Programme syllabus

Master's Programme, Systems, Control and Robotics, 120 credits
Masterprogram, systemteknik och robotik
120.0 credits

Valid for students admitted to the education from autumn 19 (HT - Autumn term; VT - Spring term).

Programme objectives

The Master's Programme in Systems, Control and Robotics includes courses in analysis, design and control of complex technical systems. Within the program the students will learn the theoretical foundations of modeling, control and optimization of complex systems.

The application areas for systems and control are many, and within the program the student can choose to focus on one of four tracks: robotics and autonomous systems, electric power systems, networked control systems and systems and control theory.

In its interdisciplinary spirit the programme brings together courses from the field of electrical engineering and computer science and communication. The students of the programme acquire the knowledge and understanding necessary when working with complex systems in different capacities both in academia and in industry.

Knowledge and understanding

For the master’s degree, the student should:

- have thorough knowledge of current theories and developments in the study area
- have thorough understanding of high competence in Systems and Control
- independently be able to identify and formulate problems related to Systems, Control and Robotics and with adequate methods be able to carry out qualified analysis.

Skills and abilities

Working with complex systems requires skills and abilities in a wide range of topics. For the master’s degree, the student should:

- acquire a broad base of skills in core technical subjects such as signal processing, modeling, control, estimation, and programming, which are key to understanding complex systems
- show ability to understand problems that may not be within their selected area of specialization
- acquire skills in working in projects and the theory and methodology of science.

Ability to make judgements and adopt a standpoint

Equipped with the above mentioned skills and abilities, an objective is also to make the students able to:

- critically review the work of others and adopt a standpoint in different matters within the technical area
- show the ability to, within the technical area, make judgments with regards to relevant scientific, social, and ethical aspects
- show insight about technology’s possibilities and limitations and its role in society
- show the ability to identify his/her need for further knowledge and take responsibility for developing his/her knowledge.
Extent and content of the programme

The programme is on the second level and comprises 120 higher education credits (equivalent to 120 ECTS) corresponding to two years of full-time studies. The language of instruction throughout the programme is English. The following specialisations are offered:

- Systems and Control Theory
- Networked Control Systems
- Electrical Energy Systems
- Robotics and Autonomous System

Each track defines a number of courses that are compulsory and conditionally elective. In addition to these courses the student must add one or two non-technical courses and optional courses to reach up to 90 credits total in courses and 30 credit degree project. Some of the courses accept a limited number of students and the students have to compete with other students at KTH on these courses. Some courses are not given every year.

Eligibility and selection

General admission requirements are:

- a degree on the first level consisting of at least 180 higher education credits or a corresponding foreign degree.
- In addition, good knowledge in English, oral and written, is required.

The following special admission requirements must be fulfilled in order to be admitted:

Previous education must include basic mathematics courses in linear algebra, calculus in one and several variables, probability theory and computer science. The student must also have taken a course in signals and systems including material about about time-continuous and time-discrete systems, sampling, linear filters and systems, transform methods (Laplace and Z) and a course in control engineering. The above can also be described as the student to have completed courses corresponding to the following of KTH courses:

- SF1624 Algebra and Geometry
- SF1625 Calculus in One Variable
- SF1626 Calculus in Several Variables
- SF1901 Probability Theory and Statistics
- SF1634 Differential Equations II
- EL1110 Automatic Control, General Course
- DD1343 Computer Science and Numerical Methods, part 1

The selection process is based on the following selection criteria: University, previous studies (grades in specific subjects and English), motivation for the studies (for instance letter of motivation, references, thesis proposal and relevant work experience). The evaluation scale is 1-75.

Implementation of the education

Structure of the education

Each academic year consists of two semesters which are 20 weeks each, and each semester is further divided into two study periods.

The programme comprises 2 years of full-time studies (120 higher education credits) including a half-year degree project (30 higher education credits). The program begins with a number of compulsory courses in the first year to ensure a certain level of knowledge within the programme’s core subjects and thus provide the students with the broad base needed to work with complex systems. The second year, the students specialize their studies in the first half and in the second half the degree project takes place.
Courses
The programme is course-based. Lists of courses are included in appendix 1.

Grading system
Courses in the first and the second cycle are graded on a scale from A to F. A-E are passing grades, A is the highest grade. The grades pass (P) and fail (F) are used for courses under certain circumstances.

Grading scale is found in the course syllabus.

