Welcome

Designing highly innovative systems for signal processing is your passion, e.g. in biomedical applications or in telecommunication. Or your interest focuses on microsystems or robotics. You want to further expand your knowledge and competencies in the field of Electrical Engineering. Specialise in a field of your preference, to be prepared for a career in science or industry. The Master of Science programme in Electrical Engineering gives you this opportunity. You learn to define your own paths in analysis, research and design. Cooperate in industrial design teams or scientific research groups. Join one of the research institutes of the university.

At the University of Twente, you specialise choosing one of five tracks: Microsystems and Microelectronics, Measurement and Control Engineering, Embedded System Design, Biomedical Systems and Telecommunication Networks. In national and international reviews, the Electrical Engineering programmes of the University of Twente rate very high, according to both students and professionals. We would soon like to work with you.

dr.ir. Wouter Olthuis
Programme Director
Electrical Engineering
Department of Electrical Engineering

The department of Electrical Engineering is part of the Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS) of the University of Twente. This study guide will provide you with information about the Master of Science programmes of the department of Electrical Engineering. The following Master of Science programmes can be found in this guide:

1 Master of Science in Electrical Engineering
2 Master of Science in Mechatronics
3 3TU Master of Science in Embedded Systems
4 3TU Master of Science in Systems and Control

In chapter 5 of this study guide you can find information about the chairs and chair holders of the Electrical Engineering department.
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Section A

Master’s programmes
1 Electrical Engineering
1.1 Goals and aims of Electrical Engineering

The department of Electrical Engineering aims to train master’s students in a spectrum of professional and personal competencies to enable them to expand their knowledge and methodology in design, through analysis and research of innovative systems in a specific discipline.

The five fields of specialization are Biomedical Systems, Electrical System Design, Measurement and Control Engineering, Microsystems and Microelectronics, and Telecommunication Networks.

The field of specialization determines the content of the master’s programme Electrical Engineering. Graduates maintain a broad Electrical Engineering qualification while being specialized in one of the specific fields. The fields of specialization are indicated on the master’s degree.

The level of Master of Science in Electrical Engineering is illustrated in the following general competencies:

• A Master has the competencies of a bachelor in Electrical Engineering of the University of Twente. In case students are admitted from other programmes with essential deficiencies, these should be repaired. These competencies are expanded in the Master’s programme.
• A Master has specialized advanced knowledge in at least one of the areas of Electrical Engineering: Biomedical Systems, Embedded System Design, Measurement and Control Engineering, Microsystems and Microelectronics, and Telecommunication Networks.
• A Master has experience in working on industry-related projects and has acquired the ability to be effective in a multidisciplinary environment.
• A Master is able to work at the frontier of research and design, and is innovative, contributing to breaking the frontiers of current technology or understanding.
• He/she defines his/her own design/research goals within the limits of his/her project, judges which parts of the problem need further analysis, carries out these analyses on abstract level, proposes experiments and carries them out in a methodologically correct way.
• A Master is able to understand, on a general level, areas adjacent to his/her own area of specialization and uses this understanding in the context of his/her own work. He/she is able to appreciate new knowledge of other disciplines (if necessary also of non-technical areas) and to integrate this in his/her work.
• A Master can carry responsibility as a leading member of a multidisciplinary design (or research/development) group and develops a broad scope, e.g., with respect to the economical aspects of his/her work, or the impact of technological innovation on society. He/she is a serious partner in discussions on aspects regarding the setting and societal environment of his/her work.

Compared to the bachelor’s level, a Master has more specialized knowledge and abilities, more industrial experience and has skills to independently solve relatively complex problems.

### 1.2 General outline

The master’s programme is a two-year programme. The programme is organized in semesters. Each semester contains 20 weeks, and is subdivided in quartiles. The unit of credit is the European Credits (EC). One EC stands for 28 hours of study load. An academic year is 60 EC. The master’s programme of Electrical Engineering is 120 EC.

### 1.3 Master’s programme

The curriculum of the Master of Science in Electrical Engineering consists of the following elements:

<table>
<thead>
<tr>
<th>Year</th>
<th>EC</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>20</td>
<td>Compulsory specialization courses</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Philosophical and Societal courses</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Electives</td>
</tr>
<tr>
<td>Second</td>
<td>20</td>
<td>Traineeship</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Master’s thesis project</td>
</tr>
</tbody>
</table>

Within the Programme of Electrical Engineering there are five specializations. They are connected to one or more of the research institutes of the University. You will carry out your master’s thesis research within one of these institutes:

• the MIRA Research Institute for Biomedical Technology and Technical Medicine
• the MESA Research Institute for Microsystems and Microelectronics
• the CTIT Research Institute for Telecommunication and Information Technology
• the IMPACT Research Institute for Energy and Resources
1.3.1 Biomedical Systems

The master’s specialization in Biomedical Systems focuses on the measurement and control of human functions, especially in the neuromuscular system and on non-invasive measurement techniques. Also the student may concentrate on advanced measurement techniques for micro-sensors, nano-sensors and related micro-systems for biomedical applications. Research projects can be carried out within the BSS or BIOS-group but also in one of the other participating groups in the MIRA Institute.

Chairs: Signals and Systems (SAS), Biomedical and Environmental sensor systems (BIOS), Biomedical Signals and Systems (BSS)
Chair holders: prof.dr.ir. C.H. Slump, prof.dr.ir. A. van den Berg, prof.dr.ir. P.H. Veltink

The compulsory courses for this specialization are:

191211350 Neurophysiology (5 EC)
191211140 Electrophysiologic Signals and Bio-electricity (5 EC)
191210720 Biomedical Signal Acquisition (5 EC)
191211150 Practical Biomedical Signal Analysis (5 EC)

The 4 compulsory courses in the specialization Biomedical Engineering are mainly in the medical field: 2 courses on Anatomy and Physiology, one course on ‘Lab on a Chip’ and one course on Practical Biomedical Signal Analysis. The first two are obvious. The third focuses on state of the art analysis systems based on integrated systems on a chip in which fluid handling, sampling and measurement are integrated. The fourth course deals with signal processing techniques to extract the useful information amidst much other disturbing measurement noise.
1.3.2 Electrical System Design

The master’s specialization of Electrical System Design focuses on the design methodology of embedded intelligence in hard- and software that is common in an ever increasing range of applications. It covers the design of integrated mixed A/D systems and real time operating systems on a ‘high’ level with a link to component level and the application context. The Embedded systems area is a key area of development in the Information Technology world. It also is an interdisciplinary area of Electrical Engineering and Computer Science. Because both departments are situated in one faculty, close cooperation exists. Students can develop themselves in either the architecture and software side or the hardware signal processing side or anything in between.

Research institutes: MESA, IMPACT, CTIT

The compulsory courses for this specialization are:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>191210770</td>
<td>Digital Control Engineering</td>
<td>5</td>
</tr>
<tr>
<td>191210750</td>
<td>System on Chip Design Project</td>
<td>10</td>
</tr>
<tr>
<td>191210760</td>
<td>Advanced Programming</td>
<td>5</td>
</tr>
</tbody>
</table>

The 3 compulsory courses in the specialization Electrical System Design give a common background of system on chip design, control and advanced programming. Specific electives can be chosen, like real time operating systems and hardware/software co-design. However, students are free to propose their programme. One of the compulsory courses is a 7-week project of System on Chips Design. During the course a signal processing chip is designed (mixed signal), including communication with the outside world and internal buses. The course on advanced programming develops skills in structured (C++) programming.
1.3.3 Measurement and Control Engineering

The master’s specialization in Measurement and Control Engineering focuses on the design of advanced measurement and control systems. New control concepts are emerging, such as intelligent, adaptive and fuzzy control for robotics, for example, and new integrated measurement and data analysis concepts. The programme can be individually tailored and can have a special focus on modelling simulation and control of dynamic systems, measurement techniques in environmental and biomedical applications, computer imaging applications or robotics. Research projects can be carried out within the CE- or SAS-group but also in one of the other participating groups of the IMPACT Research Institute for Energy and Resources.

Chairs: Control Engineering (CE)
Chair holder: prof.dr.ir. J. van Amerongen/ prof.dr.ir. S. Stramigioli

For this specialization the compulsory courses are:

191211110 Modelling and Simulation
191210770 Digital Control Engineering
191210800 Information Theory
191210760 Advanced Programming

The 4 compulsory courses give a general background in measurement and control. Modelling and Simulation introduces bond graph theory for modelling and simulation of dynamic systems. The Digital Control course builds on prior knowledge of basic control courses and describes multivariable control systems, optimal control and state estimation and time-discrete systems. The Information and Communications Theory course covers information theory, coding and detection. Advanced Programming develops essential skills in these fields.

The elective courses make it possible to specialize in areas like robotics, design of micro-measurement systems including sensor technology, signal processing, pattern classification and recognition, intelligent control and systems theory.
Research institutes: IMPACT, CTIT
1.3.4 Microsystems and Microelectronics

The master’s specialization Microsystems and Microelectronics contains the broad field of micro technology and engineering: micro electronics and integrated circuit design, micro fabrication technology, micro electro / mechanical / optical / magnetic systems, micro chemical systems as well as supporting material science fundamentals.

Research institutes: MESA+ and CTIT.
Chairs: Semiconductor Components (SC), Transducers Science and Technology (TST), Biomedical and Environmental sensor systems (BIOS), Integrated Circuit Design (ICD), Integrated Optical Microsystems (IOMS), Nano-electronics (NE)

For this specialization the compulsory courses are:

- 191210740 Material Science (5 EC)
- 191210730 Technology (5 EC)
- 191210750 System on a Chip Design project (10 EC)

The compulsory courses are meant to give a broad background in system design and technology. The technology and material science courses give an overview of micro- and nano fabrication technology, strongly related to integrated circuit technology. The Material Science course focuses on materials, their crystal structure, electrical, mechanical, magnetic and optical properties, interfaces and for most on the system applications using these effects. The System on a Chip Design course is a large system design project, where a mixed signal chip is designed. The elective courses offer you the possibility to specialize in design and/or technology in any of the areas microelectronics, magnetic systems, optical systems or micromechanical systems.
### 1.3.5 Telecommunication Networks

The master’s specialization Telecommunication Networks covers the modern field of Telematics from an electrical engineering perspective: communication systems, including communication infrastructure, optical and other transmission media, mobile communications, signal theory, (de)coding, (de)modulation and detection theory, electromagnetic interference and electromagnetic compatibility. Collaboration exists with the Computer Science programme. Research projects can be carried out within the TE, SAS or DACS-group but also in one of the other participating groups in the CTIT research institute.

**Chairs:** Design and Analysis of Communication Systems (DACS), Telecommunication Engineering (TE), Signals and Systems (SAS), Integrated Circuit Design (ICD)

**Chair holders:** prof.dr.ir. B.R.H.M. Haverkort, prof.dr.ir. F.B.J. Leferink, prof.dr.ir. C.H. Slump, prof.dr.ir. B. Nauta.

For this specialization the compulsory courses are:

- 191210800 Information Theory (5 EC)
- 191210780 Modern Communication Systems (5 EC)
- 192620000 Telematics Networks (5 EC)
- 191210760 Advanced Programming (5 EC)

One compulsory course is meant to give a sound fundament in structural programming. The information theory course deals with information theory, coding and detection theory. The compulsory course on transmission systems focuses on physical aspects of transmission and systems concepts. Finally, the compulsory course Telematics Networks focuses on advanced topics in local and wide-area networking. The elective courses make it possible for students to specialize in any area ranging from hard core physical transmission to application and communication protocols.
1.4 Programme guidelines

Besides the above mentioned compulsory courses within a specialization there are the below mentioned guidelines:

- Philosophy of Engineering has to be a part of the programme as one of the Philosophical and Societal courses.
- For each specialization a standard set of compulsory courses has been chosen with a total workload of 20 EC. The final decision about the choice of the compulsory courses is taken by the master’s thesis supervisor.
- Elective courses can be chosen from all available courses in the department or even university, provided the programme is coherent and relevant in the opinion of the Graduation Committee. See ‘Overview all EE courses’. All elective courses are 5 EC.
- The course programme will have to be approved by the master’s thesis supervisor.
- The master’s thesis project is a research oriented individual project where a last proof of engineering and scientific attitude must be given. It is always carried out in one of the research groups taking part in the specialization. External periods can be part of the thesis work. These will be organised through the responsible supervisor.

1.4.1 Procedures for planning

The Electrical Engineering master’s programme offers the student a large freedom to make choices and to setup an individual programme. Some of these choices will have to be made right after the start of the programme which may not be easy. Therefore some guidelines are given below which may give you some support. This plan is for students who obtained their bachelor’s degree at the University of Twente. Students from elsewhere can use it with some adaptations.

Step 1: making a start with your master’s programme
During the last phase of your bachelor’s programme, you will choose your master’s specialization. Every specialization has its own compulsory courses. The first semester of your programme will contain quite a number of courses. Besides compulsory courses, free electives can also be added to your programme. You can ask your bachelor’s programme mentor for advice about you master’s programme.

Step 2: choosing your research group (chair)
It is very important to make a (provisional) choice for the research group where you would like to carry out your master’s thesis as soon as possible. The choice you will make defines your programme of free electives. Even the programme of compulsory courses might undergo some changes. However, you can change courses during the programme, in which case you will be transferred from one group to another.
Step 3: creating your course programme
Contact the programme mentor of the specialization of your choice. You will be assigned a staff member of the research group, who will take over the tasks of the bachelor mentor. With him/her you can discuss your interests and preferences that finally should lead to a course programme:

- Your mentor/master’s thesis supervisor will choose the compulsory courses. Often these will be the compulsory courses mentioned under the specialization. However a different choice is possible.
- You are free to choose your electives yourself, but you are supposed to discuss your choice with your mentor/supervisor. Finally your programme will have to be approved by your supervisor.

1.4.2 International Students

International students will follow the master’s programme with some adaptations:
- Maximally 15 EC are reserved for so called homologation courses (bridging courses) to bridge possible gaps in their prior knowledge. For Dutch students, these courses are part of the bachelor’s programme.
- International students will not have a traineeship in a company. Instead they will carry out an Individual Research Project in one of the research groups of the department.

