FROM SMALL DEVICES TO LARGE SYSTEMS

Technical systems increasingly employ electronics and computers, to give the final product or system the desired properties. Driving factors are, for example, functional and quality demands, energy utilisation, environmental demands, or cost reductions. The wide range of industrial needs, from small embedded devices to large control systems for transportation, production or electric power distribution, is the primary motivation for this programme.
PROGRAMME DESCRIPTION
The aim of the programme is to prepare you for a professional career by providing a broad systems engineering base, suited to the engineering of complex, computer-controlled (embedded) products and systems. An example of the current development within this field of engineering can be found in the automotive area. Modern passenger cars increasingly depend on the integration of the car’s mechanical subsystems, with a substantial number of embedded computers, sensors, actuators, and communication devices, making it possible to create cars with active safety functions and new propulsion systems. Other evolving fields of this discipline are HVDC power transmission to minimize loss in the grid, and intelligent robots for households and industry, to name a few.

To ensure development within the field, all these systems depend on engineers making them precise, effective, flexible, fast and safe. As a student, you will be able to contribute to the development that will lead to the integration of functions for sensing, monitoring and control with a wide range of products and systems.

In the basic courses our focus lies in developing your engineering skills on a system level. In the elective part of the programme, we offer course packages toward subtopics, e.g. control, automation and mechatronics, and/or fields of application.

CAREER OPPORTUNITIES
Due to its integrating properties, the programme leads to a wide range of career opportunities with emphasis on operation, design, development, and research of complex technical systems within almost any branch of industry. The generality of many of the methods offers great opportunities in terms of choosing among many different domains of application. The acquired skills are needed at manufacturing companies, supplier companies, consulting firms, and utility companies.

Job roles range from applied research to product and system development and operation, as well as sales support and product planning. In addition, other career opportunities may arise, such as academic researchers, technical advisors, project managers, and teachers at different levels.

RESEARCH CONNECTIONS
Swedish industry has a strong tradition in systems engineering, and the long-lasting partnership between Chalmers and Swedish industry makes Chalmers a perfect choice for students wanting to pursue this rapidly evolving field of engineering.

DOUBLE MASTER’S DEGREE
In cooperation with Universität Stuttgart in Germany, Chalmers offers students in the Master’s programme Systems Control and Mechatronics a possibility of receiving double Master’s degrees. If admitted to a double degree programme, you will study your first year of the programme at Chalmers, and the second year in Stuttgart.

UNDERGRADUATE PROFILE
Major in Automation and Mechatronics Engineering, Electrical Engineering, Mechanical Engineering, Computer Science Engineering, Chemical Engineering, Chemical Engineering with Engineering Physics, Engineering Mathematics, or Engineering Physics.

PREREQUISITES
Automatic control, Physics (including Electricity, and Mechanics), Mathematics (including Linear algebra, Multivariable analysis, Transforms, and Statistics), and Basic programming.

PROGRAMME PLAN
The programme consists of five compulsory courses together with three compulsory-elective courses, and a set of elective courses. In addition, the programme provides multiple suggested course packages that can be used to specialize towards a certain application, or to further focus on general methods.

The compulsory courses focus on general systems engineering skills, and aim at providing a set of generic methods and tools.

COMPULSORY COURSES
- In Modelling and simulation, you will learn the basic tools for systematic modelling from physics, and/or experiments and simulation of those. These skills are used in many branches of systems engineering.
- Discrete event systems provides the basics for modelling and analysing systems with complex logic that is often present in manmade systems, for example, within embedded products and production systems.
- Linear control systems design describes the fundamental ideas behind feedback control systems, based upon the triplet sensing – decision – actuation, with focus on model-based control system design.
Plant-induced greenhouse lighting control

Greenhouse lighting in Europe consumes about as much electricity as Sweden produces, partly because of poor control. Plants fluoresce, but outside the visible spectrum. By investigating this light, the amount and type of light can be optimally adjusted, to save energy and to reduce stress and damage on the plants.

Aquaculture and wastewater treatment

Fish production in tanks with biologically treated recirculating water enables farming fish in an ecologically sustainable way on a large scale. However, the method implies strong demands on the water treatment, and the system becomes highly complex and can be difficult to control. By dynamic modelling and simulation, both the design and the operation can be optimized.

