

ME-422

**Multivariable control**

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<b>Cursus</b>	<b>Sem.</b>	<b>Type</b>
Mechanical engineering	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Written
Workload	90h
Weeks	14
<b>Hours</b>	<b>3 weekly</b>
Courses	2 weekly
Exercises	1 weekly
<b>Number of positions</b>	

**Summary**

This course covers methods for the analysis and control of systems with multiple inputs and outputs, which are ubiquitous in modern technology and industry. Special emphasis will be given to discrete-time systems, due to their relevance for digital and embedded control architectures.

**Content**

Several industries across engineering (e.g. manufacturing, energy, chemical, and transportation) rely on the simultaneous utilization of multiple sensing and actuation channels. Multivariable systems are also relevant for emerging technologies, such as the internet of things, and for fields beyond engineering, such as biology or finance. The first part of this course will provide methods for analyzing multi-input multi-output dynamical systems in the state-space form. The focus will be on linear discrete-time models which offer a reference framework for digital control architectures. To this purpose, several concepts of basic system theory will be recalled and developed in detail. The second part will cover popular methods for designing multivariable controllers and illustrate their application to various classes of systems.

**Structure**

- Basics of discrete-time models in the state space
- Stability analysis
- Controllability and observability
- Sampled-data systems
- State-feedback control based on eigenvalue assignment
- State observers
- Optimal control: the Linear Quadratic Regulator (LQR)
- The Kalman filter
- The Linear Quadratic Gaussian (LQG) regulator

**Keywords**

Multivariable systems, feedback control, state-space models, optimal control, LQR, Kalman filtering, LQG

**Learning Prerequisites****Required courses**

Linear algebra, Control systems

**Important concepts to start the course**

- State-space models
- Linear systems in continuous and discrete time
- Basic concepts of stability
- Feedback control

### Learning Outcomes

By the end of the course, the student must be able to:

- Construct and analyse a discrete-time model for a dynamic system, A5
- Analyze a multivariable dynamic system and design an appropriate controller for the system, A10
- Assess / Evaluate the stability, performance and robustness of a closed-loop system, A12
- Propose several control solutions, formulate the trade-offs, choose the options, A14

### Transversal skills

- Use a work methodology appropriate to the task.
- Demonstrate the capacity for critical thinking

### Teaching methods

Ex-cathedra, exercises

### Assessment methods

Written final exam

### Supervision

Office hours	No
Assistants	Yes
Forum	No

### Resources

#### Bibliography

- Course slides on Moodle

#### Ressources en bibliothèque

- [Linear optimal control systems / Kwakernaak](#)