This leads to the following programme for International students:

<table>
<thead>
<tr>
<th>Year</th>
<th>EC</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>(max) 15</td>
<td>Homologation courses</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Compulsory specialization courses</td>
</tr>
<tr>
<td></td>
<td>5 or 10</td>
<td>Philosophical and Societal courses</td>
</tr>
<tr>
<td></td>
<td>(min) 15</td>
<td>Electives</td>
</tr>
<tr>
<td>Second</td>
<td>15</td>
<td>Individual Project</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>One elective</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Master’s thesis project</td>
</tr>
</tbody>
</table>

The individual project
The individual project is a small project that must be completed before you can start with the master’s thesis assignment. The goal of the project is to become acquainted with independent research, finding your own way through the project, and formulating the details of the research questions.
Non-technical courses
If you need to do non-technical courses (that must be stated in the programme offer), contact the study adviser. You may search in Black Board for e.g. “economy”. A frequently chosen course is Philosophy of Engineering (5 EC), as it is compulsory for Dutch master’s students. It runs in quartile 2 (2.5 EC) and in quartile 4 (also 2.5 EC).

Programme offer
Before arriving in the Netherlands, an international student will have received a so-called programme offer that states which homologation courses have to be done, the actual number of electives to be completed and whether or not an individual project has to be done. In some cases, one or two non-technical courses are obligatory. If so, they replace one or two free electives. This programme offer is based on the specific content of the Bachelor’s programme that was completed and, if applicable, more advanced education and/or working experience.

Procedures for planning and advice
International students can use the plan of paragraph 1.4.1 with some adaptations in step 1.

Step 1
The starting point for an international student will be the programme offer in which the outline is given of the student’s personal master’s programme. In this programme the homologation courses are fixed. The compulsory master’s courses can be added. During the introduction the international student will be handed a provisional planning of the courses that should enable him/her to make a start. The first quarter of the programme can then be used to select a research group and to carry out step 2.

Until the research group has been chosen, dr. M. (Maarten) Korsten is available for advice.

Step 2
The individual project can be completed at each of the chairs from the Electrical Engineering department. In this study guide you can find a short description of each chair. More information can be found on the chair’s websites. When you’ve made a choice for a chair of your interest, you can contact the secretary of the chair. She will redirect you to one of the staff members who can give you information about the possible assignments. You may think about the possibility to take the individual project and the master’s thesis assignment in the same area, to deepen your insight. Or you can choose to do them in rather different areas, to broaden your scope. They cannot be combined into one assignment.

The contact-person for students from abroad, who are interested in a MSc in the department of EE is dr. M. (Maarten) Korsten; room Zilverling 1022, phone: 053 489 2763; e-mail m.j.korsten@utwente.nl
1.4.3 Post HBO programme

With a HBO degree it is possible to do a Master of Science in Electrical Engineering. A pre-master course of six months is compulsory. The post HBO programme is described extensively in a separate booklet, which is handed to the students when starting the programme.

The pre-master’s coordinator is dr. M. (Maarten) Korsten; room Zilverling 1022, phone 053 489 2763; e-mail m.j.korsten@utwente.nl

1.4.4 Individual programme

It is possible to compose an individual programme. The Board of Examiners of Electrical Engineering has to approve the programme.

Regulations:

- the total amount of EC’s should be the same as the standard programme;
- it should contain clear goals and aims;
- the goals and aims should be an equivalent of the standard programme;
- a final thesis is compulsory;
- eight or more electives should be from two different disciplines;
- 20% of the subject of the compulsory subjects of EE should be part of the individual programme;
- a study-plan should be made;
- staff members (from UT and/or other universities) should be mentioned
1.4.5 Traineeship

During the traineeship (external training) you apply your knowledge that you acquired in your master’s programme, working at a company or institution. The purpose is to work under circumstances resembling the situation after your graduation as much as possible. Included in this working experience is also the process of finding a position and a short application procedure. The traineeship has a study load of 20 EC and will last at least 14 weeks.

Organization

The following persons and organizations play a role during your external stage:

- The host organization, which is the company or institution where you will carry out the traineeship. The host organization assigns a staff member who will supervise your work.
- The Educational Supervisor is a lecturer of your master’s programme. He/she will monitor the scientific level of your traineeship. The Educational Supervisor should give approval to the traineeship before you make your final appointments with the host organization. After the traineeship, he/she will carry out the final assessment and decide about the mark.
- The traineeship office, which consists of the traineeship coordinator and the mediator. They will supervise the student from the beginning of the searching process finding a position until the end of the traineeship, when the last documents should be archived.

Options for a traineeship

Most students usually find a traineeship position at a company, but also an institution or university is possible. A traineeship can be done everywhere in the world; in Enschede but also in New Zealand or somewhere in between. “The sky is the limit”, unless you manage to find a position with NASA or ESA as an astronaut. The only place on earth definitely out of scope is the UT itself. In all cases, the host institute should provide an assignment that must be approved by the educational supervisor. Approval will only be given if the assignment has sufficient academic level.

How to find a position

One might distinguish three ways to find a host institute:

1. The database of the traineeship office: the office maintains databases containing companies and experience reports. These reports are written by students and describe their experiences during the traineeship.

2. A lecturer in a chair (research group): during research, lecturers often cooperate with companies and institutions that might also be willing to provide a traineeship position.
3. On your own: it is possible and allowed to find a traineeship position on your own. Many companies offer traineeship positions on their websites. Finding a position in this way may not be easy but it may lead to a surprising and rewarding traineeship.

In all cases the traineeship must be approved by a lecturer before you make your final appointments with the host institute. This is described above.

Information sessions
Twice a year information sessions are held about the traineeship, in September and April. You can find them in the rosters of the master’s programmes.

First contact
Make an appointment with the traineeship mediator (stages@ewi.utwente.nl) if you start to think about a traineeship. During this talk, the course of things will be discussed and a planning will be made for the preparation, the traineeship and the completion after return. See your mediator at least six months before you plan go. After this talk, the Blackboard site with training positions will be opened for you.

Web references
Static information: http://www.ewi.utwente.nl/en/education/external_training/
Blackboard site with training position database: http://blackboard.utwente.nl.

Dr. M (Maarten) Korsten (coordinator) Zilverling 1022 and mrs. B. (Belinda) Jaarsma (mediator): Zilverling 1030
1.4.6 Final Project

The final project or master’s thesis assignment is the final proof of the ability of the student to handle more complex problems rather independently within the area of electrical engineering, and to work as a “scientific engineer” on advanced level. The scheme to arrive to a specific assignment, as explained for the individual project, also applies for the master’s thesis assignment.

The assignment is supervised by a committee of at least 3 persons and maximally 5 persons; at least one of them is full professor, also at least one must be member of the permanent scientific staff. It is advised to compose the committee rather broadly, e.g. with persons from other chairs, working on related areas.

1.4.7 Study Abroad

A student is allowed to study 30 credits externally. To gain international experience a student is given the chance to study abroad to another university or institute to follow courses or doing projects. The choice of courses or projects has to be approved by the programme mentor in the same way as the other part of the programme is approved.

Carrying out a traineeship abroad is one way of gaining international experience. In some cases it is possible to carry out the final project abroad under joint supervision, where the lead in supervision will always be taken by the own chair. Our faculty has agreements with partner universities and institutes to accommodate students smoothly. Information about going abroad to partner or non-partner universities/institutes, the procedures and the possibilities of financial support can be given by dr. M. (Maarten) Korsten; room Zilverling 1022, phone 053 489 2763; e-mail m.j.korsten@utwente.nl.

1.4.8 Teaching degree

The institute Elan offers MSc graduates the possibility to specialize as a teacher. For MSc EE this is only possible for the specialization of Teacher in Mathematics and Physics after additional courses. For more information visit the educational programme’s website: http://onderwijs.math.utwente.nl/Onderwijs/Lerarenopleiding.
1.5 Organization

1.5.1 Programme Director

The programme director for Electrical Engineering is dr. ir. W. (Wouter) Olthuis. You can find him in building Carré, room 2409; Phone: 053 489 2688; E-mail: w.olthuis@utwente.nl.

1.5.2 Mentor

Every chair has a mentor. He or she can support you with personal or non personal issues

<table>
<thead>
<tr>
<th>Chair</th>
<th>Mentor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomedical and Environmental Sensorsystems</td>
<td>BIOS Wouter Olthuis</td>
</tr>
<tr>
<td>Biomedical Signals and Systems</td>
<td>BSS Ciska Heida</td>
</tr>
<tr>
<td>Computer Architecture for Embedded Systems</td>
<td>CAES Hans Kerkhoff</td>
</tr>
<tr>
<td>Control Engineering</td>
<td>CE Job van Amerongen</td>
</tr>
<tr>
<td>Design and Analysis of Communication Systems</td>
<td>DACS Pieter Tjerk de Boer</td>
</tr>
<tr>
<td>Integrated Circuit Design</td>
<td>ICD Ronan van der Zee</td>
</tr>
<tr>
<td>Integrated Optical MicroSystems</td>
<td>IOMS Hugo Hoekstra</td>
</tr>
<tr>
<td>Nano Electronics</td>
<td>NE Wilfred van der Wiel</td>
</tr>
<tr>
<td>Signals and Systems</td>
<td>SAS Kees Slump</td>
</tr>
<tr>
<td>Semiconductor Components</td>
<td>SC Cora Salm</td>
</tr>
<tr>
<td>Telecommunication Engineering</td>
<td>TE Chris Roeloffzen</td>
</tr>
<tr>
<td>Transducers Science and Technology</td>
<td>TST Niels Tas</td>
</tr>
<tr>
<td>Part Systems and Materials for Information Storage</td>
<td>TST-SMI Leon Abelmann</td>
</tr>
</tbody>
</table>
1.5.3 Study adviser

The study adviser for Electrical Engineering is T.H. (Thea) de Kluijver, M.A.. If you have any questions about regulations within the faculty or university; if you want to talk about study related issues or private matters that are of influence of your study and/or being you can contact her: room Zilverling 1003; phone: 053 489 3697; E-mail: t.h.dekluijver@utwente.nl

1.5.4 Coordinator International Students

The coordinator for the Electrical Engineering master’s programme for international students is dr. M. (Maarten) Korsten. He can be contacted for any questions about the programme; room: building Zilverling 1022; telephone +31 53 489 2763, e-mail m.j.korsten@utwente.nl
2 Mechatronics
2.1 Mechatronics

Mechatronics involves a synergistic combination of mechanical engineering, electronics and measurement and control in the design of products and processes. It focuses on Mechatronic Design that can be defined as: the integrated and optimal design of a mechanical system and its embedded control system.

By means of an integrated design of the mechanical parts and the measurement and control system, realised in electronic circuits or as an embedded computer programme, mechanical constructions can get a superior performance, lower price and can become more flexible. Well known examples are the audio CD-player and its successors the CD-ROM and DVD as well as many automotive applications, robots, advanced production machines and so on.

To present a coherent package of courses and lab works, this wide application area inevitably means that the programme will consist of specializations in one application area; the possibility to tailor the programme to individual needs is kept open. Research projects can be carried out within the Control Engineering group, the Mathematical Systems and Control Theory group or in the Mechanical Automation and Mechatronics group of the Faculty of EEMCS.

After the academic year 2010-2011 the Mechatronics programme will be continued as a specialization of the master’s programme Systems and Control. Students starting in September 2010 will be offered the choice to finish the Mechatronics master’s programme or to switch to the Mechatronics specialization within the Systems and Control master’s programme.

For information about the programme you can contact dr. M.J. (Maarten) Korsten, building Zilverling room 1022; telephone +31 53 489 2763, e-mail m.j.korsten@utwente.nl

The programme director for Mechatronics is dr.ir. W. (Wouter) Olthuis. You can find him in building Carré, room 2409; Phone: 053 489 2688; E-mail: w.olthuis@utwente.nl.

Programme coordinators of the Master of Science in Mechatronics are:
prof.dr.ir. J. (Job) van Amerongen
prof.dr.ir. B. (Ben) Jonker
prof.dr.ir P.P.L. (Paul) Regtien
prof.dr.ir. A. (Arjan) van der Schaft

For more information about the Master of Science in Mechatronics, please check the website: http://onderwijs.el.utwente.nl/Onderwijs/InternationalMastersEE/Mechatronics
3 Embedded Systems
Embedded systems are hardware/software systems built into devices that are not necessarily “recognized” as computerized devices, but these systems do control the functionality and perceived quality of these devices. Some specific examples of embedded systems include: controllers for the ABS of a car or the operation of its engine; the automatic pilot of an aircraft; the chip set and software within a set-top box for a digital TV; a pacemaker; chips within telecom switching equipment; ambient devices, and control systems embedded in process plants (including its sensors, actuators, control algorithms, filters, etc).

The importance of embedded systems is growing continuously. Exponentially increasing computing power (Moore’s law), ubiquitous connectivity and convergence of technology have resulted in hardware/software systems being embedded within everyday products and places. Already today 90% of computing devices are in Embedded Systems and not in PCs. The growth rate in embedded systems is more than 10% per annum and it is forecasted there will be over 40 billion devices (5 to 10 embedded devices per person on earth) worldwide by 2020. Today 20% of the value of each car is attributed to embedded electronics and this will increase to an average of 35-50% by 2020. Moreover, the value added to the final product by embedded software is often orders of magnitude higher than the cost of the embedded devices themselves.

### 3.1 Goals and Aims of Embedded Systems

The design of embedded systems requires an interdisciplinary approach of both Computer Science as well as Electrical Engineering. The master’s programme Embedded Systems combines expertises from both fields and is also open to students from both bachelor orientations. Four key attributes that we believe are characteristic for the 3TU Master Embedded Systems are: resource boundedness, dependability, systems design approach, and multi-disciplinary.

The most distinguishing characteristic of an embedded system, as opposed to a “normal” ICT system, is that it is embedded in a physical environment that poses constraints on the operation of the system. Characteristic for Embedded Systems is their resource boundedness, where resources can be: cost of devices, chip area, size, response time, energy costs, but also development costs. In embedded systems the designers have to face these resource constraints. Therefore, next to functional specifications they have to deal with non-functional (or extra-functional) properties determined by the application domain.

A second aspect is that embedded systems are often functioning independently and should in their functioning be dependable. Our society has become increasingly dependent on complex, distributed embedded systems. Systems must continually provide
services in the face of harsh environmental conditions, partial system failures or loss of resources, and human errors. People will no longer tolerate products that do not meet a certain level of dependability. Many Embedded Systems have tight cost constraints that make traditional dependability techniques infeasible. Adding additional hardware for fault tolerance mechanisms such as dual or triple modular redundancy often cannot be justified. Moreover, embedded systems are often software intensive. Millions of lines of code in an embedded system are not an exception. The use of embedded systems sometimes requires a software quality that is far better than that of common software (e.g. pacemakers, brake-control components, etc.).