Conditions for participation in the programme
Participation requires admission to courses within the programme and course registration.

For further studies, special admission requirements for the course are to be fulfilled. Special admission requirements are listed in the respective course syllabus

Degree project
The degree project is the final part of the education and comprises 30 higher education credits. The project work may begin when special admission requirements for the course are fulfilled.

The degree project should be performed within the area of technology for which the degree is being prepared. The degree project is carried out individually and must be within an area corresponding to the courses which the student has taken. Before the degree project is started, it must be approved both by the KTH examiner and the program director.

Degree
Students who have completed the two-year Master's programme in Systems, Control and Robotics (120 ECTS) will be able to apply for a Degree of Master of Science (two years).

To be able to apply for the degree the student has to fulfill the national qualification requirements and have completed courses corresponding to 120 higher education credits including:

- all of the compulsory courses depending on track
- a sufficient number of conditionally elective technical courses depending on the chosen track
- one or two elective non-technical courses
- one project course in the subject area
- other elective courses for a total of 90 higher education credits
- Degree project of 30 higher education credits.

The main field of the degree is indicated in the text of the diploma.

Appendix 1 - Course list
Appendix 2 - Programme syllabus descriptions
Appendix 1: Course list

Master's Programme, Systems, Control and Robotics, 120 credits (TSCRM), Programme syllabus for studies starting in autumn 2019

**General courses**

**Year 1**

**Mandatory courses (25.5 credits)**

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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<tbody>
<tr>
<td>DD2410</td>
<td>Introduction to Robotics</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>EL2220</td>
<td>The Sustainable Systems and Control Engineer</td>
<td>3.0</td>
<td>Second cycle</td>
</tr>
<tr>
<td>EL2520</td>
<td>Control Theory and Practice, Advanced Course</td>
<td>7.5</td>
<td>Second cycle</td>
</tr>
<tr>
<td>EL2820</td>
<td>Modelling of Dynamical Systems</td>
<td>7.5</td>
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**Recommended courses**

<table>
<thead>
<tr>
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<th>Course name</th>
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<tbody>
<tr>
<td>DD2419</td>
<td>Project Course in Robotics and Autonomous Systems</td>
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<td>Second cycle</td>
</tr>
<tr>
<td>DD2420</td>
<td>Probabilistic Graphical Models</td>
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</tr>
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<td>DD2424</td>
<td>Deep Learning in Data Science</td>
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<td>DD2425</td>
<td>Robotics and Autonomous Systems</td>
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<td></td>
<td><em>Project Course</em></td>
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<tr>
<td>DD2438</td>
<td>Artificial Intelligence and Multi Agent Systems</td>
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<td></td>
<td><em>Project Course</em></td>
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<tr>
<td>DH1620</td>
<td>Human-Computer Interaction, Introductory Course</td>
<td>6.0</td>
<td>First cycle</td>
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<tr>
<td></td>
<td><em>Non-technical/merged with DH2620</em></td>
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<tr>
<td>DT2140</td>
<td>Multimodal Interaction and Interfaces</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>EG2210</td>
<td>Electricity Market Analysis</td>
<td>7.5</td>
<td>Second cycle</td>
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<tr>
<td>EH2030</td>
<td>Business Development and Quality Management</td>
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<tr>
<td></td>
<td><em>Non-technical</em></td>
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<td>EH2720</td>
<td>Management of Projects</td>
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<td>EH2745</td>
<td>Computer Applications in Power Systems</td>
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<td>Automatic Control, General Course</td>
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<td>EL2222</td>
<td>Systems and Control in Practice</td>
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<td>EL2425</td>
<td>Automatic Control, Project Course, Smaller Course</td>
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<td>EL2450</td>
<td>Hybrid and Embedded Control Systems</td>
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<td>Nonlinear Control</td>
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<td>Reinforcement Learning</td>
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<td>Signal Theory</td>
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<td>Speech and Audio Processing</td>
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<td>Second cycle</td>
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<td>EQ2871</td>
<td>Cyber-Physical Networking</td>
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<td>Second cycle</td>
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<tr>
<td>II2302</td>
<td>Sensor Based Systems</td>
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<td>Second cycle</td>
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<td>IL2206</td>
<td>Embedded Systems</td>
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<td>Second cycle</td>
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<td>Second cycle</td>
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<td>Rhetoric - the Art of Persuasion</td>
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<td>Technical Communication in English</td>
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<td>English for Writing and Presenting a Degree Project in Science and Engineering</td>
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<td>Leadership in Cross-Cultural and Industrial Contexts</td>
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<td>MF2007</td>
<td>Dynamics and Motion Control</td>
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<td>MF2030</td>
<td>Mechatronics basic Course</td>
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<td>MF2042</td>
<td>Embedded Systems for Mechatronics, I</td>
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<td>MF2043</td>
<td>Robust Mechatronics</td>
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<td>Credits</td>
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<td>SD2231</td>
<td>Applied Vehicle Dynamics Control</td>
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<td>Optimization</td>
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<td>First cycle</td>
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<td>SF2568</td>
<td>Parallel Computations for Large- Scale Problems</td>
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<td>Second cycle</td>
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<td>SF2812</td>
<td>Applied Linear Optimization</td>
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<td>SF2940</td>
<td>Probability Theory</td>
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<td>Second cycle</td>
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<tr>
<td>SF2943</td>
<td>Time Series Analysis</td>
<td>7.5</td>
<td>Second cycle</td>
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</tbody>
</table>

