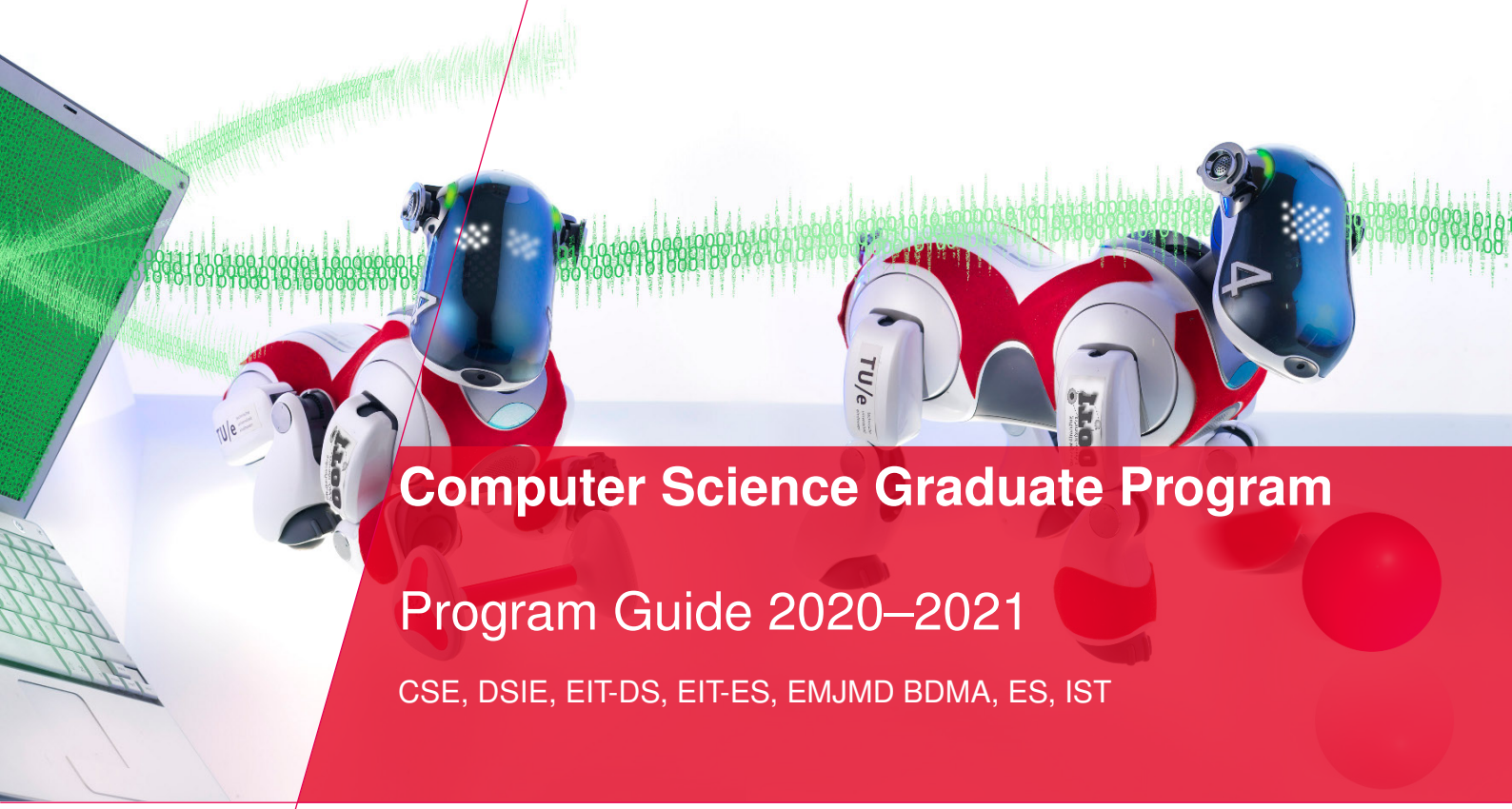
Department of Mathematics and Computer Science

Technische Universiteit
Eindhoven
University of Technology



Computer Science Graduate Program

Program Guide 2020–2021

CSE, DSIE, EIT-DS, EIT-ES, EMJMD BDMA, ES, IST

Where innovation starts

Computer Science Graduate Program

Program Guide 2020–2021

Computer Science and Engineering
Embedded Systems
Data Science in Engineering
Information Security Technology
EIT Service Design and Engineering
EIT Embedded Systems
EIT Data Science
Erasmus Mundus Joint Master Degree:
Big Data Management and Analytics