A third aspect is that for the design of embedded systems a systems design approach is required that mixes functional and non-functional requirements right from the start. Embedded Systems can no longer be designed as two separate threads of hardware and software that are merged at a later stage. Central to this approach is the need to understand the interaction of the embedded system with its physical and network environments. This point of view requires engineering teams that possess skills in a wide range of disciplines such as: computer science, electrical engineering, real-time computing, computer architecture, control and signal processing, computer networking, mathematics, etc. Creating these cross-disciplinary skills requires fundamental changes in engineering education. The scientific challenge to the embedded systems engineers is to learn how to successfully integrate these different domains. Systems design is therefore a key characteristic of our embedded systems curriculum.

3.2 General outline

The master’s programme is a two-year programme. The programme is organized in semesters. Each semester contains 20 weeks, and is subdivided in quartiles. The unit of credit is the European Credits (EC). One EC stands for 28 hours of study load. An academic year is 60 EC. The master’s programme is 120 EC
3.3 Master’s programme

The field of Embedded Systems is by definition multi-disciplinary; it consists of cooperation between technical disciplines such as Computer Science, Electrical Engineering, Mechanical Engineering and, possibly non-technical, application domains. Also the different application domains that can be found in infotainment, transport and logistics, health and wellness, security and safety, industrial control systems etc. require a basic understanding of these different domains. Therefore, the Embedded Systems master’s programme should stimulate a multidisciplinary attitude.

Hence, the study programme contains the following components:

- core courses to introduce the student to the design of embedded systems and its most important aspects such as requirement engineering, modelling, architectures, testing and verification. In these courses special attention is paid to the above mentioned aspects of systems design approach, dependability, resource boundedness;
- homologation courses to complement the EE bachelor orientation with CS competences and the CS bachelor orientation with EE competences to create a multi-disciplinary basis for the core programme;
- Elective (sometimes called specialization) course to address certain aspects or applications in more detail;
- Traineeship;
- Final Project.
3.3.1 Specializations

The 3TU Master’s programme Embedded Systems at the three sites is strongly embedded within research groups covering the following topics:

<table>
<thead>
<tr>
<th>TUD</th>
<th>TU/e</th>
<th>UT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel and distributed systems</td>
<td>Formal methods</td>
<td>Pervasive systems</td>
</tr>
<tr>
<td>Software engineering</td>
<td>System analysis and design</td>
<td>Energy efficient systems</td>
</tr>
<tr>
<td>(prof. van Deursen)</td>
<td>(prof. Groote)</td>
<td>(prof. Smit)</td>
</tr>
<tr>
<td>Embedded software</td>
<td>Embedded system design</td>
<td>Embedded control systems</td>
</tr>
<tr>
<td>(prof. Langendoen)</td>
<td>(prof. Corporaal)</td>
<td>(prof. Stramigioli)</td>
</tr>
<tr>
<td>Network architectures and services</td>
<td>System architecture and networking</td>
<td>Dependable (networking) systems</td>
</tr>
<tr>
<td>(prof. Van Mieghem)</td>
<td>(prof. Lukkien)</td>
<td>(prof. Haverkort)</td>
</tr>
<tr>
<td>Wireless and mobile communications</td>
<td>Electronic Systems</td>
<td>Formal methods and tools</td>
</tr>
<tr>
<td>(prof. Niemegeers)</td>
<td>(prof. Otten)</td>
<td>(prof. van de Pol)</td>
</tr>
<tr>
<td>Computer engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(vacancy)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The core courses (25 EC) is a common core for the three sites. Students can add elective courses from the other site and even perform the final project at one of the other sites. Contact the study adviser (sometimes referred to as master’s coordinator) from the site where you want to perform the final project as soon as possible to compose a well-balanced individual student programme.
3.4 Programme guidelines

This paragraph describes the composition of the master's programme in Enschede. The programmes in Delft and Eindhoven have a similar structure. A student registered in Enschede should also receive accounts for Delft and Eindhoven.

3.4.1 Core courses (25 EC)

The courses in the core are considered to represent necessary knowledge and competences for all graduates in Embedded Systems. The core programme is the same at the three sites. The core programme consists of the following courses:

<table>
<thead>
<tr>
<th>TUD Code</th>
<th>TU/e Code</th>
<th>UT Code</th>
<th>Subject</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN4340</td>
<td>TBA</td>
<td>192130240</td>
<td>Embedded Computer Architecture</td>
<td>5</td>
</tr>
<tr>
<td>IN4341</td>
<td>4C390</td>
<td>192130500</td>
<td>Performance Analysis</td>
<td>5</td>
</tr>
<tr>
<td>IN4342</td>
<td>5KK03</td>
<td>201000168</td>
<td>Embedded Systems Laboratory</td>
<td>5</td>
</tr>
<tr>
<td>IN4343</td>
<td>2IN16</td>
<td>192130200</td>
<td>Real-time Systems</td>
<td>5</td>
</tr>
<tr>
<td>IN4387</td>
<td>2IW26</td>
<td>192140122</td>
<td>System Validation</td>
<td>5</td>
</tr>
</tbody>
</table>

Notes:
1. Course Performance Analysis was previously named Quantitative Evaluation of Embedded Systems.
2. Course Embedded Systems Laboratory replaces the course Multi-Disciplinary Design Project (10 EC).
3.4.2 Homologation courses (≤15 EC)

Students who have completed a bachelor’s degree programme in Computer Science from the TUD, TU/e or UT are required to include some subjects in the homologation part of the master’s programme.

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>191560810 (or 191561800)</td>
<td>Signals and Transformation (Signal and Systems)</td>
<td>5</td>
</tr>
<tr>
<td>191210001</td>
<td>Instrumentation of Embedded Systems</td>
<td>5</td>
</tr>
<tr>
<td>and one of the courses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>191210441</td>
<td>Control Theory</td>
<td>5</td>
</tr>
<tr>
<td>191210341</td>
<td>Physical modelling of Embedded Systems</td>
<td>5</td>
</tr>
<tr>
<td>191210590</td>
<td>Embedded Signal Processing</td>
<td>Note: 6</td>
</tr>
</tbody>
</table>

Students who have completed a bachelor’s degree programme in Electrical Engineering from the TUD, TU/e or UT are required to include some subjects in the homologation part of the master’s programme.

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>192110452</td>
<td>Operating systems</td>
<td>5</td>
</tr>
<tr>
<td>192135050</td>
<td>Programming</td>
<td>5</td>
</tr>
<tr>
<td>and one of the courses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>192135201</td>
<td>Formal methods for software engineering</td>
<td>5</td>
</tr>
<tr>
<td>192135100</td>
<td>Software Engineering Models</td>
<td>5</td>
</tr>
<tr>
<td>192112051</td>
<td>Functional Programming</td>
<td>5</td>
</tr>
<tr>
<td>191211090</td>
<td>Real time software Development</td>
<td>5</td>
</tr>
</tbody>
</table>

Students who have completed a polytechnic programme (HBO) of Computer Science or Electrical Engineering taking the pre-master’s programme for polytechnic graduates are required to include some subjects as homologation subjects in the master’s degree programme. For students that completed successfully the pre-master (hbo-bachelors) an individual homologation programme is made upon instruction of the programme mentor. If a homologation course is included in the bachelor’s programme it is replaced with an elective course.
3.4.3 Elective courses (≥15 EC)

A list of elective courses is on the website of the master’s programme, see: [http://onderwijs.cs.utwente.nl/Studenten/Masters/EmbeddedSystems/index.html](http://onderwijs.cs.utwente.nl/Studenten/Masters/EmbeddedSystems/index.html).
The student may also select elective courses from the embedded systems programme from the TUD and TU/e.

Furthermore the 3TU is offering six courses by telefacility:

<table>
<thead>
<tr>
<th>Site</th>
<th>Code</th>
<th>Subject</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>UT</td>
<td>192130250</td>
<td>Embedded Computer Architectures 2</td>
<td>5</td>
</tr>
<tr>
<td>UT</td>
<td>191211090</td>
<td>Real-Time Software Development</td>
<td>5</td>
</tr>
<tr>
<td>TUD</td>
<td>ET4170</td>
<td>Computer Arithmetic</td>
<td>5</td>
</tr>
<tr>
<td>TUD</td>
<td>SC4081</td>
<td>Knowledge Based Control Systems</td>
<td>Note: 4</td>
</tr>
<tr>
<td>TU/e</td>
<td>2IW15</td>
<td>Automated Reasoning</td>
<td>5</td>
</tr>
<tr>
<td>TU/e</td>
<td>SKK80</td>
<td>Multiprocessors</td>
<td>5</td>
</tr>
</tbody>
</table>
3.4.4 Traineeship (20 EC)

If a traineeship was part of the bachelor’s programme than a traineeship is not included in the individual student programme. Therefore students with a polytechnic bachelor do not have a traineeship. Instead they have elective courses. For the other students the traineeship is strongly recommended.

During the traineeship (external training) you apply your knowledge that you acquired in your master’s programme, working at a company or institution. The purpose is to work under circumstances, resembling the situation after your graduation as much as possible. Included in this working experience is also the process of finding a position and a short application procedure. The traineeship has a study load of 20 EC and will last at least 14 weeks.

Organization
The following persons and organizations play a role during your external stage:

- The host organization, which is the company or institution where you will carry out the traineeship. The host organization assigns a staff member who will supervise your work;
- The Educational Supervisor is a lecturer of your master’s programme. He/she will monitor the scientific level of your traineeship. The Educational Supervisor should give approval to the traineeship before you make your final appointments with the host organization. After the traineeship, he/she will carry out the final assessment and decide about the mark;
- The traineeship office. The office consists of the traineeship coordinator and the mediator. They will supervise the student from the beginning of the searching process finding a position until the end of the traineeship, when the last documents should be archived.

Options for a traineeship
Many students will find a traineeship position at a company, but also an institution or university is possible. Traineeship can be done everywhere in the world; in Enschede but also in New Zealand or somewhere in between. “The sky is the limit”, unless you manage to find a position with NASA or ESA as an astronaut. The only place on earth definitely out of scope is the UT itself. In all cases, the host institute should provide an assignment that must be approved by the educational supervisor. Approval will only be given if the assignment has sufficient academic level.
How to find a position
One might distinguish three ways to find a host institute:
The database of the traineeship office: the office maintains databases containing
companies and experience reports. These reports are written by students and describe
their experiences during the traineeship; A lecturer in a chair (research group): during
research, lecturers often cooperate with companies and institutions that might also be
willing to provide a traineeship position; On your own: it is possible and allowed to find
a traineeship position on your own. Many companies offer traineeship positions on their
websites. Finding a position in this way may not be easy but it may lead to a surprising and
rewarding traineeship. In all cases the traineeship must be approved by a lecturer before
you make your final appointments with the host institute. This is described above.

Information sessions
Twice a year information sessions are held about the traineeship, in September and April.
You can find them in the rosters of the master’s programmes.

Starting talk
Make an appointment with the traineeship mediator (stages@ewi.utwente.nl) if you start
to think about a traineeship. During this talk, the course of things will be discussed and a
planning will be made for the preparation, the traineeship and the completion after return.
See your mediator at least six months before you plan go. After this talk, the Blackboard
site with training positions will be opened for you.

Web references
Static information: http://www.ewi.utwente.nl/en/education/external_training/
Blackboard site with training position database: http://blackboard.utwente.nl.

Dr. M. (Maarten Korsten) (coordinator) Zilverling 1022 and mrs. B. (Belinda) Jaarsma
(mediator): Zilverling 1030
# 3.4.5 Final Project (40 EC)

The final project or graduation work consists of an individual project (191211749) of 10 credits and a final project (192199978) of 30 credits.

**Final project**
The final– or graduation project is performed under the supervision of one of the chairs CAES, CE, DACS, FMT, ICD, PS or SAS (or an embedded systems chair from the TUD or TU/e). The final project often contributes to ongoing research. The website of the chairs can be used to orientate on the research themes.

**Some procedural aspects:**
- Contact the chair of your choice approximately three month before your desired start date of the graduation project;
- The student may only start the graduation project if at least 70 EC of the master's courses have been obtained;
- At least two EWI staff members should be in the graduation committee;
- A month after the start of the final project a final project description, signed by the first supervisor, should be handed over to Educational Office;
- A month before the end of the final project presentation the first supervisor should report this to the Educational Office (the so called “green light”). The educational Office will also inform the Board of Examiners.

# 3.4.6 Pre-master

The pre-master's programme for students with a polytechnic bachelor (Computer Science, Electrical Engineering, or similar) is:

<table>
<thead>
<tr>
<th>Quartile</th>
<th>Code</th>
<th>Subject</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>191512000</td>
<td>Calculus A</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>191512060</td>
<td>Lineaire Algebra A</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>191512020</td>
<td>Calculus B</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>191512040</td>
<td>Calculus C</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>191231401</td>
<td>Inleiding Systeem- en Signaaltheorie</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>191512080</td>
<td>Lineaire Algebra B</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>191210001</td>
<td>Instrumentatie van Embedded Systems</td>
<td>5</td>
</tr>
</tbody>
</table>
3.4.7 Individual programme

The individual student programme (ISP) needs to be approved, on behalf of the board of examiners, by the study adviser. Contact the study adviser in the first quarter of the master. An ISP should have at least 120 EC and it should be a coherent programme.

3.5 Organization

3.5.1 Programme Director

The programme director of ES is prof.dr.ir. G.J.M. (Gerard) Smit. You can find him in building Zilverling, room 4057; Phone: 053 489 3734; E-mail: g.j.m.smit@utwente.nl.

3.5.2 Programme Mentor

The programme mentor of ES is ir. E. (Bert) Molenkamp. You can find him in building Zilverling, room 4052; Phone: 053 489 3704; E-mail: e.molenkamp@utwente.nl.
3.5.3 Study Adviser

The study adviser for ES students is T.H. (Thea) de Kluijver, MA. If you have any questions about the regulations within the programme, or if you want to talk about study related issues, you can contact her. Building Zilverling, room 1003; Phone: 053 489 3697; E-mail: t.h.dekluijver@utwente.nl

3.5.4 HBO coordinator

The HBO coordinator of ES is dr. M.J. (Maarten) Korsten. He can be contacted for any questions about the programme; room: building Zilverling 1022; Phone +31 53 489 2763, e-mail m.j.korsten@utwente.nl

3.5.5 Internationalisation coordinator

The internationalisation coordinator of ES is drs. J (Jan) Schut. You can find him in building Zilverling, room A108; Phone +31 53 489 4350; E-mail: j.schut@utwente.nl
4 Systems and Control
The two-year Master of Science programme Systems and Control (SC) is aimed at students with a technical Bachelor of Science background interested in analysis and control of dynamic systems in their widest sense.

