Welcome at the online TU/e Graduate School Event

Master Systems and Control (S&C)
Erjen Lefeber, assistant professor (ME, D&C Group)
Saray Bakker, student MSc S&C
Today’s program:

• Presentation Master’s & pre-Master’s program S&C (30 min)

• Time for questions (15 min)
CONTENT

• **Brainport region**
  • Systems and Control: why?
  • Systems and Control: what?
  • After graduation
  • Studying S&C at TU/e
  • Systems and Control pre-Master program
  • Application / More information
Top-ranking Dutch university

At the heart of the Brainport region

Strong technology heritage in Eindhoven

The Netherlands

Brainport

Eindhoven

Accounts for 23.1% of total Dutch private R&D expenditure*

Student growth

<table>
<thead>
<tr>
<th>Year</th>
<th>BS</th>
<th>MS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>5,591</td>
<td>3,608</td>
<td>9,199</td>
</tr>
<tr>
<td>2019</td>
<td>7,501</td>
<td>4,750</td>
<td>12,251</td>
</tr>
</tbody>
</table>

More than 93 nationalities

Engineers for the future

12,251 total number of students

92% of the graduated students finds a job within 6 months. Nationwide this is 89%

3,298 total degrees awarded

1.441 BSc / 1.455 MSc
120 PDEng / 282 PhD

59,341 total number Alumni

83% Male, 17% Female
Brainport: the beating technological heart of Europe
The TU/e campus covers an area of 75 hectares

**Ecosystem and characteristics**
- 47 new patent applications
- 7 patents filed by third parties
- 29 provisionals converted
- 35 transferred via a transfer or license
- 2747* Scientific publications

**International working environment**
- 54 New start-ups and spin-offs
- 15 Large research labs
- 50 Smaller research facilities
- 3,301.3 Total staff (fte)
- 2,122 Research staff (fte)
- 64.3% Dutch
- 35.7% International
- 61.5% Male
- 38.5% Female
- 154 Full professors
- 138 Part time professors
- 144 Associate professors
- 300 Assistant professors
- 1,572 PhD fellows

**Rankings:**
- CWTS Leiden Ranking 2020: TU/e no. 4 in industry cooperation
- Times Higher Education: 2021 no. 187 of 1000
- QS-Ranking 2021: no. 120 of 1003
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• **Systems and Control: why?**
• Systems and Control: what?
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Systems and Control

- Plant
- Sensor
- Actuator
- Controller
Systems and Control

• Technological contributions in many fields
• Hidden but crucial technology
• Generic theory for many applications
• Applications in high tech industry, communication, health, 3D printing, etc...
• Key ingredient of AI for engineering systems

Communication | Additive manufacturing | Health and care | Aviation systems | Energy distribution | Automotive applications
• Systems and Control: Brainport region
• Systems and Control: why?
• **Systems and Control: what?**
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Systems and Control: an interdisciplinary study

Partner universities:

TU/e
Mechanical Engineering

TU/e
Electrical Engineering

TU Delft
Delft University of Technology

TU/e
Technische Universiteit Eindhoven
University of Technology

University of Twente

4TU
# Program overview

<table>
<thead>
<tr>
<th>1st year</th>
<th>2nd year</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Core program (25 EC)</td>
<td>Internship (15 EC)</td>
</tr>
<tr>
<td>• Specialization courses (20 EC)</td>
<td>Graduation project (45 EC)</td>
</tr>
<tr>
<td>• Free electives (incl. homologation, 15 EC)</td>
<td></td>
</tr>
</tbody>
</table>

*double degree with AI&ES is not allowed*
Education - core program S&C

- Control engineering (ME)
- System theory for control (ME)
- Integration project
- Modeling dynamics (EE) or Multibody and non-linear dynamics (ME)
- System identification (EE)
First year schedule

Quarter 1
- Control Engineering
- System theory for control
- Homologation, or choice, or Modeling Dynamics*

