study/Qualification | Automation and Applied Informatics (English) |
| 1.7 Form of education | Full time |
| 1.8 Codul disciplinei | 31.00 |

## 2. Data about the subject

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|---|---|---|---|---|---|
| 2.1 Subject name | ***System Theory II*** | | | | |
| 2.2 Course responsible/lecturer | Assist. Prof. Mirela Dobra – mirela.trusca@aut.utcluj.ro | | | | |
| 2.3 Teachers in charge of applications | Assist. Prof. Mirela Dobra – mirela.trusca@aut.utcluj.ro | | | | |
| 2.4 Year of study | 3 | 2.5 Semester | 1 | 2.6 Assessment *(E/C/V)* | E |
| 2.7 Type of subject | *DF – fundamental, DD – in the field, DS – specialty, DC – complementary* | | | | DD |
| | *DI – compulsory, DO – elective, Dfac – optional* | | | | DI |

## 3. Estimated total time

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|---|---|---|---|---|---|---|---|---|---|---|
| 3.1 Number of hours per week | 5 | of which: | Course | 2 | Seminar | 1 | Laboratory | 2 | Project | 0 |
| 3.2 Number of hours per semester | 70 | of which: | course | 28 | Seminar | 14 | Laboratory | 28 | Project | 0 |
| 3.3 Individual study | | | | | | | | | | |
| (a) Manual, lecture material and notes, bibliography | | | | | | | | | | 25 |
| (b) Supplementary study in the library, online and in the field | | | | | | | | | | 10 |
| (c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays | | | | | | | | | | 12 |
| (d) Tutoring | | | | | | | | | | 28 |
| (e) Exams and tests | | | | | | | | | | 5 |
| (f) Other activities: | | | | | | | | | | - |

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| 3.4 Total hours of individual study (sum of (3.3(a)…3.3(f))) | 80 |
| 3.5 Total hours per semester (3.2+3.4) | 150 |
| 3.6 Number of credit points | 6 |

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

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| 4.1 Curriculum | Mathematical analysis I (Differential calculus); Special mathematics (Complex analysis and transforms); Linear algebra and analytical geometry; System Theory I. |
| 4.2 Competence | Physics, Electrotechnics, Analog and digital circuits; Process modelling. |

## 5. **Requirements** (where appropriate)

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| 5.1. For the course | N/A |
| 5.2. For the applications | Applications are compulsory |

## 6. Specific competences

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| 6.1 Professional competences | C3.1 Identification of basic concepts of system theory, control engineering, of fundamental principles of modelling and simulation, as well as of process analysis methods in order to explain the basic problems of the field.<br>C3.2 Explaining and interpreting some process automation problems through the application of automatic control fundamentals, of modelling, identification and simulation methods as well as of the computer aided design techniques.<br>C3.3 Solving some types of control problems through: use of modelling methods and principles, development simulation scenarios, application of methods for the identification and analysis of processes (including technological processes) and systems.. |

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| 6.2 Cross competences | N/A |

**7. Course objectives**

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| 7.1 General objective | - Frequency response analysis;<br>- Discrete time control structures modelling;<br>- State space approach in LTI system control algorithms. |
| 7.2 Specific objectives | - Analyze Bode and Nyquist diagrams<br>- Simulate, test and validate the modes of continuous and discrete time LTI system<br>- Analyze the frequency response of dynamic LTI systems using Matlab/Simulink<br>- Test the behavior of dynamic LTI control systems using digital equipment |

**8. Contents**

| 8.1 Lecture | No.hours | Teaching methods | Notes |
|---|---|---|---|
| Frequency Response<br>Nyquist diagram, encirclements and number of closed loop poles, Nyquist contour, Nyquist stability criteria. | 2 | Comprehensive slides<br>Blackboard annotations<br>Oriented discussions on the subject | |
| Frequency Response:<br>Bode response, Bode theorem, the relation between magnitude and phase, cross over frequency, bandwidth, and frequency domain characteristics of second order systems. | 2 | | |
| Frequency Response: stability characteristics, poles and zeros on imaginary axis, controller design based on Nyquist diagram, relation between Bode and Nyquist plot. | 2 | | |
| Stability analysis via Frequency response: Basic definitions, stability margins, gain and phase margin, bandwidth, cross over frequencies, relation between time and frequency response. | 2 | | |
| Dead Time Systems; Nonminimum phase systems: Stability analysis via Frequency response | 2 | | |
| Sampled-data control systems: Sample and hold, sampling modeling, data reconstruction, Shannon theorem, aliasing. | 2 | | |
| Discrete time system representation: Z-transform, difference equation, state transition matrix, system characteristics. | 2 | | |
| Digital implementation of analog controllers: Forward difference, backward difference, bilinear Tustin, Tustin with pre-warping. | 2 | | |
| State Space Analysis<br>Linear system theory: State transition matrix derivation methods: Dynamical modes, Cayley-Hamilton, Sylvester methods, similarity transformations. | 2 | | |
| Canonical Forms:<br>Controller Canonical Form, Observer Canonical Forma, Controllability Canonical Form, Observability Canonical Form | 2 | | |
| Controllability and Observability: Observability, observability matrix, eigenvector test, controllability, duality | 2 | | |
| State feedback: State feedback properties, tracking objective, pole placement methods. | 2 | | |
| State Observer: State observer general idea, full state observer, Luenberger Observer. | 2 | | |
| Multivariable Systems | 2 | | |