### 4.1 Goals and aims of Systems and Control

The Master of Science in Systems and Control theory is driven by practical problems and concrete applications. The major aim is to develop methods and tools that are applicable not only to the specific application but to a wide range of similar problems. At the same time there is a strong interest in applying general theoretic results to specific technological problems.

Control problems have been around for a long time. With the rise of automated manufacturing in the nineteenth century, control mechanisms gained in importance. Watt’s fly-ball governor, a device that controls the steam pressure, meant a breakthrough and directly contributed to the industrial revolution. Up to this day the manufacturing of servo mechanisms plays an important part in mechanical engineering (e.g. in robot technology.) Within the electrical engineering community the need for a theoretical underpinning of the behavior of interconnected components arose through questions like: how may we mathematically model a (complicated) electrical circuit, and conversely, given a mathematical model, how may we implement it as an electrical device. Once mathematically formulated, it was found that the above problems of mechanical en electrical engineering had much in common and that in fact they belong to a single area, an area that nowadays is called ‘systems and control’. The mathematics of systems and control involve analytical as well as algebraic notions, possibly because “change over time” and “relation between quantities” both are central in systems and control problems.

In the past thirty years systems and control has experienced a strong development. Applications no longer are restricted to electrical, mechanical and chemical engineering. In econometrics and time series analysis methods of system theory are used, controllers are designed to influence fermentation processes, and filters to estimate car densities on high ways are being developed. Furthermore, due to the impact of computer science, new control problems have emerged on the interface between control and informatics. The mathematical disciplines explored by system theoreticians have diversified. They range from Hilbert spaces to Bezout domains, from analytical functions to probability measures and from Lie groups to Petri nets.
Research themes:
• Robust Control. The design of controllers for uncertain systems.
• Adaptive Control. The design of controllers with the ability to adapt to gradual or sudden changes in the system to be controlled.
• Hybrid Systems. Systems with both time driven and event driven dynamics.
• Optimal Control. The design of controllers that minimize a performance index.
• Signal Processing.
• Saturated control. The design of controllers under input constraints.
• Infinite dimensional systems and control. Modeling and control of systems described by partial differential equations and systems with delays.
• Modeling. The study of methods and frameworks, a modeling paradigm, for dynamical systems in the widest sense

4.2 General outline

The two-year MSc programme in Systems and Control is aimed at students with a technical BSc background interested in analysis and control of dynamic systems in their widest sense. The programme addresses both fundamental and application-specific features, emphasizing the multidisciplinary character of the field. It gives attention to applications in mechanical engineering, electrical engineering, applied physics, chemical and aerospace engineering.

Students with a bachelor in Technical Mathematics are automatically admitted. The programme is flexible through the large number of elective courses and through the research oriented courses. Participating chairs: MSCT, SST (both within Applied Mathematics), CE (Electrical Engineering) and Mechanical Automation and Mechatronics (Mechanical Engineering). Depending on the chair, focus is on both fundamentals and applications in:

• biomedical engineering;
• robotics;
• precision equipment;
• MEMS (mechanical electronic micro systems);
• hybrid systems.

Expertise centers around general mathematical systems theory, robust control, infinite dimensional systems, hybrid systems, learning and adaptive control systems and modelling of physical systems with applications in such domains as mechatronics, robotics, machine dynamics, signal processing, embedded control systems and computer science. It is also possible to follow lectures in Eindhoven and Delft. For further information, please contact J.W. Polderman (programme director), see paragraph 4.5.1 of this chapter.
4.3 Master’s programme

The master’s programme is a two-year programme. The programme is organized in semesters. Each semester contains 20 weeks, and is subdivided in quartiles. The unit of credit is the European Credits (EU). One EC stands for 28 hours of study-load. An academic year is 60 EC. The master’s programme is 120 EC.

<table>
<thead>
<tr>
<th>EC</th>
<th>activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Introduction Project</td>
</tr>
<tr>
<td>20</td>
<td>Compulsory Courses: Modelling, Control and Identification; and Integration Project</td>
</tr>
<tr>
<td>27</td>
<td>Elective Courses</td>
</tr>
<tr>
<td>10</td>
<td>Research Oriented Courses specific to profile</td>
</tr>
<tr>
<td>20</td>
<td>Practical training (traineeship)</td>
</tr>
<tr>
<td>40</td>
<td>Graduation Project</td>
</tr>
</tbody>
</table>

The programme has two specializations:

4.3.1 Robotics and Mechatronics

This specialization is the continuation of the successful MSc programme “Mechatronics”. The research is more and more in the field of advanced robotics, including robotics in medical applications.

4.3.2 Control Theory

Systems theory is concerned with problems related to dynamic phenomena in interaction with their environment. These problems include:

- Modeling. Obtaining a mathematical model that reflects the main features. A mathematical model may be represented by difference or differential equations, but also by inequalities, algebraic equations, and logical constraints.
- Analysis and simulation of the mathematical model.
- Prediction and estimation.
- Control. By choosing inputs or, more general, by imposing additional constraints on some of the variables, the system may be influenced so as to obtain certain desired behavior. Feedback is an important example of control.
### 4.4 Programme guidelines

The programme consists of homologation courses, compulsory courses and elective courses.

#### 4.4.1 Homologation courses

These are courses to provide students with different backgrounds with the knowledge needed to fully appreciate the interdisciplinary programme of Systems and Control. The homologation programme is an individual programme, to be decided by the programme coordinator, together with the student. Typical examples of homologation courses for students in the mechatronics and robotics specialization are:

<table>
<thead>
<tr>
<th>course code</th>
<th>title</th>
<th>EC's</th>
</tr>
</thead>
<tbody>
<tr>
<td>191560810</td>
<td>Signals and Transformations</td>
<td>5</td>
</tr>
<tr>
<td>191210001</td>
<td>Instrumentation of embedded systems</td>
<td>5</td>
</tr>
<tr>
<td>191210430</td>
<td>Dynamic Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

For students with a mechanical engineering background, these courses are:

<table>
<thead>
<tr>
<th>course code</th>
<th>title</th>
<th>EC's</th>
</tr>
</thead>
<tbody>
<tr>
<td>191157001</td>
<td>Statics</td>
<td>2</td>
</tr>
<tr>
<td>113136</td>
<td>Design Methods</td>
<td>5</td>
</tr>
<tr>
<td>19115714</td>
<td>Dynamics 2</td>
<td>3.5</td>
</tr>
<tr>
<td>19115711</td>
<td>Introduction to the Finite Element Methods</td>
<td>5</td>
</tr>
</tbody>
</table>
4.4.2 Compulsory courses

The Systems and Control master’s programme has the following compulsory courses:

<table>
<thead>
<tr>
<th>course code</th>
<th>Course name</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>200900013</td>
<td>Introduction project</td>
<td>3</td>
</tr>
<tr>
<td>191211110</td>
<td>Modelling: Modelling and Simulation or</td>
<td>5</td>
</tr>
<tr>
<td>191211100</td>
<td>Mechatronic Design of Motion Systems</td>
<td>5</td>
</tr>
<tr>
<td>191571090</td>
<td>Time series analysis</td>
<td>5</td>
</tr>
<tr>
<td>191210770</td>
<td>Control: digital control engineering (optimal control I)</td>
<td>5</td>
</tr>
<tr>
<td>200900012</td>
<td>Integration project</td>
<td>5</td>
</tr>
</tbody>
</table>

4.4.3 Elective courses (recommended)

The Systems and Control master’s programme recommends the following elective courses:

<table>
<thead>
<tr>
<th>course code</th>
<th>Course name</th>
<th>EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>191560671</td>
<td>Robust Control</td>
<td>5</td>
</tr>
<tr>
<td>191561620</td>
<td>Optimal Control</td>
<td>5</td>
</tr>
<tr>
<td>191211060</td>
<td>Modern Robotics</td>
<td>5</td>
</tr>
<tr>
<td>191211110</td>
<td>Modelling and simulation</td>
<td>5</td>
</tr>
<tr>
<td>191131700</td>
<td>System identification and parameter estimation</td>
<td>5</td>
</tr>
<tr>
<td>191210760</td>
<td>Advanced Programming</td>
<td>5</td>
</tr>
<tr>
<td>191211080</td>
<td>Systems Engineering</td>
<td>5</td>
</tr>
<tr>
<td>191211090</td>
<td>Real-Time Software Development</td>
<td>5</td>
</tr>
<tr>
<td>191211100</td>
<td>Mechatronic Design of Motion Systems</td>
<td>5</td>
</tr>
<tr>
<td>191561750</td>
<td>Infinite Dimensional Linear Systems</td>
<td>6</td>
</tr>
<tr>
<td>191561680</td>
<td>Nonlinear control</td>
<td>5</td>
</tr>
<tr>
<td>191571200</td>
<td>Hybrid Dynamical Systems</td>
<td>5</td>
</tr>
<tr>
<td>192140122</td>
<td>System Validation</td>
<td>5</td>
</tr>
<tr>
<td>191211070</td>
<td>Intelligent Control</td>
<td>5</td>
</tr>
<tr>
<td>191571501</td>
<td>Stochastic Differential Equations</td>
<td>6</td>
</tr>
<tr>
<td>191571160</td>
<td>Stochastic Filtering and Control</td>
<td>5</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credit</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>191131720</td>
<td>Advanced motion and vibration control</td>
<td>5</td>
</tr>
<tr>
<td>191131730</td>
<td>Dynamics of machines</td>
<td>5</td>
</tr>
<tr>
<td>191131360</td>
<td>Design Principles for precision mech.</td>
<td>5</td>
</tr>
<tr>
<td>191210930</td>
<td>Measurement Systems for Mechatronics</td>
<td>5</td>
</tr>
<tr>
<td>191157740</td>
<td>Advanced Dynamics</td>
<td>5</td>
</tr>
<tr>
<td>191210920</td>
<td>Optimal Estimation in Dynamic Systems</td>
<td>5</td>
</tr>
<tr>
<td>191561560</td>
<td>Systems and Control</td>
<td>6</td>
</tr>
<tr>
<td>191157170</td>
<td>Statics</td>
<td>2</td>
</tr>
<tr>
<td>191157140</td>
<td>Dynamics 2</td>
<td>3.5</td>
</tr>
<tr>
<td>191157110</td>
<td>Introduction to the Finite Element Method</td>
<td>5</td>
</tr>
<tr>
<td>196700120</td>
<td>Dynamical Systems</td>
<td>5</td>
</tr>
<tr>
<td>191210001</td>
<td>Instrumentation for embedded systems</td>
<td>5</td>
</tr>
<tr>
<td>191210430</td>
<td>Engineering System Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>191157150</td>
<td>Mechanics of Materials 2</td>
<td>3.5</td>
</tr>
</tbody>
</table>
4.4.4 Traineeship

During the traineeship (external training) you apply your knowledge that you acquired in your master’s programme, working at a company or institution. The purpose is to work under circumstances, resembling the situation after your graduation as much as possible. Included in this working experience is also the process of finding a position and a short application procedure. The traineeship has a study load of 20 EC and will last at least 14 weeks.

Organization
The following persons and organizations play a role during your external stage:
- The host organization, which is the company or institution where you will carry out the traineeship. The host organization assigns a staff member who will supervise your work.
- The Educational Supervisor is a lecturer of your master’s programme. He/she will monitor the scientific level of your traineeship. The Educational Supervisor should give approval to the traineeship before you make your final appointments with the host organization. After the traineeship, he/she will carry out the final assessment and decide about the mark.
- The traineeship office. The office consists of the traineeship coordinator and the mediator. They will supervise the student from the beginning of the searching process finding a position until the end of the traineeship, when the last documents should be archived.

Options for a traineeship
Many students will find a traineeship position at a company, but also an institution or university is possible. Traineeship can be done everywhere in the world, in Enschede but also in New Zealand or somewhere in between. “The sky is the limit”, unless you manage to find a position with NASA or ESA as an astronaut. The only place on earth definitely out of scope is the UT itself. In all cases, the host institute should provide an assignment that must be approved by the educational supervisor. Approval will only be given if the assignment has sufficient academic level.

How to find a position
One might distinguish three ways to find a host institute:
1. The database of the traineeship office: the office maintains databases containing companies and experience reports. These reports are written by students and describe their experiences during the traineeship.
2. A lecturer in a chair (research group): during research, lecturers often cooperate with companies and institutions that might also be willing to provide a traineeship position.
3. On your own: it is possible and allowed to find a traineeship position on your own. Many companies offer traineeship positions on their websites. Finding a position in this way may not be easy but it may lead to a surprising and rewarding traineeship.

In all cases the traineeship must be approved by a lecturer before you make your final appointments with the host institute. This is described above.

Information sessions
Twice a year information sessions are held about the traineeship, in September and April. You can find them in the rosters of the master’s programmes.

First contact
Make an appointment with the traineeship mediator (stages@ewi.utwente.nl) if you start to think about a traineeship. During this talk, the course of things will be discussed and a planning will be made for the preparation, the traineeship and the completion after return. See your mediator at least six months before you plan go. After this talk, the Blackboard site with training positions will be opened for you.

Web references
Static information: http://www.ewi.utwente.nl/en/education/external_training/
Blackboard site with training position database: http://blackboard.utwente.nl.

Contact
dr. M. (Maarten) Korsten (coordinator) Zilverling 1022 and mrs. B. (Belinda) Jaarsma (mediator): Zilverling 1030
4.4.5 Final Project

The final project or master’s thesis assignment is the final proof of the ability of the student to handle more complex problems rather independently within the area of electrical engineering, and to work as a “scientific engineer” on advanced level. The scheme to arrive to a specific assignment, as explained for the Individual project, also applies for the master’s thesis assignment.

The assignment is supervised by a committee of at least 3 persons and maximally 5 persons; at least one of them is full professor, also at least one must be member of the permanent scientific staff. It is advised to compose the committee rather broadly, e.g. with persons from other chairs, working on related areas.

4.4.6 Study Abroad

A student is allowed to study 30 credits externally. To gain international experience a student is given the chance to study abroad to another university or institute to follow courses or doing projects. The choice of courses or projects has to be approved by the programme mentor in the same way as the other part of the programme is approved.

Carrying out a traineeship abroad is one way of gaining international experience. In some cases it is possible to carry out the final project abroad under joint supervision, where the lead in supervision will always be taken by the own chair. Our faculty has agreements with partner universities and institutes to accommodate students smoothly. Information about going abroad to partner or non-partner universities/institutes, the procedures and the possibilities of financial support can be given by the coordinator of internationalization: Drs. J. (Jan) Schut.