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Timeline of the master program

1. Attend the Master kick-off (August 24–27, 2020). Information related to the study program of your choice will be provided on **August 25, 2020**.
2. If you are a Computer Science and Engineering or an Embedded Systems student choose your stream by registering for one of the 2IMC-courses (Section 1.12.1) **as soon as you start**. Based on this registration you will be assigned a mentor. If you have an urgent question and the mentor has not yet been assigned, please contact the Academic Advisor (Section 10.1.7).
3. **When you start** please check the rules and regulations (Section 1.2), read the code of conduct very carefully and sign the declaration. Please submit this declaration to your mentor or student administration (Section 10.1.8).
4. Register for *three* courses in Q1 based on the information in the chapter corresponding to your program. Start with mandatory and homologation (if required) courses. If your program has less than three mandatory or homologation courses in Q1, pick a course from the (stream) electives list. Students that have studied at TU/e previously should do this before **August 23, 2020**; other students should do this before **September 4, 2020**.
5. Check the deadlines for course and exam registrations and register **on time** to avoid paying the extra administration fee.
6. Accept the invitation to join the course 2CSE000 (for students in CSE or one of its tracks) or 2ES000 (for ES students) when you get it. Watch out for regular announcements by the Academic Advisor via this course.
7. If you plan on going abroad to take courses or do an internship, you should start organizing your stay abroad (Section 1.7.1) **during the second quarter** of your studies.
8. **Once you have obtained 30-40 EC** fill in the study program form, sign it, and submit it to student administration (Section 10.1.8). We recommend that you discuss your study program with your mentor or graduation supervisor as well. If you are an EIT Digital student and TU/e is your entry-point university, you should do this before the end of the third quarter. If you are an EIT Digital student and TU/e is your exit-point university, or a BDMA-student you should do this before the end of the second quarter.
9. If you are an Embedded Systems student (following the regular ES program and not the EIT-ES program), then you need to do a preparation for graduation project (Section 6.3). It usually takes place in the **first and second quarter of the second year**.
10. **Half-way the second quarter of the second year** you should decide who will act as your graduation supervisor (Section 9). Please fill in the graduation plan form, attach a project description, sign the form, get a signature of the graduation supervisor and submit the papers to the student administration (Section 10.1.8). EIT-exit and BDMA-students should do this before the end of the second quarter of their Eindhoven year.
11. Consult the dates of the examination committee meetings and register for one of them **at the latest four weeks in advance** via OSIRIS (dates of the examination committee meetings are the same for all our master programs).
12. Ensure that the assessment committee is composed **at the latest one month before your final presentation**. The graduation supervisor must assemble the committee according to the regulations, sign the form, and submit it to the student administration for approval by the Examinations Committee.
13. After your final presentation, fill out the "Graduation Form", which you receive by email from the student administration. Submit it **two weeks before the examination committee meeting** to the student administration.
14. Attend the graduation ceremony (you can check the dates here). You will get an email with the invitation from the student administration.

Contents

Part I

General Information

1 Studying in the Computer Science Graduate Program

The Department of Mathematics and Computer Science (W&I) at the Eindhoven University of Technology (TU/e) offers undergraduate (Bachelor of Science), graduate (Master of Science) and postgraduate (PhD, PDEng) courses in Computer Science and Applied Mathematics.

The Computer Science Charter (CS) focuses on Algorithms, Formal Systems Analysis, Security, Software Engineering and Technology, System Architecture and Networking. The CS Charter offers its graduate and postgraduate courses in the Computer Science Graduate Program. There are two master programs:

- Computer Science and Engineering (CSE). This master program has a track on Information Security Technology (IST), an interdisciplinary variant in cooperation with the Mathematics Division of the TU/e and the Radboud University Nijmegen, and a track on Data Science in Engineering (DSiE), an interdisciplinary variant in cooperation with the Mathematics Division of the TU/e. Furthermore, this program has an EIT Digital Data Science track and hosts a Big Data Management and Analytics Erasmus Joint Master Degree.
- Embedded Systems (ES), an interdisciplinary master program in cooperation with the Department of Electrical Engineering (EE). This program has an EIT Digital Embedded Systems track.