Supplementary information

Course list: Information is based upon the curriculum for academic year 2017/2018. Changes may occur.

Requirements for all tracks

- Compulsory courses: EL2820, AK2036, EL2520, EL2220, DD2410
- Select one or two non-technical courses
- Select at least one project course from the study area
- Requirements from one track
- Complement with recommended courses up to 120cr

NOTE: Compulsory and conditionally elective courses from one track are recommended on all other tracks.

NOTE: A course can only be listed once below and is listed only as compulsory if it is compulsory on one track and only conditionally elective on another. Please use the course list for each separate track for a complete account of the conditionally elective courses.

Year 2

Mandatory courses (10.5 credits)

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<tr>
<td>AK2036</td>
<td>Theory and Methodology of Science with Applications (Natural and Technological Science)</td>
<td>7.5</td>
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<td>EL2220</td>
<td>The Sustainable Systems and Control Engineer</td>
<td>3.0</td>
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### Recommended courses

<table>
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<tbody>
<tr>
<td>DD1385</td>
<td>Software Engineering</td>
<td>6.0</td>
<td>First cycle</td>
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</table>
| DD1388      | Program System Construction Using C++  
Replaces DD1387 | 7.5     | First cycle |
| DD2352      | Algorithms and Complexity | 7.5     | Second cycle |
| DD2401      | Neuroscience | 7.5     | Second cycle |
| DD2420      | Probabilistic Graphical Models | 7.5     | Second cycle |
| DD2425      | Robotics and Autonomous Systems  
*Project Course* | 9.0     | Second cycle |
| DD2435      | Mathematical Modelling of Biological Systems | 9.0     | Second cycle |
| DD2438      | Artificial Intelligence and Multi Agent Systems  
*Project Course* | 15.0    | Second cycle |
| DD2447      | Statistical Methods in Applied Computer Science | 6.0     | Second cycle |
| DD2459      | Software Reliability | 7.5     | Second cycle |
| DD2464      | Bigger Advanced, Individual Course in Computer Science | 9.0     | Second cycle |
| DD2476      | Search Engines and Information Retrieval Systems | 9.0     | Second cycle |
| DH1620      | Human-Computer Interaction, Introductory Course  
*Non-technical* | 6.0     | First cycle |
| DT2140      | Multimodal Interaction and Interfaces | 7.5     | Second cycle |
| EG2210      | Electricity Market Analysis | 7.5     | Second cycle |
| EH2030      | Business Development and Quality Management  
*Non-technical* | 7.5     | Second cycle |
| EH2720      | Management of Projects  
*Non-technical* | 7.5     | Second cycle |
| EH2745      | Computer Applications in Power Systems | 4.5     | Second cycle |
| EL2425      | Automatic Control, Project Course, Smaller Course  
*Project Course* | 7.5     | Second cycle |
| EL2450      | Hybrid and Embedded Control Systems | 7.5     | Second cycle |
| EL2620      | Nonlinear Control | 7.5     | Second cycle |
| EL2700      | Model Predictive Control | 7.5     | Second cycle |
| EL2805      | Reinforcement Learning | 7.5     | Second cycle |
| EP2520      | Building Networked Systems Security  
*Project Course* | 7.5     | Second cycle |
<p>| EQ2310      | Digital Communications | 9.0     | Second cycle |
| EQ2321      | Speech and Audio Processing | 7.5     | Second cycle |
| EQ2401      | Adaptive Signal Processing | 7.5     | Second cycle |</p>
<table>
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<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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<tr>
<td>EQ2871</td>
<td>Cyber-Physical Networking</td>
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<td>Sensor Based Systems</td>
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<td>Embedded Systems</td>
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<td>Second cycle</td>
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<td>English for Employment</td>
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<td>First cycle</td>
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<td>Rhetoric - the Art of Persuasion</td>
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<td>First cycle</td>
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<td>ME2089</td>
<td>Leadership in Cross-Cultural and Industrial Contexts</td>
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<td>MF2007</td>
<td>Dynamics and Motion Control</td>
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<td>Mechatronics basic Course</td>
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<td>Embedded Systems for Mechatronics, I</td>
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<td>Robust Mechatronics</td>
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<td>SD2231</td>
<td>Applied Vehicle Dynamics Control</td>
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<td>Complex Analysis</td>
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<td>Optimization</td>
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<td>First cycle</td>
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<td>SF2568</td>
<td>Parallel Computations for Large- Scale Problems</td>
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<td>Applied Linear Optimization</td>
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<tr>
<td>SF2852</td>
<td>Optimal Control Theory</td>
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</table>
### Supplementary information