Room: Zilverling A-108 Phone: 053 489 4350; E-mail: j.schut@utwente.nl

4.4.7 Teaching degree

The institute Elan offers MSc graduates the possibility to specialize as a teacher. For MSc S&C is this only possible for the specialization of Teacher in Mathematics and Physics after additional courses. For more information visit the educational programme’s website: http://onderwijs.math.utwente.nl/Onderwijs/Lerarenopleiding.
4.5 Organization

4.5.1 Programme director

The programme director is dr. J.W. (Jan Willem) Polderman; room Citadel H213; phone: 053 489 3438; E-mail: j.w.polderman@utwente.nl

4.5.2 Programme coordinator

The programme coordinator is prof.dr.ir. J. (Job) van Amerongen; room Carré 3605; phone: 053 489 2791; E-mail: j.vanamerongen@utwente.nl

4.5.3 Coordinator international students

The coordinator for the master’s programmes of EEMCS for foreign students is drs. J. (Jan) Schut. He can be contacted for any questions about the programme, room Zi A-108; phone 053 489 4350, e-mail j.schut@utwente.nl

4.5.4 Study adviser

The study adviser for Systems and Control is T.H. (Thea) de Kluijver, M.A.. If you have any questions about regulations within the faculty or university; if you want to talk about study related issues or private matters that are of influence of your study and/or being you can contact her: room Zilverling 1003; phone: 053 489 3697; E-mail: t.h.dekluijver@utwente.nl
5 Chairs
5.1 Biomedical and Environmental Sensorsystems (BIOS)

“We want to make a Lab-in-a-Cell using nanotechnology”: during the past decade we have spent a lot of effort to develop Labs-on-a-Chip. This has resulted in enormous advancements in knowledge of micro- and nanofluidic phenomena and application thereof in clinical applications. Recently, we are trying to use single living cells to do experiments on a chip, using a combination of new micro- and nanotechnologies.

Part of the work in our group is devoted to trying to understand phenomena in micro- and nanofluidic devices. We have for instance developed advanced techniques to transport fluids in micro- and nanochannels using electrical fields, and are now investigating similar electrophoretic effects to analyse DNA molecules in nanochannels using electrical fields. In another project, we try to fabricate nanowires for extremely sensitive detection of DNA for early cancer diagnostics. The idea is to ultimately implement these nanowires in a pill, that will sense cancer-specific, hypermethylated DNA in the intestines, as early warning for intestinal cancer. Earlier efforts devoted at measuring lithium (an important drug used by manic-depressive patients) has resulted in a chip that is now being commercialized by the start-up company Medimate for Point-of-Care application. All the above examples share in common that they use micro/nanofluidic devices and electrical manipulation and/or detection techniques to measure biofluids such as saliva or blood. Recently, we have extended the ideas about Lab-on-a-Chip towards using a single living cell as experimentation platform, or, to make a “Lab-in-a-Cell”. Using very short electrical pulses we have been able to bring DNA material into a single (stem) cell, which resulted in a change of the genetic properties of that particular cell. Such research is extremely important for so-called reprogramming of stem cells, so that they can be used for tissue-engineering purposes such as e.g. cure after heart attacks. The crucial aspect is here that we are able to manipulate and localize single cells and treat them with electrical methods.

In a related project, in collaboration with the biotech company Modiquest, we are investigating the fusion of individual cells for highly efficient production of drugs. Using micro- and nanotechnology and electrical techniques we can obtain a much higher control of parameters and thus a much
higher yield of the electrofusion process. For students in our group it is important that they have a solid background in electrical engineering and micro/nanotechnology, but also have an open mind to multidisciplinary research, and are willing e.g. to investigate clinical application or train themselves in biology.

prof.dr.ir. Albert van den Berg
5.2 Biomedical Signals and Systems (BSS)

‘Supporting the human body with signals’

Neural engineering is directed to the support of human body functions by exchange of information in the form of signals. Electrical stimulation of the brain is clinically used to improve motor function in Parkinson’s patients, the vagal nerve is stimulated to suppress epilepsy and the spinal cord and cortex of the brain are stimulated to suppress pain. These examples of neuromodulation techniques have in common that they are extensively used in the clinic although the mechanisms are still unknown.

We try to understand these mechanisms and improve the neurostimulation methods based on the knowledge about the physical mechanisms of neural excitation by electrical stimulation and the dynamics of the central nervous system. This is a challenging multidisciplinary field of research in which engineers, neuroscientists, neurologists and neurosurgeons closely cooperate. International neurostimulation companies are highly involved and have great interest in our research, so has the clinical community.

Key issues in neurostimulation research include increasing our understanding of brain functioning, and the influence and selectivity of electrical stimulation on the closed-loop interactions of the neural system. These issues are addressed both fundamentally in cultured neural networks grown on multi-electrode arrays produced in the clean room, as well as in actual clinical applications. Selectivity of stimulation is crucial for optimal interaction with the neural system: it can make the difference between improved motor control and the induction of, for example, depression in Parkinson’s patients. Knowledge of local neuroanatomy, volume conduction characteristics and neural excitation dynamics is essential for designing selective neurostimulation interfaces. Neurophysiology and neuroscience expertise is indispensible in understanding the brain. This is why having a part-time neurophysiology professor is essential for our group. But also the engineering systems approach is crucial for understanding the brain and the way it controls body functions in a closed-loop manner. Finally, we try to understand how the supply of information to the neural system based on sensory signals measured from the body influences the physiological functions we want to support. Crucial is to realize that we connect a dynamic signalling system to a physiological function that is closed-loop controlled by the brain. We should realize that we do not take over the function, but only support it by intelligent signalling. Our support system should be designed such that the total system, including our support by neurostimulation, should perform optimally.
Finally, we realize that these implanted neurostimulation systems will become more intelligent and are part of the human body. This requires a completely new way of medical treatment: first of all, the intelligent medical system in or on the body of the patient provides a constant medical support that adapts to circumstances automatically, providing both constant monitoring and treatment. In addition, this intelligent support system will be under clinical supervision via telecommunication means. Medical treatment is not anymore provided solely in the hospital. For this reason, we investigate and develop such new telemonitoring and treatment modalities.

prof. dr. ir. Peter Veltink

http://bss.ewi.utwente.nl/
5.3 Computer Architecture for Embedded Systems (CAES)

‘Energy efficient architectures’: our mission is to perform research on energy-efficient dependable architectures for networked embedded systems, by combining efficient computer architectures, systems software, networking, and tools.

Energy-efficiency is important for streaming applications found in battery powered mobile devices (e.g. PDAs and portable multimedia players) but also in high-performance computers. The research on energy efficient architectures focuses on reconfigurable processors for streaming applications. In cooperation with Recore Systems, a spin-off company of our group, we developed an energy efficient reconfigurable architecture called the Montium®. In real life the Montium is a Chameleon, a reptile that adapts to its environment, also our Montium adapts to its environment. In cooperation with Atmel, specialist in design and manufacture of advanced semiconductors, a reconfigurable multi-processor System-on-Chip (MPSoC) called the Annabelle is produced that contains 4 reconfigurable Montium tiles in CMOS technology (2 mm² per Montium).

An interesting high-performance streaming application is medical image processing. For example: a doctor wants in real time X-ray images of the patient during surgery. Also signal processing for phased array antennas (for radar and radio astronomy) is part of our research. In MPSoC systems for streaming applications dependability (i.e. availability, reliability, integrity and maintainability) techniques play an important role. One of the problems in manufacturing a MPSoC with millions of transistors using deep-submicron technologies (90 nm and below), is an increase in the probability of defects in silicon, which results in decreasing manufacturing yield. We develop methods to deal effectively with the increased defect density for fault detection, localization, and fault tolerant architectures implemented on-chip. Not only mobile devices can profit from energy efficient solutions. In cooperation with E.ON, Essent and HOMA software, we work on the successor of the classic (high-efficiency) boiler in your home: the Micro Combined Heat and Power System (microCHP). The microCHP produces heat but also electricity, that can be used during peak load or during power outage. Due to the reduced peak load energy is generated more efficiently. We concentrate on the peak load reduction within a single household, scheduling a fleet of microCHPs and islanded operation in case of power outage.

prof.dr.ir. G.J.M. Smit
5.4 Control Engineering (CE)

The research of Control Engineering is carried out in the Institutes IMPACT, CTIT and MIRA. Control Engineering participates in the national research school DISC (Dutch Institute of Systems and Control). The research of the group tries to develop new concepts and theories for real relevant robotics applications.

The three main pillars of application within robotics are service/home, medical and humanoid robotics. A real mechatronic approach is used which combines and integrates modeling, control, embedded software and new design concepts to achieve real working applications. We see mechatronics as a synergistic approach to the integrated and optimal design of a mechanical system and its embedded control system, where solutions are sought that cross the borders of the different domains. The research of the group covers the whole design trajectory of a (mechatronic) system, starting with modelling of the physical system followed by the design of an (intelligent) controlled system and realization of the controller in an embedded computer system. The concept of ports for interconnecting (parts of) models and controllers and pieces of software is a common factor in these research activities. The group has a unique name for the development of new concepts and applications using ports based methods like bond graphs and port-Hamiltonian systems for real systems. Various types of robotics applications will become more important in the coming years. Example of running projects are robots for pipe inspection of the low pressure gas network, surgical robots, automatic cleaning robots, walking machines, intelligent prosthetic devices, robot hands and more.

Where possible we cooperate with industrial partners. Results of research by PhD and MSc students also find their way into tools for mechatronic and robotics design. Due to the cooperation with our spin-off company Controllab Products these results become globally available after some time, mostly in the form of extensions of the mechatronic design programme 20-sim. The group is also one of the initiators of the LEO Center for Service Robotics which tries to better coordinate and enforce robotic related activities in Twente in order to strive for word excellence in the field.

prof. dr. ir. S. Stramigioli

http://www.ce.utwente.nl/
5.5 Design and Analysis of Communication Systems (DACS)

‘Avoid the rain’: one of the first things I’ll do every morning, is to go to the living room and take a look at the screen of my Apple notebook. This screen not only gives the latest news, but also shows the radar pictures that predict whether and where rain will fall within the next few hours. Depending on these pictures, the decision is made whether I’ll go by bike, or by car to the UT.

Next to me, there are everyday millions of users worldwide that depend on infrastructures like the Internet and GSM/UMTS networks for making decisions. Although these infrastructures are continuously getting faster, the key challenge however is to make these infrastructures more reliable. The Design and Analysis of Communication Systems (DACS) group therefore focuses on dependable networked systems. Research and education within DACS covers the whole spectrum of network technologies: from well-established technologies (like the wired Internet), via technologies that are under development (such as wireless networks) to emerging technologies (like embedded network systems).

In the case of well-established technologies, research concentrates on operational aspects, here, in particular, of the wired Internet. Specific topics include bandwidth allocation, accounting, self-management of lambda switches and protection against scans, denial-of-service attacks and phishing. Taking and interpreting measurements plays an important role in this research. For technologies under development, research focuses on the design, evaluation, and prototype implementation of new protocols and algorithms for wireless and ad-hoc networks. Topics include algorithms for context- and power-aware routing in ad-hoc networks, and, lately, more and more on car-to-car communications and wireless sensor networks. The research on embedded networking technologies focuses on system specification and evaluation techniques to describe such systems, and the resource con-straints (performance, dependability, energy usage) they have to operate under. This includes the development of new stochastic model checking techniques and the application thereof to predict dependability and performance properties. Such models are applied, for example, to analyse control networks for critical infrastructures, such as the water and electricity networks. Whenever possible, within DACS M.Sc. projects are part of bigger projects, facilitating close collaboration between M.Sc. and Ph.D. students. In the past this has resulted into several joint papers by M.Sc. and Ph.D. students, and presentations of these papers by M.Sc. students at international conferences.

dr. ir. Aiko Pras
5.6 Integrated Circuit Design (ICD)

‘Omnipresent yet invisible’ Walk around. Observe everything. Pay attention to all those remarkable little and big things. Amaze yourself with all those utilities, appliances, gadgets and machines around, all operating flawlessly, many of them communicating with others or just communicating inside themselves in some – for most of us – mysterious way. It seems like a fact of life that almost every sensible thing we use has a battery or a mains outlet plug, and that its functionality increases with time.

Imagine that all those appliances and thing that come with a battery or main cord fail to work. Maybe due to some power failure, maybe just because they’re on strike. Just try to imagine what still works. That’s not so much.

No cars that were build in the past 20 years would run, and even those would run for as long there’s fuel in the car. No radios, no lights, no TV, no automatic doors, no phone, no cell phone, no remote control, no fridge nor microwave, no mp3 player, no heating, no internet... hardly anything would be operational anymore. And that’s basically because most of the things that we use and see are packed with electronic systems. Electronic systems that add functionality, nicely compensate for non-idealities, control everything, protect things and send and receive data. Most of these electronic systems are largely invisible for most people, but are present in and around almost everything we use.

The evolution of electronic systems goes quite rapidly. Every year the processing power of electronics and its storage capabilities increase significantly, see for example the evolution in PCs or in cell phone features. At the same time communication capabilities increase, most notably in WLAN, and again in cell phones. Digital receivers emerge for radio and video, electronics are used to control cars, control and secure access, are required for novel energy saving lighting... there’s no end to it. Every year more electronic functionality occurs in more and more items; this increased functionality is due to being able to pack more and more components on one IC – currently up to about 500 million completely functional components – and is due to smarter electronic circuit and system design. This evolution in electronic systems is the playing field of one of the largest industries on this planet: the electronics industry.

At the IC-Design group the research focuses on the evolution in integrated electronics, and as such we have many contacts and research contracts with major (European, American and Asian) players in the electronics industry. The ICD research aims at creating technological breakthroughs in electronic circuit and system design that lead to higher performance, more functionality and lower power consumption, or just lead to new possibilities and new applications. In this creative process, we strive to find fundamental solutions that are widely applicable. Our approach requires a solid theoretical back
ground, good analytical skills, and last but not least creativity: all spear points in the education and research programme at ICD. Within the wide field of integrated electronics, the playing field of ICD is mainly in the mainstream integrated electronics technology: standard CMOS. Our research field ranges from small analog and digital circuits through complex mixed-signal systems like analog-digital converters and RF-frontend circuits to high level electronic system design. In all these the signal frequencies may range from DC to several GHz, spanning almost all relevant circuits and systems in mainstream IC-technologies. Examples of these include wireless radio circuits and systems, AD/DA converters, frequency synthesizers, noise reduction, accurate references, high speed fiber-optic interfaces, microwave integration and complete RF transceiver systems.