Bibliography

1. R. C. Dorf, R. Bishop, “Modern Control Systems”, Addison-Wesley, 2004;
2. K. Ogata, “Modern Control Engineering”, Prentice Hall, 1990.
3. Discrete-time control systems (2nd edn) by Katsuhico Ogata, Prentice-Hall, Upper Saddle River, NJ, 1995, 745 pages.
4. Digital Control Systems by Benjamin Kuo, 1980
5. Benjamin Kuo, Matlab Tools for Control System Analysis and Design, 1995

6. SKOGESTAD Sigurd, POSTLETHWAITE Ian, Multivariable feedback control : analysis and design, 1997.
7. Golub, G. H., C.F. Van Loan, – Matrix computations, John Hopkins Univ. Press, Baltimore, 1984
8. M.Hanganut, "Teoria sistemelor", Vol 2., UTCN 1996
9. Ionescu, V. – Teoria Sistemelor , Editura Didactică şi Pedagogică, Bucureşti, 1985.

| **8.2 laboratory** | No.hours | Teaching methods | Notes |
|---|---|---|---|
| Plot and analyze Nyquist diagrams in Matlab | 2 | Solving problems using Matlab | |
| Plot and analyze Bode diagrams in Matlab | 2 | | |
| Plot and analyze Bode diagrams in Matlab for dead time and nonminimum phase systems | 2 | | |
| Stability analysis via frequency response using Matlab | 2 | | |
| Analog filters in Simscape /Simulink | 2 | | |
| Matlab/Simulink representation of discrete-time systems | 2 | | |
| Response of discrete time systems in Matlab | 2 | | |
| Discrete time control systems: Root Locus analysis in Matlab | 2 | | |
| Discrete time control systems for DC motors in Matlab | 2 | | |
| DC motor: state space analysis in Matlab | 2 | | |
| Canonical Forms in Simulink | 2 | | |
| Controllability and Observability tests: script in Matlab | 2 | | |
| DC motor: state space analysis | 2 | | |
| State Observer for DC Motors | 2 | | |
| **8.2 seminar** | No.hours | Teaching methods | Notes |
| Drawing and analyzing Nyquist diagrams. | 2 | Solving problems | |
| Drawing and analyzing Bode diagrams. | 2 | | |
| Stability analysis using frequency response | 2 | | |
| Discrete time control systems: Root Locus analysis | 2 | | |
| Discrete time control systems for DC motors | 2 | | |
| DC motor: state space analysis | 2 | | |
| Ackerman algorithm for DC motor case | 2 | | |

Bibliography
1. R. C. Dorf, R. Bishop, "Modern Control Systems", Addison-Wesley, 2004;
2. K. Ogata , "Modern Control Engineering", Prentice Hall, 1990.
3. Benjamin Kuo, Matlab Tools for Control System Analysis and Design, 1995
4. SKOGESTAD Sigurd, POSTLETHWAITE Ian, Multivariable feedback control : analysis and design, 1997.
5. Golub, G. H., C.F. Van Loan, – Matrix computations, John Hopkins Univ. Press, Baltimore, 1984
6. M. Hanganut, "Teoria sistemelor", Vol 2., UTCN 1996
7. Ionescu, V. – Teoria Sistemelor , Editura Didactică şi Pedagogică, Bucureşti, 1985.

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

Practical applications by examples

**10. Evaluation**

| Activity type | Assessment criteria | Assessment methods | Weight in the final grade |
|---|---|---|---|
| Course | Solution correctness | Written examination; Face-to-face evaluation; on-line evaluation; Course assignments | 80% |
| Seminar | N/A | N/A | 0% |
| Laboratory | Solving problems using Matlab | Colloquium; Face-to-face evaluation; on-line evaluation; | 20% |
| Project | N/A | N/A | 0% |
| Minimum standard of performance: Final grade equal or above 5 | | | |

| Date of filling in: | | Title Firstname NAME | Signature |
|---|---|---|---|
| 17.02.2025 | Course | Assist. Prof. Mirela Dobra | |
| | Aplications | Assist. Prof. Mirela Dobra | |
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| Date of approval by the Department Board<br>Automation Department<br>_____ | Head of Departament .....<br>Prof.dr.ing. Honoriu VĂLEAN |
| Date of approval by the Faculty Council ……<br>Computer Science and Automation Faculty<br>_____ | Dean<br>Prof.dr.ing. Vlad Mureșan |