In Model-based Development of Cyber-Physical Systems, you will apply the knowledge from the previous courses in modelling and control in a real project that includes all phases from modelling, simulation, and control design, to implementation, and validation and testing.

In Design project in Systems, control and mechatronics, a structured project methodology is used in solving a larger design and implementation problem in a team where the skills from the previous courses are necessary to successfully solve the project.

SPECIALIZATION COURSE PACKAGES

Note that the course packages below are only suggestions, and that you are free to compose a course package of your interest.

- **Algorithms and Artificial Intelligence** provides knowledge about autonomous agents and biologically inspired optimisation methods.
- **Autonomous Systems** contains courses that focus on perception, sensor fusion, and control. This will prepare you for building autonomous systems, for example, self-driving cars.
- **Control and Signal Processing** focuses on general methods for control, signal processing and optimisation.
- **Electric and Hybrid Powertrains** – The powertrain in cars and trucks is now often partially or fully electrified. In this course package, you will learn about batteries, the electric and hybrid powertrains, and the control of those.
- **Embedded Systems** focuses more on the hardware/software aspects of implementing embedded control systems.
- **Industry 4.0** within production artificial intelligence together with new sensors, e.g. cameras, will make the next generation of automation systems self-configurable, and able to optimize and do self-diagnostics on the production system.
- **Machine Learning** – Artificial intelligence and machines that can learn skills based on data will be an important technique in many applications. In this course package, you will learn the key techniques in deep machine learning, and other data-driven methods, like system identification.
- **Mathematical Systems Theory** further focuses on general system-oriented courses for modelling and analysis of dynamic systems.
- **Power Systems** is focused on power systems and power electronic equipment connected to the grid including technologies like HVDC power transmission.
- **Process Control** is focused on control for chemical engineering applications, with more courses in process engineering.

**MASTER’S THESIS**

The Master’s degree is completed with a 30 ECTS credit Master’s thesis project, which can be conducted within a company or within one of our research divisions.

**MORE INFORMATION**

www.mpsys.se

Find out more about our specialization course packages in the following pages.
COMPOSE YOUR OWN COURSE PACKAGE – OR CHOOSE ONE OF THESE TEN SUGGESTIONS

In order to guide you through the available compulsory-elective and elective courses, the programme provides ten suggested course packages, that can be used to specialize towards a certain application, or to further focus on general methods. You are of course free to compose your own course package according to interest. Please note that you need to choose at least three compulsory-elective courses out of the available courses (in purple) displayed below. Some of the course packages contain courses with specific prerequisites, e.g. the course package in process control contains courses that require you to have a background in chemical engineering or similar.

Systems, Control and Mechatronics, MPSYS

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
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<tbody>
<tr>
<td>Modelling and simulation</td>
<td>Design project in Systems, control and mechatronics</td>
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<tr>
<td>Linear control system design</td>
<td>Compulsory elective / Elective</td>
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<td>Compulsory elective / Elective</td>
<td>Compulsory elective / Elective</td>
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<tr>
<td>Model-based development of cyber-physical systems</td>
<td>Compulsory elective / Elective</td>
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<tr>
<td>Discrete event systems</td>
<td>Master's thesis</td>
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Compulsory-elective / Elective courses

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<tr>
<th>Q1 / Q5</th>
<th>Q2 / Q6</th>
<th>Q3 / Q7</th>
<th>Q4 / Q8</th>
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</thead>
<tbody>
<tr>
<td>Robust and nonlinear control</td>
<td>Applied signal processing</td>
<td>Modelling and control of mechatronic systems</td>
<td>Sensor fusion and nonlinear filtering</td>
</tr>
<tr>
<td>Constraint programming and applied optimisation</td>
<td>Simulation of production systems</td>
<td>Model predictive control</td>
<td>System identification</td>
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<tr>
<td>Nonlinear optimisation</td>
<td>Computer vision*</td>
<td>Discrete optimisation</td>
<td>Linear and integer optimisation with applications</td>
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<tr>
<td>Deep machine learning*</td>
<td>Advanced topics in control*</td>
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- Compulsory course
- Elective course, (*MPSYS-owned)
- Compulsory-elective course, choose at least three
# Mechatronics Specialization Course Packages