Integrated electronic research and design, fundamental solution for practical problems, aimed at CMOS integration in which the sizes are – nowadays – a fraction of the wavelength of visible light: true nanotechnology. Truly omnipresent and truly invisible to the human eye but very visible in the (electronics) world to be. ICD’s world. Your world.

prof. dr. ir. B. Nauta

text: dr. ir. Anne-Johan Annema
5.7 Integrated Optical MicroSystems (IOMS)

‘The challenge of manipulating light on a micro and nano scale’: photonics is going in the same direction as electronics has gone for decades: miniaturization, with the additional advantage of an enormous bandwidth - at the speed of light! Imagine a tiny optical micro-chip that includes everything from the light source via a number of optical manipulation and control elements towards the optical detection: a highly sophisticated optical coherence tomograph, Raman spectrometer or DNA sequencer held in a hand and at the cost of a few light bulbs!

‘Well, it is still a long way towards this goal. When looking at what is available on the market today, one receives the feeling that the world is still connecting single components by optical cables, just like electronics did in the 1960s. We have taken up the challenge! Work in our group deals with the design, realization and characterization of highly integrated optical devices, including fundamental physical phenomena, materials aspects and system applications. We are concentrating on three closely interacting research lines, (i) active photonic devices, including miniaturized integrated light sources and amplifiers, (ii) photonics integration technology, including integrated spectrometers, routers, filters, and light detection, and (iii) optical sensors, including opto-mechanical and opto-fluidic interactions as well as light interaction with nano-cavities such as photonic crystals.’

‘Being active in the highly multidisciplinary field of integrated optics, the IOMS group is positioned at the crossing between fundamental academic and applied industrial research, thus providing a highly interdisciplinary environment and making our group equally interesting for students from Applied Physics and Electrical Engineering. Knowledge about the relevant disciplines, scientific networks and contacts with relevant companies is distributed among the scientific staff. Intense internal communication and teamwork is needed to carry out projects and supervise master and Ph.D. students.

The roles of all the staff members are crucial, as each of them carries her or his own scientific background, professional networks and contacts with companies. In addition, all translate their innovative ideas and skills into successful national and European projects which then lead to novel research results.’

‘We are developing a new active material, Al2O3:Er3+, which provides optical gain over a bandwidth covering the entire telecom C-band. In this material we demonstrated high-speed amplification at 170 Gbit/s – beyond the specifications of future telecom components – and a laser with wavelength selectivity over the entire telecom C-band. We are now heading towards single-longitudinal-wavelength, on-chip tunable and ultrashort-pulse integrated lasers.’
‘On another project, we are sequencing DNA molecules from a diagnostically relevant region of a human breast cancer gene on a tiny opto-fluidic chip with unprecedented resolution and sensitivity by separating the molecules and exciting their fluorescent labels via integrated optical waveguides. Placing exclusive fluorescent labels on copies from independent regions of a gene, in combination with multi-color excitation through these optical waveguides, enables simultaneous investigation of several gene regions and detection of multiple DNA mutations in a single sample. Ultimately, this leads the way towards complete DNA analysis on a chip. This research is carried out in close collaboration with three companies in the Twente region.’

‘Simple ideas are often the best ideas! Emission of light which is excited in biomedical tissue needs to be captured, spectrally analyzed and finally detected on a chip. However, capturing light that is emitted into a large solid angle with a small-area waveguide is highly inefficient. Instead, exploiting the large-angle propagation region of the subsequent optical element on the chip, an arrayed waveguide spectrometer, for simultaneously capturing the emitted light by hundreds of parallel waveguides leads to an increase in light detection by two orders of magnitude, thus enabling even the detection of weak Raman signals. This idea has recently been filed as a patent.’

‘During our group meetings the running projects as well as the entire programme of the group are evaluated and discussed. Important new directions and novel ideas are carefully weighted and introduced in agreement with the scientists involved, thus leading our group into the emerging century of light.’

prof. dr. Markus Pollnau

text: dr. Hugo J.W.M. Hoekstra and prof. dr. Markus Pollnau
5.8 NanoElectronics (NE)

‘Nano-revolution in electronics’: the Chair NanoElectronics (NE), part of the MESA+ Institute for Nanotechnology, performs research and provides education in the field of nanoelectronics. Nanoelectronics comprises the study of the electronic and magnetic properties of systems with critical dimensions in the nanoregime, i.e. sub ~100 nm. Hybrid inorganic-organic electronics, spin electronics and quantum electronics form important subfields of nanoelectronics. The research goes above and beyond the boundaries of traditional disciplines, synergetically combining aspects of Electrical Engineering, Physics, Chemistry, Materials Science, and Nanotechnology.

Our research entails the development of novel (concepts for) electronic devices and systems with nanoscale dimensions for application in future generations of electronics and information storage. The present research extends over hybrid inorganic-organic electronics, spin-based electronics, and quantum electronics. One of the future challenges will be to smartly combine top-down and bottom-up technology for electrically addressing single nanosystems, bridging the micro-nano gap in a reliable fashion.

The group has dedicated infrastructure for performing low-noise electron transport measurements and magnetic characterization at low temperatures (down to 250 mK) and high magnetic fields (up to 10 tesla).

The NanoElectronics group provides a diverse and stimulating environment with a successful international group of post-doctoral and PhD scientists and MSc students with backgrounds in physics, electrical engineering, chemistry, nanotechnology and materials science.

prof.dr.ir. Wilfred van der Wiel
W.G.vanderWiel@utwente.nl
http://ne.ewi.utwente.nl/
5.9 The Signals and Systems Group (SAS)

The Signals and Systems Group (SAS) performs research on sensory data analysis in biometrics and medical imaging. This concerns complex high dimensional signals and systems and the development of methods for processing and analysing these signals and modeling of these systems. Medical imaging and biometrics have strong image processing and pattern recognition components in common.

Biometrics is the use of body or behavioural characteristics in order to identify a person or to verify his or her claimed identity. At present, biometrics is receiving world-wide attention as a potential means to secure access to content and locations and to authenticate (Internet) transactions. At SAS different biometrics are investigated: finger prints, faces, hand grip for different applications: access control (access to data or a place), security (border control), surveillance (camera surveillance), convenience (at home). Current projects include: robust finger print recognition, template privacy protection, robust face recognition for surveillance and 3D face recognition, hand grip recognition to identify the rightful owner of a gun and face recognition for PDA’s.

The medical imaging research at SAS addresses several topics in image reconstruction, visualization and detection/segmentation. Current projects include: automated radiologic assessment of joint damage, photo-acoustic image reconstruction, stent detection and modelling, vessel detection and tracking, 2D and 3D active contour snakes and interactive 3D visualisation. Photo-acoustic image reconstruction is a hybrid imaging approach applying simultaneous reconstruction of optical absorption and acoustic attenuation and speed of sound in tissues. A stent is a flexible metallic frame wrapped with a kind of foil to protect a weakened blood vessel from rupturing. It is very important to monitor the proper operation and position of the stent as function of time. Snakes can be seen in 2D as a “rubber band” described by some markers on which image forces act, or in 3D as a “rubber balloon”. They are used for robust segmentation of 2D and 3D images (in medical images for finding the boundaries of different tissues).

The research of SAS also finds application in the audio domain and in wireless communication. In audio, the applications are: active noise control, sound source localisation and signal processing for audio and speech signals. In active noise control the aim is to develop advanced devices to reduce noise by generating a kind of “anti-noise”. In sound source localisation, a grid of acoustic sensors, so-called “microflowns” are used for accurate localisation of certain sounds like annoying vibrations.
The wireless communication at SAS concerns the part of the wireless world in which signal-processing algorithms and hardware/software design meet: the design and implementation of digital radio-front-end functionality. Current projects include cognitive radio (methods for intelligent dynamic sharing of the bandwidth of the radio spectrum) and MIMO (multiple-input multiple-output) systems, where multiple antennas are used for better coverage of wireless connections and data rates.

prof. dr. ir. C.H. Slump
5.10  Semiconductor Components (SC)

“Surprising microchips”: microchips have enabled the Digital Revolution and continue to improve year after year. These chips are produced with a tremendous amount of engineering skill. Researchers at the group of Semiconductor Components investigate new applications for that same microtechnology, by teaching CMOS microchips new tricks. Ever seen a CMOS chip with a light emitter inside, a chemical sensor, or a radiation imager? That’s where we’re going.

The microchip of today is excellent in two tasks: computing, and information storage. Its communication is quite slow, and for any other function, we need additional electronic components. Why doesn’t a microchip do more work for us? For instance, in your cellular phone, the chip should be your microphone, speaker, touch-screen display, and radio transmitter all in one. That would make a lower-power solution, cheaper to produce, and with less waste - everybody wins! The trouble is, most microchip engineers have become addicted to Moore’s Law, and concentrate their efforts into the miniaturization of the transistor. This improves the two earlier mentioned functions: computing and information storage. But it does not give us anything radically new.

The Semiconductor Components group benefits from integrated circuit technology to create new functions in CMOS chips. We study silicon LED’s, high-quality tunable components and filters, gas sensors, radiation sensors and the like. Also, we’re pushing the underlying technology ahead, for instance by introducing new materials or reducing the temperature of the manufacturing process.

Does it take an electrical engineer, a chemist or a physicist to do this work? The answer is: all three! We’re a multidisciplinary group, where quantum theory and hands-on technology meet.

prof. dr. Jurriaan Schmitz
5.11 Telecommunication Engineering (TE)

“We send your wanted signal in the proper direction!” Did you ever try to talk to your friend in a noisy pub? And what if your friend is several meters away? You have to shout, like others do. A waste of energy, and actually it does not help because the total noise level increases and becomes more and more a problem. Your friend could make a shell around the ears using the hands, or you can create a horn around your mouth. In that way, the directivity is improved. We do that all the time, not for audible signals, but for electromagnetic signals. Electromagnetic waves are everywhere. The main trick is to get them at the right place, without any interference. This is a key aspect of our research in the Telecommunication Engineering group.

By converting electrical signals in the optical domain, change the phase of the optical signal and convert it back to the electrical signal, we create wideband beamforming networks. These networks are applied in phased array antennas, such as in the communication system in a plane. Because a plane is moving fast, and the energy of an electromagnetic signal from a communication satellite is extremely small, we have to direct the antenna in the plane very accurately towards the satellites. Like the horn created by your hands in the pub. Much faster, better, and we do it for several satellites at the same time with the same antenna!

We are also investigating techniques to deliver your signal only to the person you would like to talk to, at short distance. And without disturbing the others. The first aspect is a key research topic in the short range radio group. The next generation of wireless LAN and body-networks are being developed in our group. The disturbance is what we call electromagnetic interference. The interference people are developing novel techniques to reduce the (received) noise, or to reduce the impact of the noise on the signal.

prof.dr. Frank Leferink
5.12 Transducer Science and Technology (TST-SMI)

Micro ElectroMechanical Systems (MEMS) are penetrating in all systems in which miniaturization plays a role. These range from scientific instrumentation to consumer products, such as accelerometers (airbag, Wii), information processing systems (beamers) and medical applications (lab-on-a-chip). MEMS forms the bridge between the human interface and nanotechnology – no nano-systems without this enabling technology! At TST we span the range from the development of (nano-)fabrication techniques (within the MESA+ institute) all the way up to the design of complex systems (IMPACT institute).

Microfabrication
The starting point of micromachining is the thin film deposition and lithography techniques developed for integrated circuit technology. To make mechanical structures, etching techniques are used to remove parts of the substrate or sacrificial layers, so that freestanding 3D structures can be made, often with moving parts. By bonding surfaces together, embedded structures can be realized, allowing for complex designs.

Microsensors
Using the microfabrication techniques developed at TST, many different types of microsensors are made, sensing for instance flow in air or liquids, forces, pressures, accelerations and radiation. The microdimensions allow for very sensitive, small and cheap devices. Moreover, many can be used in parallel to improve noise characteristics, or allow for distributed sensing.

Bio inspired sensors and actuators
Also nature uses multiple sensors in parallel. They can be either identical (but deriving different information due to the embedding), such as the cochlear sensor in your ear, or have a variation in properties, such as the flow sensors on (parts of) the body of insects. We can learn a lot from nature, and we try to mimic the sensors we find there in micromachined versions. The arrays allow us to use advanced detection techniques, like stochastic resonance (you need some noise to hear).
Nanotechnology

The lithography techniques we use, allow us to design structures with micrometer dimensions. By using clever tricks however, we can realize individual features in the nanometer range. We do this by using the edges of structures, which can be atomically sharp. In this way we can contact the human world to the nanoregime, where many interesting effects can be exploited. A good example are probes; cantilever structures with all kinds of tips which are used to sense or modify surfaces. When used in parallel arrays, they become very powerful tools.

Probe based data storage

Probes can be used to modify surfaces. One obvious application which comes to mind is data storage, with mind boggling data densities down to the molecular or atomic level. Sufficiently high data rates can only be achieved if we use thousands of probes in parallel. In such a probe recording systems, many research lines in MEMS are combined; probe arrays, sensors and actuators. In order to learn to store data into discrete media, we study magnetic patterned media, including write synchronization and coding techniques.

prof. dr. ir. Elwenspoek
Section B

Appendices
1 The Faculty of EEMCS

The Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS) comprises three disciplines, each of which again has connections with other disciplines. Besides teaching, research is carried out in the faculties by our research groups/chairs. This research is entirely clustered in the university research institutes Institute for Nanotechnology (MESA+) and the Centre for Telematics and Information Technology (CTIT), IMPACT and MIRA.

1.1 Organisation chart EEMCS
Dean
Dean of the faculty of EEMCS is prof.dr.ir. Ton Mouthaan. With him rests ultimate responsibility for all of the faculty’s educational programmes.

Faculty Council EEMCS
The Faculty Council EEMCS is a representative advisory body of the faculty. The Council consists of eight students and eight staff members. The students are elected annually, the staff members serve on the Faculty Council for a period of two years. Nominations for the Council take place in April, the elections are held in June. Depending on the subject at hand, the Faculty Council has advisory powers or the right of consent about the proposed decisions of the faculty dean. If he wants to take decisions about the outlines of personnel policy, regulations in the field of terms of employment and the occupational health and safety policy, the dean requires the consent of the Faculty Council beforehand. The dean also requires the Faculty Council’s consent beforehand if he wants to take decisions on setting or modifying the faculty Education and Examination Regulation (OER), rules in the field of safety, health and well-being or policy on students’ facilities.

For more information concerning the Faculty Council, please refer to:
http://www.ewi.utwente.nl/organisatie/bestuur/faculteitsraad/

The Board of Professors
The Board of Professors consists of all professors and programme directors of the faculty.
1.2 Educational programmes

The faculty offers the following educational programmes:

- **Bachelor’s programmes:**
  Electrical Engineering (EE)
  Computer Science (CSC)
  Applied Mathematics (AM)
  Creative Technology (CreaTe)

- **Master’s programmes:**
  Applied Mathematics (AM)
  Computer Science (CSC)
  Electrical Engineering (EE)
  Embedded Systems (EMSYS) (3-TU)
  Human Media Interaction (HMI)
  Mechatronics (MT)
  Systems and Control (SC) (3-TU)
  Telematics (TEL)

At the head of every educational programme is a programme director. He marks the outlines of the educational programme and is responsible for the content of the educational programme and its courses.