**Course list:** Information is based upon the curriculum for academic year 2017/2018. Changes may occur.

### Requirements for all tracks

- Compulsory courses: EL2820, AK2036, EL2520, EL2220, DD2410
- Select one or two non-technical courses
- Select at least one project course from the study area
- Requirements from one track
- Complement with recommended courses up to 120cr

**NOTE:** Compulsory and conditionally elective courses from one track are recommended on all other tracks.

**NOTE:** A course can only be listed once below and is listed only as compulsory if it is compulsory on one track and only conditionally elective on another. Please use the lists above for a complete account of the conditionally elective courses.

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### Year 3

#### Track, Electrical Energy Systems (ELEM)

#### Year 1

**Mandatory courses (13.5 credits)**

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<td>EG2100</td>
<td>Power System Analysis</td>
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<tr>
<td>EL2450</td>
<td>Hybrid and Embedded Control Systems</td>
<td>7.5</td>
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**Conditionally elective courses**

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### Year 3

**Track, Networked Control Systems (NCSS)**

### Year 1

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Year 2

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### Study Programme for Master's Programme, Systems, Control and Robotics, 120 credits batch autumn 19.

#### Appendix 1, page 9 of 11

### Course code | Course name | Credits | Edu. level |
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### Year 3

#### Track, Robotics and Autonomous Systems (RASM)

### Year 1

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### Year 3

#### Track, Systems and Control Theory (SCTY)

#### Year 1

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### Year 3
Appendix 2: Specialisations

Master's Programme, Systems, Control and Robotics, 120 credits (TSCRM), Programme syllabus for studies starting in autumn 2019

Track, Electrical Energy Systems (ELEM)

Requirements for track Electrical Energy Systems (ES)

- Compulsory courses year 1: EG2100, EL2450
- Conditionally elective (at least 3 of): EL2421, EL2425, EL2620, EL2700, EJ2301, EG2110, EJ2201, IS1200, EK2350, EK2360, EH2741, EH2745

Track, Networked Control Systems (NCSS)

Requirements for track Networked Control Systems (NC)

- Compulsory courses year 1: EL2450
- Compulsory courses year 2: EP2700
- Conditionally elective (at least 3 of): EP2200, EL2320, EL2425, EL2620, EL2700, EL2805, EP2500, MF2043, MF2007, DD2421, SF2852

Track, Robotics and Autonomous Systems (RASM)

Requirements for track Robotics and Autonomous System (RA)

- Compulsory courses year 1: EL2320, DD2423
- Conditionally elective (at least 3 of): DD2380, DD2411, DD2419, DD2421, DD2425, DD2429, DD2434, DD2437, EL2425, EL2450, EL2620, EL2700, EL2805, EQ2321, EQ2300, MF2007

Track, Systems and Control Theory (SCTY)

Requirements for track Systems and Control Theory (SC)

- Compulsory courses year 1: EL2620, EL2700
- Conditionally elective (at least 3 of): SF1691, SF2832, SF2842, SF2852, EL2425, EL2450, EL2805, EQ2300, EQ2401, EQ2800, EQ2810, EQ2820