Quarter 2
- Multi-body and Non-linear Dynamics*
- Choice
- Choice

Quarter 3
- System Identification
- choice
- choice

Quarter 4
- Integration Project
- choice
- choice

*Students have to choose one of these 2 courses

Choice = free elective or specialization
Education

Core courses (25 EC), compulsory:

• **Control engineering**
• System theory for control
• Modeling dynamics or Multibody and non-linear dynamics
• System identification
• Integration project

Specialization courses (20 EC):
Choose in consultation with your mentor
Education

Core courses (25 EC), compulsory:
• Control engineering
• **System theory for control**
• Modeling dynamics *or* Multibody and non-linear dynamics
• System identification
• Integration project

Specialization courses (20 EC):
Choose in consultation with your mentor
Education

Core courses (25 EC), compulsory:
• Control engineering
• System theory for control
• **Modeling dynamics or Multibody and non-linear dynamics**
• System identification
• Integration project

Specialization courses (20 EC):
Choose in consultation with your mentor
Education

Core courses (25 EC), compulsory:
• Control engineering
• System theory for control
• Modeling dynamics or Multibody and non-linear dynamics
• System identification
• Integration project

Specialization courses (20 EC):
Choose in consultation with your mentor
Integration project

- Apply all knowledge from the other core courses
- Define the goal yourself on a given set-up such as a 3-DOF gyroscope or a drone
- Work in a multidisciplinary project team (+/- 4 members)
- Develop your professional skills
### Specialization in the program

<table>
<thead>
<tr>
<th>Year</th>
<th>Component</th>
<th>Credits</th>
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<tbody>
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<td></td>
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<td>15 EC</td>
</tr>
<tr>
<td>2nd year</td>
<td>Internship</td>
<td>15 EC</td>
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<td></td>
<td>Graduation project</td>
<td>45 EC</td>
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- Curriculum = coherent, in line with specialization, guidance from mentor

- Internship and graduation project: independent work, explore new research questions, within university or in cooperation with industry
Sections S&C

**Control Systems Technology** / prof. Steinbuch prof. Heemels

**Dynamics & Control** / prof. Van de Wouw

**Control Systems** / prof. Van den Hof

**Electro-mechanics and Power Electronics** / prof. Lomonova

MECHANICAL ENGINEERING DEPARTMENT

ELECTRICAL ENGINEERING DEPARTMENT

- high precision and accuracy / hybrid and network control / nuclear fusion / systems engineering
- non linear control / automotive / vehicle dynamics / cooperative driving / manufacturing networks
- hybrid and electrical driving / electromagnetics / actuator design / power electronics
- high-tech / process control / multi agent systems / energy management / dynamic networks
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TU/e Graduate School Event 2022 – MSc Systems and Control
Research groups

- TU/e world class in control:
  IEEE/IFAC Fellows, National and European Grants (ERC, VICI)
- Contacts and contracts with many industrial partners
- Staff members are authors and editors in top journals
- and have a world-wide network
- Spin-off companies
- Guiding and coaching research of close to 100 PhD students
- Follow-up PhD and graduate work in national Dutch Institute of Systems and Control (DISC)
Project examples

Cooperative vehicles and traffic control

Reservoir modeling and control

Energy distribution

Process control

3D printing: modeling and control
Project examples

- Magnetically levitated planar motor
- Active car suspension
- Wafer scanner
- Care and cure robotics
- Mechatronic designs, cooperative robotics
- High tech for agriculture
Examples of graduation projects

• “Nonlinear modeling for dynamic analysis of directional drilling processes.”
• “Robust control of an adaptive optics system under non-stationary turbulence conditions.”
• “Constrained Control of An interventional X-ray machine using Sampling-based Nonlinear Model Predictive Control”
• “Controlling structural deformation of a wafer stage: a disturbance-observer based approach.”
• …..
Internship project in Trondheim

Interaction control for submarine snake robots
Graduation project @Philips

Model predictive control (MPC) with obstacle avoidance for medical robots
Coaching

• Mentor program: Full, associate or assistant professor
• Student mentor
• Academic advisor
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After graduation

Research:
• PhD (graduate school DISC)
• PDEng (Automotive Systems Design, or...)

