**Syllabus**

**Course title**  Modern Control  
**Course code**  42412  
**Scientific sector**  ING-INF/04  
**Degree**  Bachelor in Electronics and Cyber-Physical Systems Engineering  

**Semester**  II  
**Year**  II  
**Academic Year**  2023/24  
**Credits**  9  
**Total lecturing hours**  36  
**Total lab hours**  54  
**Prerequisites**  Lectures and exercises of Mathematical Analysis I and II, Linear Algebra, Physics I, and Physics II  

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**Specific educational objectives**  The student should understand the basic principles of methods of modern control with focus on state-space control and optimal control and be able to apply them in exercises, but also in laboratory experiments on real hardware.

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**Lecturer**  
**Scientific sector of the lecturer**  ING-INF/04 – AUTOMATION  
**Teaching language**  English  
**Office hours**  After consultation and agreement with lecturer  
**Teaching assistant (if any)**  -  
**Office hours**  -  

**List of topics covered**  
1. Modelling and system analysis in state space: dynamic system modelling in time domain and state-space representation, dynamic system response derived from state-space representation, stability in state space, steady-state error for systems in state space  
2. Control design in state space: pole placement design techniques, controllability, observability, full-state observers  
3. Optimal control of dynamic systems: problems with fixed and variable end-points as well as with equality and inequality constraints, maximum principle, Hamilton-Jacobi-Bellmann equation, linear quadratic regulator  
4. Laboratory: computer-aided analysis and design using
Matlab/Simulink, implementation of controllers and experimental evaluation on real-hardware setups

<table>
<thead>
<tr>
<th>Teaching format</th>
<th>The lessons are divided into i) theoretical classroom lessons, ii) classroom exercises and iii) lab exercises.</th>
</tr>
</thead>
</table>

Learning outcomes (ILOs)
Knowledge and understanding
Knowledge and understanding in the field of:
1. State-space modelling and control
2. Optimal control

Applying knowledge and understanding
3. Ability to apply knowledge for solving given problems, including solving them with numerical data using software packages like Matlab/Simulink and their implementation and evaluation on real hardware setups.

Making judgements
4. Ability to judge plausibility of results.

Communication skills
5. Maturing of technical-scientific terminology.

Ability to learn
6. Learning skills to independently study and apply methods of modern control for specific applications beyond topics covered in this lecture.

Assessment
Formative assessment

<table>
<thead>
<tr>
<th>Form</th>
<th>Length /duration</th>
<th>ILOs assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-class exercises</td>
<td>Continuously as part of course-accompanying exercises</td>
<td>1-6</td>
</tr>
</tbody>
</table>

Summative assessment

<table>
<thead>
<tr>
<th>Form</th>
<th>%</th>
<th>Length /duration</th>
<th>ILOs assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-class exercises (Mid-term) *</td>
<td>15</td>
<td>120 minutes</td>
<td>1-6</td>
</tr>
<tr>
<td>Written</td>
<td>60</td>
<td>180 minutes</td>
<td>1-6</td>
</tr>
<tr>
<td>Programming</td>
<td>25</td>
<td>120 minutes</td>
<td>1-6</td>
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* For those students unable to attend the mid-term in-class exercise, the final written exam will account for 75% of the grade.

Assessment language
English

Evaluation criteria and criteria for awarding marks
The final exam consists of two parts.
The first one will focus on several mathematical tasks to be solved, which are distributed among the main topics covered. Judged will be:

- the correctness of the approach and the mathematical steps of the solution, the calculation of numerical results;
- the correctness of the provided answers and arguments presented and the terminology used.

The second part will focus on examining the ability of the student to solve a problem with the help of Matlab and Simulink. The student will have to develop a script and/or Simulink diagram and to deliver them as part of the exam. Judged will be:

- the correctness of the implementation and achieved simulation results.

<table>
<thead>
<tr>
<th>Required readings</th>
<th>Blackboard</th>
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