For EE (BSc and MSc) this is dr.ir. W. Olthuis (Wouter)
For AM (BSc and MSc) and SC this is dr. J.W. Polderman (Jan Willem)
For CSC (BSc and MSc) and TEL this is dr.ir. R. Langerak (Rom)
For CreaTe en HMI this is dr. G.F. van der Hoeven (Gerrit)
For EMSYS this is prof.dr.ir. G.J.M. Smit (Gerard)
1.3 Services and units

The faculty has a number of EEMCS-wide service groups which are under the direction of the director of operations, ing. H. van Egmond.

SAFETY AND HEALTH CARE EEMCS

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<th>Position</th>
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<tr>
<td>Coordinator</td>
<td>ing. S. Visser (Sjoerd)</td>
<td>053 489 3153</td>
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<tr>
<td></td>
<td>ir. F. Houweling (Frans)</td>
<td>053 489 3583</td>
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OFFICE OF THE DEAN OF THE FACULTY OF EEMCS (BFD-EEMCS)

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<td><a href="mailto:BFD_ewi@ewi.utwente.nl">BFD_ewi@ewi.utwente.nl</a></td>
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<td>Dean</td>
<td>prof. dr. ir. A.J. Mouthaan (Ton)</td>
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<tr>
<td>Director of Operations</td>
<td>ing. H. van Egmond (Harm)</td>
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<td>Faculty secretariat</td>
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<tr>
<td>director of operations and MT</td>
<td>E.C. Bosch-van der Heijden (Els)</td>
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## EDUCATION SUPPORT OFFICE EEMCS (BOB-EEMCS)

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<td>H.J. van Laar (Jolanda)</td>
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<td>Internationalization</td>
<td>drs. J. Schut (Jan)</td>
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<td>dr. M.J. Korsten (Maarten)</td>
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<td>Quality assurance</td>
<td>drs. J.H. Romkema (Hans)</td>
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<tr>
<td>Computer Science and</td>
<td>S.B.A.M. Vonk MSc (Sharon)</td>
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<td>K. Veldhuis (Karin)</td>
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## COMMUNICATIONS

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<td>H. Barry-Mulder (Hinke)</td>
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<td>Bachelor Electrical</td>
<td>H. Barneveld-Hobbelink (Henriëtte)</td>
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PREMISES MANAGEMENT

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<td>ir. M.J.B. ten Bulte (Michel)</td>
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<td>054 489 4100</td>
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<td><a href="mailto:Zilverling@fb.utwente.nl">Zilverling@fb.utwente.nl</a></td>
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LIBRARY & ARCHIVE

Library & Archive is a service centre of the University Library of the University of Twente

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<tr>
<td>Information Specialist</td>
<td>Mw.drs. P. de Willigen (Petri)</td>
<td>+31 53 489 2085</td>
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<td>Computer Science,</td>
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<td>Applied Mathematics</td>
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<tr>
<td>Electrical Engineering</td>
<td>ir. W.C. Oosterling (Wim)</td>
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FACILITY SERVICE CENTRE

The Facility Service Centre is a shared service centre that offers its services within and for the various faculties, including EEMCS.

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<td>Contact</td>
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<tr>
<td>Hogekamp, Zilverling, Carré</td>
<td>N.C.M. Heijnekamp (Nancy)</td>
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<td>Citadel</td>
<td>M. Drewes (Martine)</td>
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ICT SERVICE CENTRE (ICTS)

ICTS is a shared service centre within the University of Twente. The following contacts apply for the faculty of EEMCS.

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<td>Accountmanager EEMCS</td>
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<tr>
<td>ICTS Servicedesk</td>
<td><a href="mailto:icts.servicedesk@utwente.nl">icts.servicedesk@utwente.nl</a></td>
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STUDENT & EDUCATION SERVICE CENTRE

The Student & Education Service Centre performs tasks on a central level as well as within the various faculties. The Student & Education Administration (S&OA) EEMCS deals with all sorts of educational affairs and is part of this service centre. The Student & Education Administration is also known as the Bureau Onderwijszaken (BOZ, Educational Affairs Office).

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<td>M.H. Huiskes - Borghuis</td>
<td>053 489 4605</td>
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<td>(Miranda)</td>
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<tr>
<td>OSIRIS/Blackboard key user</td>
<td>D. Muller (Diane)</td>
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</table>

Education support

Education support is provided by the university Student & Education Service Centre (S&O) and the Education Support Office (BOB) of the faculty. The education administration is part of the Bureau Onderwijszaken (BOZ/S&O). See also section 4.1.

EEMCS-wide coordination in the fields of Internationalization, Quality assurance, Traineeship and Study advice takes place from the BOB.
1.4 Facilities

**PC-rooms**
For practical courses the faculty of EEMCS has a number of PC-rooms available. The W-zaal (West-room) and the flexoffice of SmartXP, situated in Zilverling/Hal A, are mainly scheduled for Electrical Engineering and Creative Technology practicals. Furthermore, in the Zilverling building rooms are situated on floor 2 (room 2042), floor 3 (3042) and floor 4 (4054) containing 12, 24 and 36 PCs respectively. During lecture hours a room assistant is present in room 3042. At night this room is open until 20.30h. After 18.00h, you can obtain entrance at the night porter at the main entrance of the Zilverling building. Please note that near the course rooms in the Zilverling builing staff rooms are situated. So please keep quiet in the building, do not use your phone in the corridors but, for example, go to the stairwell or the Educafe instead, and limit talking in the corridors. Eating is prohibited in the PC-rooms; drinking is allowed, using lockable bottles.

**Year room**
For first-year bachelor students of Applied Mathematics a year room is available in the Citadel building (T100); most of their training will take place there. In the Citadel building (T300), there is also a year room available for the Creative Technology programme. Outside lecture hours this room can be used for self-study or as a project space by CreaTe students.

**Smart XP Lab**
In this new multifunctional area in the Zilverling building, it is possible for both parties of the faculty of EEMCS and exterior parties to conduct research in an interactive manner. The lab is a true research playground and offers ample opportunity for testing and experimenting. It is the intention that scientists from different disciplines become acquainted with each other’s fields, which may be to the benefit of their own research. This lab is, as it were, a meeting point where every possible research set-up is imaginable.

**Educafé**
Next to the (main) entrance of the Zilverling building, you will find the Educafe: a space where you can study, work in groups and relax with your fellow students. There are computer workspaces and you can grab a drink or snack from the vending machines. In short: this is an ideal environment to work together on projects. On the first floor, the EEMCS student associations are situated: Scintilla (Electrical Engineering), Abacus (Applied Mathematics) and Inter-Actief (Computer Science). At present, the study association for the Bachelor’s programme Industrial Design, Daedalus, still accommodates the new bachelor’s programme CreaTe.
The Educafe also hosts two shops: IAPC and Stores. IAPC is a non-profit shop where you can turn to when you have questions about or want information on computers. Besides, you can buy laptops and all sorts of computer parts there for reasonable prices. ‘Stores’ sells components (such as resistors and capacitors) and office supplies. Furthermore, IAPC as well as Stores sells study books. Both shops are run entirely by volunteers and they are open during weekday lunch breaks for most of the year.
2 The organization of education

2.1 Students’ Charter

As every institute for higher education in the Netherlands, the University of Twente also holds a Students’ Charter. The Students’ Charter is legally based in art. 7.59 of the Dutch Higher Education and Research Act (WHW). The Dutch text of the Students’ Charter is law-making. This means that in case of problems or conflicts you can appeal to the content of the Dutch text of the Students’ Charter (or Studentenstatuut). The Students’ Charter contains a programme-specific section (the OSS) and an institute-specific section. The institute-specific section of the Charter is at all times available in its most up-to-date form on the website http://www.utwente.nl/studentenbalie/regelingen_statuut/charter/.

If you would like to have a printed version of the Charter, it is available on request from the Red Desk: the information desk of the Student Counselling Service. For the programme-specific section of the Charter (OSS), which contains the Education and Examination Regulation (OER), please refer to the regulations and forms section on the website of your programme. http://www.ewi.utwente.nl/en/education/

2.2 Student Enrolment/Re-enrolment

Each academic year you are required to re-enrol at the University of Twente using Studielink. This re-enrolment is grafted on to the regulations in the Dutch Higher Education and Research Act (WHW) and it must be completed before 1 September. As soon as your request for re-enrolment by Studielink is received by the Central Student Administration (CSA), it will be verified whether you satisfy the conditions for enrolment. If you qualify for enrolment, your enrolment will be completed as soon as all enrolment documents have been submitted and the payment of your tuition fees is processed.

If you wish to be sure of your enrolment as from 1 September, you must complete all enrolment formalities in time – preferably before 1 August.

When your enrolment is complete, as proof of enrolment you will receive your student card and two declarations of enrolment. The declaration contains, among other things, the programme(s) and the period for which you are enrolled.

On the university level there are various student service centres, which are united in the Student & Education Service Centre (S&O). The student desk accommodates the service centres. The main services are mentioned below.
2.2.1 Student Services

Student Services offers various support services: you can go there to have your digital picture taken for your student card, to register, enrol or de-enrol. Student Services is situated in the Vrijhof building. See also: http://www.utwente.nl/studentenbalie/en/.

Student Counselling Service
The desk of the Student Counselling Service (the “Rode Balie”) is responsible for individual care and support of UT students at a coordinating level (besides the care educational programmes take for their “own” students). This includes for example a student psychologist, various courses (“self management”, graduating, job application) and the student counsellor.

Student psychologist
You can get help from the student psychologist when you need to talk to someone, for instance when you experience personal problems such as problems in your relation with your parents, friends or fellow students. You do not need a referral: you can make an appointment yourself. The student psychology service aims at having the first session within a week after the student contacted them.

Student counsellor
The student counsellor offers help when you have questions about, for instance, student grants, UT financial support, switching disciplines, problems involved with switching from a school for Higher Vocational Education to University, personal problems, appeal procedures, studying abroad, studying with a disability, and entrance examination (colloquium doctum). In order to make an appointment you need to telephone the secretariat. You have to take the initiative yourself to make an appointment with the student counsellor.

The “Rode Balie” is situated in the Bastille building. For more information, go to: http://www.utwente.nl/studentenbalie/en/.
2.3  Communication and Information

When you want to take up a study at the University of Twente, from the very start you will be faced with various means of communication the university, the faculty and your programme use to communicate with you. As soon as your preliminary enrolment at the University of Twente is received, you will be provided with an e-mail account, user name and password. You will also be provided with some writing space of your own, where you can save your documents and where you might put your own home page. The Internet is by far the most important means of communication of the programme and the university.

E-mail

Whenever the programme or a particular lecturer wants to communicate quickly with a particular student or a small group of students, this will be done by e-mail.

The Student & Education Service Centre (S&O) also uses e-mail to communicate with large groups of students. This occurs, for instance, when a lecture is suddenly cancelled or when an examination has to be rescheduled. In those situations, S&O is unable to contact the students in time through the usual channel of communication of the educational programmes, which is the Education announcement. S&O also uses e-mail to announce, for example, information sessions about study-related matters.

UT students in general have e-mail addresses like: <student name>@student.utwente.nl. In this address <student name> is replaced with a person’s initials and surname. Exceptions do occur, especially when a number of UT students have identical initials and surnames. You can find e-mail addresses of UT students and staff on the UT website.

Go to http://my.utwente.nl/.

MyUniversity

MyUniversity, the UT student portal, gives access to all UT data systems (OSIRIS, Blackboard). You can log on at http://my.utwente.nl/. Besides, the portal gives access to the timetables for teaching and to some other services.

Education announcements

Changes in the timetables for teaching and examination are announced by means of an ‘Education announcement’ (Onderwijsmededeling). Every Education Announcement is spread through the Internet. The same applies for announcements concerning graduation colloquia and presentations of bachelor’s and master’s assignments. You can read them via the MyUniversity portal.nl. The Education announcement is the programme’s main means of communication to communicate with all of its students. It is important to check if there are any changes in the timetable every day, in order to be informed as much as possible and to prevent sitting in the wrong lecture-room at the wrong time.
Timetable for teaching activities
The portal MyUniversity gives access to the timetables for teaching activities.

OSIRIS (Student information system)
OSIRIS is the new self-service student information system which has recently been put into use by the UT. Via MyUniversity you can log in on OSIRIS using an ‘s’ plus your student number and the corresponding password. You can find a user manual on http://www.utwente.nl/so/osiris/english/Manual%20Osiris%20Student.pdf

If you have any questions, you can turn to Student Services (Vrijhof building). http://www.utwente.nl/studentenbalie/en/student_services/

Blackboard
Blackboard is the digital learning environment of the UT. It offers all the information you need to follow a course, such as the timetable, the contents of the lectures and additional information on the course material and the examination or assignment. Within a Blackboard site you can also communicate with fellow students and lecturers or work together on assignments.

Blackboard is a lecturer’s main means of communication to communicate with his students about a course. On this site you may also find important announcements and news items on the course.

You will need to sign up for each course you will take via Blackboard. To get access to the courses, you will need an account. After your registration at the CSA, the ICTS will usually provide you with a user name and password, the so-called ICT account, which you will receive by letter within 10 workdays.

If you were not provided with an ICT account or if you lost your password, please report this at the ICTS servicedesk, located at Horstring W122 (icts.servicedesk@utwente.nl, phone number +31 53 489 5577) and keep your student card at hand.

If you have any questions on Blackboard or OSIRIS, within the faculty you can turn to S&O, Diane Muller, the Zilverling building, room A104, phone +31 53 489 2681.

2.4 Student card

The student card issued by the University of Twente is valid proof of identity within the UT and it is also a proof of enrolment. You are required to show the student card at request when making use of university facilities such as attending lectures, taking examinations, or visiting libraries. You will receive your student card and two declarations of enrolment through the post as soon as you are registered. So please see to it that the Student Administration (CSA) has your correct address.

Toepassingen collegekaart:

- **Student card**
  The card is a valid proof of enrolment for the academic year 2010-2011

- **Library pass**
  The student card barcode enables the card to serve as a library pass.

- **Xtra-card**
  If you want to make use of the sports and cultural facilities in Enschede via http://www.xtra-card.nl/en, the card serves as Xtra card as well.