Industry:
• High-tech industry
• Aviation
• Process industry
• Health
• Automotive industry

Consultancy / Start-up / Spin-off company

Foto: Bart van Overbeeke
TU/e Graduate School – shape your own future!
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Studying S&C at TU/e

• Not easy!
• Small scale (approx. 50 students in year 1)
• Highly motivated peers
• Excellent job opportunities
• Good student evaluations

National Student Survey 2021 (1-5 scale):
- Content 4.1
- Lecturers 4.1
- Academic guidance 4.0
- General 4.0
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• **Systems and Control pre-Master program**
Pre-Master Systems and Control

- Duration: 1 years (30 EC)
- Time of entry: September
- Language: English

Why?
- Eliminate deficiencies

What?
- Program of 30 EC, to be achieved within one year
- Focus on mathematics (10 EC)
# S&C pre-Master program 2021-2022

## Compulsory courses

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>q 1</td>
<td>2DL60</td>
<td>Linear Algebra</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>2WBB0</td>
<td>Calculus variant 2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>5ESC0</td>
<td>DSP fundamentals (signals II)</td>
<td>5</td>
</tr>
<tr>
<td>q 2</td>
<td>2DL40</td>
<td>Advanced Calculus I</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>4DB00</td>
<td>Dynamics and control of mechanical systems</td>
<td>5</td>
</tr>
<tr>
<td>q 3</td>
<td>4CC10</td>
<td>Mechatronic Design</td>
<td>5</td>
</tr>
<tr>
<td>q 4</td>
<td>5EMA0</td>
<td>Mathematics II</td>
<td>5</td>
</tr>
</tbody>
</table>

### Mandatory trainings
- RSI (healthy use of laptop)
- Safety & environment

### Recommended
- Matlab training
Difference WO & HBO (in general)

University of technology:
• Developing new technology and design methods to solve technological problems
• Education focusses on concepts and their implications
• Guaranteeing performance of controlled and engineered systems
• Internship is a research project

University of applied science:
• Applying existing technology and design methods to solve technological problems
• Education focusses on practical application
• Internship in industry
How to prepare during your bachelor’s program?

• A pre-master’s program is more work than one might think. You must be willing to work hard.

• It is not advised to do the pre-master in combination with a part-time job in industry.

• Subscription for a pre-master via Studielink before May 1st.

• required minimum level of mathematics: pre-university (VWO) mathematics B or [TU/e mathematics B test](#) completed before September 1st

• required minimum level of English proficiency: pre-university (VWO) level English or [English language proficiency test](#) completed before September 1st
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Admission with a BSc degree in:

• Aerospace Engineering
• Applied Mathematics
• Applied Physics
• Electrical Engineering (including Automotive)
• Mechanical Engineering

Prior education needs to be of sufficient academic level and quality to be able to complete this Master's degree program.
Admission via pre-master’s program with

→ Direct admission:
- Automotive
- Electrical and Electronic Engineering
- Mechanical Engineering
- Technische wiskunde
- Aviation / Aeronautical Engineering
- Engineering Physics
- Mechatronics

• Tailor-made pre-master’s programs for other (university + HBO) diplomas via admission committee Admission.Mech@tue.nl
APPLICATION MASTER PROGRAMS

For Dutch students:
• More information about admission: www.tue.nl/admission
• Application via http://www.studielink.nl/
• Questions: studeren@tue.nl

For international students:
• Check the requirements for admission via www.tue.nl/admission
• Apply at the online application form (available from 1 Oct – 1 May)
• Application fee of €100 for each application (non refundable)
• Application procedure takes +/- 8 weeks
• You will be informed by email about the outcome of your application
• Questions: io@tue.nl
More information

Information:
• Master S&C: https://www.tue.nl/en/education/graduate-school (info on Master’s program, curriculum, interviews with students and alumni)

Questions:
• Content program: me.studyinformation@tue.nl