## Algorithms and Artificial Intelligence

<table>
<thead>
<tr>
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<tr>
<td>Deep machine learning</td>
<td>Applied signal processing</td>
<td>Model predictive control</td>
<td>Sensor fusion and nonlinear filtering</td>
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<tr>
<td>Formal methods in software development</td>
<td>Functional programming</td>
<td>Introduction to artificial intelligence</td>
<td>System identification</td>
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<td>Computer vision</td>
<td>Image analysis</td>
<td>Algorithms (also available in Q1)</td>
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## Autonomous Systems

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<thead>
<tr>
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<th>Q4 / Q8</th>
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<tr>
<td>Deep machine learning</td>
<td>Applied signal processing</td>
<td>Model predictive control</td>
<td>Sensor fusion and nonlinear filtering</td>
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<tr>
<td>Stochastic optimisation algorithms</td>
<td>Computer vision</td>
<td>Intelligent agents</td>
<td>Autonomous robots</td>
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<tr>
<td>Algorithms (also available in Q4)</td>
<td>Image analysis</td>
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</table>

## Control and Signal Processing

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<thead>
<tr>
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<td>Introduction to communication engineering</td>
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<td>Random signal analysis</td>
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<td>Linear and integer optimisation with applications</td>
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<td>Image analysis</td>
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## Electric and Hybrid Powertrains

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<th>Q4 / Q8</th>
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<td>Applied signal processing</td>
<td>Model predictive control</td>
<td>Sensor fusion and nonlinear filtering</td>
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<tr>
<td>Electric drives 1</td>
<td>Li-ion battery systems for vehicles and energy storage applications</td>
<td>Model predictive control</td>
<td>System identification</td>
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<td>Chalmers formula student (special application procedure)</td>
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<td>Power electronic converters</td>
<td>Electric and hybrid vehicle propulsion</td>
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<td>Vehicle dynamics</td>
<td>Electric drives 2</td>
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<td>Electromagnetism</td>
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</tbody>
</table>
# Systems, Control and Mechatronics

## Power Systems
- Power system analysis
- Applied signal processing
- Modelling and control of mechatronic systems
- Linear and integer optimisation with applications
- Power electronic solutions for power systems
- Power electronic converters

## Applied signal processing
- Sensor fusion and nonlinear filtering

## Sensor fusion and nonlinear filtering
- Autonomous robots

## Computer vision
- Communication systems
- Methods for electronic system design and verification

## Introduction to electronic system design
- Formal methods in software development
- Introduction to communication engineering

## Process Control
- Robust and nonlinear control
- Applied signal processing
- Model predictive control
- Linear and integer optimisation with applications
- Advanced chemical reaction engineering
- Industrial energy systems
- Advanced chemical engineering and process analytical technology
- Advanced separation technology

## Industry 4.0
- Robust and nonlinear control
- Simulation of production systems
- Model predictive control
- Linear and integer optimisation with applications
- Robotics and manufacturing automation
- Design and scheduling of automated production systems
- Communication systems
- Formal methods in software development
- Computer vision
- Image analysis

## Machine Learning
- Deep machine learning
- Stochastic optimisation algorithms
- Algorithms for machine learning and inference

## Mathematical Systems Theory
- Robust and nonlinear control
- Applied signal processing
- Model predictive control
- Sensor fusion and nonlinear filtering
- Nonlinear optimisation
- Advanced topics in control
- Partial differential equations, first course
- Linear and integer optimisation with applications

## Computer vision

## Elective course
- Elective course
- Compulsory-elective course, choose at least three

## Embedded Systems
- Constraint programming and applied optimisation
- Methods for electronic system design and verification
- Communication systems
- Autonomous robots

## Sensor fusion and nonlinear filtering
- Algorithms for digital signal processing systems

## Advanced chemical reaction engineering
- Advanced separation technology

## Advanced chemical engineering and process analytical technology

## Industrial energy systems

## Advanced separation technology

For more information on the Master’s programme Systems, Control and Mechatronics, visit: 

mps.se

For more information on how to apply, visit: 

chalmers.se/masters