**Declaration of enrolment**

With a declaration of enrolment you can prove your enrolment (for instance to get a student grant or at your insurance company). The declaration contains, among other things, the programme(s) and the period for which you are enrolled.

**Theft/loss**

In case of theft or loss of the card, you can apply for a new student card on payment of EUR 5.- at the Student Services desk in the Vrijhof building.

**No student card yet?**

If your enrolment has not yet been fully completed, no student card will be produced. In addition to your enrolment the CSA requires a digital photograph. On workdays between 09.00 and 17.00h you can have your picture taken at the Student Services desk in the Vrijhof building (room 239B), across the library.
2.5 Year’s schedules

The year is divided into two semesters, each of which is divided into two quarters. Most courses will take one quarter and will be completed in the same quarter, mostly through a written examination. In every quarter 15 ECTS-credits are scheduled. The quarters run as follows:

- Quarter 1 from week 35 (30 August 2010) until week 44 (7 November 2010)
- Quarter 2 from week 45 (8 November 2010) until week 04 (30 January 2011)
- Quarter 3 from week 05 (31 January 2011) until week 15 (17 April 2011)
- Quarter 4 from week 16 (18 April 2011) until week 26 (03 July 2011)

For the exact schedule of courses see the timetables on the website http://myutwente.nl/ut/.

For a brief summary in English: http://www.utwente.nl/so/roosterwerkgroep/jaarcirkels/jaarcirkels.doc/summary_in_english.html
Jaartijden 2010-2011,

**Student & Onderwijs Administratie**

**Student & Onderwijs Service Centrum**
2.6 Lectures

The lecture hours have been altered as of the last academic year 2009-2010. This resulted in identical lecture hours on a 3TU level at all three institutes. This facilitates the exchange of education between the 3TU institutes by means of real time video conferencing.

The new lecture hours fit in very well with a very simple and straightforward model: all lecture hours start at a quarter to the hour and end at the half hour.

There are fifteen-minute breaks between lecture hours, lunch and dinner breaks last 75 minutes. Starting times of written examinations fit in with this schedule. The longer breaks between the morning and afternoon lectures and the afternoon and evening lectures respectively, are included in a consecutive numeration.

<table>
<thead>
<tr>
<th>Period</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st period:</td>
<td>08:45 - 09:30 uur</td>
</tr>
<tr>
<td>2nd period:</td>
<td>09:45 - 10:30 uur</td>
</tr>
<tr>
<td>3rd period:</td>
<td>10:45 - 11:30 uur</td>
</tr>
<tr>
<td>4th period:</td>
<td>11:45 - 12:30 uur</td>
</tr>
<tr>
<td>5th period = lunch break:</td>
<td>12:45 - 13:30 uur</td>
</tr>
<tr>
<td>6th period:</td>
<td>13:45 - 14:30 uur</td>
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<tr>
<td>7th period:</td>
<td>14:45 - 15:30 uur</td>
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<tr>
<td>8th period:</td>
<td>15:45 - 16:30 uur</td>
</tr>
<tr>
<td>9th period:</td>
<td>16:45 - 17:30 uur</td>
</tr>
</tbody>
</table>

2.7 Taking courses

You will need to sign up for each course via Blackboard. To get access to the courses you require an account. The ICTS will provide you with a user name and password.

2.8 Knowing your way on campus

All of the faculty of EEMCS teaching takes place in rooms situated in buildings which are spread all over campus. In the time tables the lecture rooms are indicated using a code in which the first two letters indicate the building where the room is situated. The list below contains the most frequently occurring abbreviations of buildings. The computer practicals generally take place in one of the Zilverling rooms.
2.9  Study material

Textbooks, lecture notes, readers or syllabuses are required for virtually every course. For those you can turn to the student association and the UnionShop. The lecture notes, readers and syllabuses will be sold from the beginning of every semester at the UnionShop. You can check the website to see if they are in stock:
http://www.studentunion.utwente.nl/en/

2.10  PC-privé scheme for UT students and PC, laptop and printer purchase

As a student you are entitled to take part in a special subsidized PC purchase scheme (referred to as the PC-privé scheme) offered by the UT. You can take part in this scheme cheaply with an interest-free loan. Every regular full-time student enrolled at the UT can take part in the PC-privé scheme as follows.

Principal requirement:
Once in the bachelor’s phase and once in the master’s phase, provided the student in question is 60 ECTS-credits or more away from the degree in the respective phase.

Exceptions:
1. When attending a one-year master’s course, the student may sign up for the scheme no later than one month after the beginning of the programme;
2. Students enrolled in a bachelor’s programme who take courses in the bachelor’s phase as well as in the master’s phase and who still have to attain at least 60 ECTS-credits for both phases taken together are also entitled to take part in the scheme. Taking part in the scheme is then regarded as taking part during the master’s phase.

Note: this also includes students entering a programme via an alternative route who are attending a so-called ‘bridging programme’.

As a UT student you can purchase a high-quality PC and communication equipment in the IT shop at a highly competitive price. The University of Twente will lend you a maximum of EUR 1,362.- interest-free, which is to be repaid in a number of monthly instalments. Whether the student is required to repay the loan in 12 or up to 24 months depends on the remaining duration of the course. If the remaining study duration is 12 months, the loan has to be repaid in 12 months. A graduated calculation related to the remaining duration of the course may mean that the repayment term is longer. Via the Notebook Service Centre general UT software (such as Maple, Virusscanner, SPSS) can be downloaded. Special software may be available via your faculty. For more information on the PC-privé scheme, refer to:
http://www.utwente.nl/studentenbalie/regelingen_statuut/charter/appendix_57_pc_privet_scheme_fo.html
2.11 Examinations

At the start of the academic year, for every student a timetable of teaching activities and examinations is available. This timetable shows, among other things, the weeks in which examination are held (see also section 2.5). The timetables for teaching are also available on the websites of the programmes. Any changes, such as, for instance, the examination dates, will be announced via the Blackboard sites of the courses concerned and through Education announcements. So no new timetables will be distributed among the students if any changes might occur.

For the sake of students’ and teachers’ clarity the starting time of written examinations is identical to the first morning or afternoon lecture respectively. So:

- morning examinations start at 08.45h
- afternoon examinations start at 13.45h

Timetables of examinations are available via: http://my.utwente.nl/.

General rules

1. The student himself is responsible for registering or deregistering for the examinations.
2. Twice a year students are given the opportunity to take written and oral examinations belonging to a particular educational unit. Practical training can be completed at least once a year. The rules that apply for practical training will be communicated at the start of the educational unit.
3. The student who has not gained a mark 6 or higher after two markings by an educational unit and who still wishes to gain such a mark, is to appeal to the examination board for permission to take another examination in the educational unit concerned. This appeal must be accompanied by a working plan drawn up by the student in consultation with the examiner of the educational unit concerned and the study advisor. The examination board will decide on the appeal.
4. On the authority of the examination board at least one month before the start of the semester the timetable of examination of that semester will be announced, in which dates and times of the examinations are fixed.
5. The examination board may give permission to deviate from the number of times an examination will be held and the way in which examinations can be taken.
6. Rescheduling an examination to a time different from the one indicated in the timetable is only permitted after the examination board’s consent.
3 UT regulations

3.1 Studiefinanciering (Dutch student grant)

The contribution of the Dutch government towards the cost of education is called studiefinanciering. It consists of either a conditional grant plus an additional loan (the so-called blended studiefinanciering), or just a loan. The grant of IBG (Informatie Beheer Groep, the government institution responsible for the Dutch student grants) allows students to receive part or all of their training outside the Netherlands. The entitlement to studiefinanciering depends on your first year of enrolment. In any case, you have to be enrolled as a student and you should not be over 30.

3.2 Transitional arrangements

If courses are radically changed or if they are cancelled, at the beginning of the academic year you will be informed in writing about the consequences which this entails.

3.3 Garantiebeurs

The ‘Regulation Guarantee Grants First-year Students’ is meant for students who start an educational programme at the UT from VWO (Dutch pre-university secondary education) and who make a serious effort for the educational programme. If such a student decides to discontinue his educational programme before 1 February of the first year of study at the UT, the UT offers the opportunity to start a new educational programme with only limited loss of studiefinanciering possibilities (with as many equal opportunities as possible). The background of this regulation is that a lot of VWO students who would make good university students tend to choose for Higher Vocational Education nonetheless because they are under the impression that they will run less financial risk doing so.

3.4 Regulation graduation support

Students at the UT with certain special circumstances can make use of the Regulation graduation support. Students can appeal to this regulation when they have run into a delay due to recognized special circumstances during a period of blended studiefinanciering. The blended studiefinanciering concerns the period for which the studiefinanciering can partially be converted to a gift; in other words: the period in which the student is entitled to the basisbeurs (basic grant). To apply for graduation support you can contact the student counsellor in the Bastille building.


3.5 Top-level sport

Combining university-level studies and top-level sport can be problematic for many students. It generally proves impossible to postpone either academic studies or a career in sport until later; both activities require the practitioner to achieve results within a relatively short period of time. The UT is aware of the problems involved and has developed a policy covering the practice of top-level sport.

See also:

3.6 Regulation encouragement student activism

Within the framework of encouragement of student activism there is a special regulation for active students. This involves the individual readjustment of educational obligations for active students, in order for them to have more flexibility in their studies and so that they will run into less delay because of their activism. If you want to know if you qualify for this regulation or if you want more information, go to:
http://www.utwente.nl/studentenbalie/regelingen_statuut/charter/.
3.7 Studying with a disability

Being disabled, following an educational programme is not always easy. However, the UT makes a serious effort to enable the disabled to study. Physically or sensory disabled students or dyslexic students are given the opportunity to take examinations in a way that is tailored to the requirements of their personal disabilities as much as possible.

Students who fall under this regulation have been brought to the attention of S&O/BOZ and the EEMCS lecturers concerned through a letter of the study advisor.

See also: www.utwente.nl/studentenbalie/rode_balie/handicap and http://www.onderwijsenhandicap.nl/

In general, being disabled, it may be wise to talk to the student counsellors and the study advisor of the faculty before the start of your studies. This may prevent any disappointments.
4 UT facilities

4.1 Educational Affairs Office EEMCS

The Educational Affairs Office (BOZ, Bureau Onderwijszaken) of the faculty of EEMCS is part of the Student & Education Service Centre (S&O) and assists the faculty in registering study results, supervising the (individual) students’ study programmes, organizing everything surrounding final assessment, making timetables, organizing examinations and organizing administrative systems.

BOZ is situated on the ground floor of the Zilverling building, room A104-A116. You can turn to them with most of your practical questions. They are reachable by telephone number +31 53 489 3794 or by e-mail boz@ewi.utwente.nl. In addition to this, you can turn to Student Services on the first floor in the Vrijhof building with any questions concerning education.

4.2 Union Shop

The UnionShop is situated on the ground floor in the Bastille building. The UnionShop sells lecture notes, readers and syllabuses. It also runs a copy service. In the self-service section not only copies can be made, but also reports can be bound, flyers cut, etc.

4.3 Notebook Service Centre

Nowadays, a notebook is virtually indispensable to any student at the University of Twente. You require your notebook to communicate with others, to collect information, to make calculations and drawings, to perform simulations and even to take examinations. Are you planning to buy a notebook in July or August? Every year in the summer, the ICTS Notebook Service Centre of the UT selects notebooks which most assuredly will meet the requirements of your educational programme! For more information, go to: http://www.utwente.nl/icts/en/nsc/
Service Desk
All students and university staff members can turn to the ICTS Service desk if they have problems or questions in the field of ICT. The ICTS Service desk is open from 08.30 until 17.00h and is reachable by telephone number +31 53 489 5577.

The service desk is situated in Horstring W122 (next to the Notebook Service Centre). With ‘general’ questions on ICTS you can turn to icts.servicedesk@utwente.nl. For more information, go to: http://www.utwente.nl/icts/en/servicedesk/.

4.4 Library/information specialist EEMCS

The central library of the University of Twente, situated in the Vrijhof building, contains books and journals on a number of disciplines. In addition, it contains study facilities such as study places in the reading rooms, quiet study places, working areas and PC work areas. The University Library catalogue, which includes the faculty libraries and the central library, is available online (www.utwente.nl/ub). Here you can also consult the catalogues of all Dutch University Libraries.

You need a student card if you want to lend publications or if you want to make use of the study facilities, for the student card serves as a library pass. Further information on lending or ordering publications is available at the desk of the library. The University of Twente is working on the accessibility of scientific journals. More and more journals can be consulted through the Internet.

The opening hours of the central library are from 08.30 until 22.00h on workdays, and from11.30 until 16.30h on Saturdays (for study purposes only, during examination periods). The information desk is open from Monday to Friday from 08.30 until 17.00h. You will find more information on www.utwente.nl/ub.

The University of Twente has a team of information specialists who offer support in the purchase of books, provide information on how to use the (digital) library and how to find scientific information on research and education for both staff and students. For EEMCS, the information specialists are:

- Mrs drs. P. (Petri) de Willigen, Citadel building H203, phone +31 53 489 2085
4.5 Student restaurant

In the Waaier building, the student restaurant of the UT is situated. The restaurant is based on the so-called free-flow system, which means that at various free-standing points of distribution a broad assortment is offered. Here you can get a hot day’s menu, the Dagmenu. You can also choose to have the more luxurious menu, or select from a broad assortment of sandwiches, rolls, snacks, desserts and hot and cold drinks.
5  Student activism

Organizing various activities requires qualities and skills which you may benefit from for the rest of your life. So being active in an association (being on a committee or a board) will always beneficial to your CV. In the professional field, surely students will be watched for who did more than just study.

Being active also helps you getting introduced to people you might never meet otherwise. Moreover, board members often have a specific position, such as chairman, secretary or treasurer. Positions like this will teach you how to draw up an agenda, to chair meetings, to take minutes or, for instance, to draw up an estimate.

5.1  Student associations

Every educational programme has its student association. They all organize all sorts of study-related activities, such as lectures, excursions and conferences. But also recreational activities are laid on, such as get-togethers and parties. In addition, the student association for instance takes care of the book sale.

The student association for Electrical Engineering is Scintilla, for Creative Technology it is (for the time being) Daedalus, Abacus is the student association for Applied Mathematics and Inter-Actief for Computer Science.

5.2  Student participation and other committees

Within the faculty of EEMCS you may become a member of various committees, such as:

The Faculty Council (see also page 1 of this appendix)
Programme Committee
Support Committee for Programme quality
Although every effort has been made to ensure that all the information presented is correct, information in this study guide is subject to changes. No rights may be derived from the information in this guide. For up-to-date information refer to: www.ewi.utwente.nl/onderwijs/