The two postgraduate programs are:

- Software Technology, a Master of Technological Design (PDEng) program,
- The PhD program.

The CS Division also contributes to the Computer Science specialization of the master program Science Education and Communication (SEC), offered by the Eindhoven School of Education (ESoE), see https://www.tue.nl/esoe. Graduates in the CS specialization

from the program are entitled to teach computer science at Dutch high schools. Graduates from one of the above mentioned master programs will also be admitted to the SEC-program and are offered a one-year program. Since 2009, a double-degree program is offered for CSE & SEC (see Section 3.5) which comprises 150 credits.

1.1 Structure of the master programs

All master programs comprise two years of study or 120 credit points (EC); a credit point is equivalent to 28 hours of study and homework for an average student. Most courses are standardized to 5 credit points per course.

The two years of course work and practical training are divided into four parts, consisting of:

1. Mandatory core courses to create a sufficient layer of theory and general or program-related knowledge.

2. Elective courses to prepare for the specialization. Depending on the specialization there may be a longer or shorter list of preferred electives. In addition there is room for free electives. Most of the master programs are organized in *streams*. You choose a stream (with corresponding core courses and/or elective package) when you start the master. You are allowed to switch between streams after the start, provided that you can still fulfill the requirements of the stream you wish to switch to.

3. International experience. Students who do not have any international experience (a degree from another country or at least 15 EC of credits from a university outside the Netherlands) are encouraged to take courses abroad or to do an internship abroad.

4. Master project and thesis to be spent on a specialist topic of theoretical or practical nature. This part presents the opportunity to show your independent engineering and academic skills in research and design. (International experience can also be gained by doing the master project abroad.)

1.2 Rules and regulations

Master programs of the department are subject to the following rules and regulations.

- Program and Examination Regulations. This is a legal document describing the master program. Topics covered include admission, structure of the program, testing and final examinations, study counseling and transitional arrangements.
- Regulations of the Examination Committee. Topics covered include exams, fraud, graduation and internship.
- Directive Double Diplomas.

The aforementioned documents can be found on the websites of the master programs: CSE (including DSIE, IST, EIT-DS and BDMA), ES (including EIT-ES).

Furthermore, everyone involved in education and research at TU/e bears personal responsibility for observing and maintaining scientific integrity. At TU/e we require strict

compliance with the overall principles of professional scientific conduct in all cases. TU/e has its own Code of Scientific Conduct effective on September 1, 2014. Please read the code of conduct very carefully: you will be required to sign a declaration stating that you have read it and carrying out research, design and educational activities, you shall observe the five central values of scientific integrity, namely: trustworthiness, intellectual honesty, openness, independence and societal responsibility, as well as the norms and principles which follow from them.

A particular kind of integrity violation is **academic fraud**. Fraud includes any behavior or negligence on part of the student that makes it impossible for an examiner to form a correct judgement of his or her knowledge, insight and skills, or that is aimed at intentionally manipulating the examination process. Examples of fraud include identity fraud (e.g., when a student offers their work to others with the aim, knowledge or expectation that this work be submitted it as their own work), exam fraud (e.g., using not-allowed materials during an exam), plagiarism (e.g., taking credit for material that is not your own) and scientific fraud (e.g., fabricating data). In cases of fraud sanctions may be imposed not only on the perpetrator but also on others who are complicit in the fraud. Examples of possible sanctions in case of fraud are denying the student the right to take one or more examinations during a period up to one year or termination of the student's enrollment.

1.3 Lecture and interim examination periods

Each study year is divided into two semesters (September to January and February to July). Each semester consists of two quarters (quartiles), each consisting of eight weeks of lectures followed by an examination period of two weeks.

Quarter	Period
1	August 31, 2020—November 7, 2020
2	November 9, 2020—January 30, 2021
3	February 1, 2021—April 17, 2021
4	April 19, 2021—July 3, 2021
interim	August 9, 2021—August 14, 2021

You are expected to be available and present during all weeks with classes as well as weeks with exams. Some courses may have activities planned during the exam weeks, not yet scheduled before the course starts. Going on vacation during weeks with classes or with exams is not a valid reason for missing an activity!

1.4 Course and exam registration

Participation in a course is possible only if you have registered for the course via OSIRIS. In the first quarter, the registration deadline is set at the end of the first lecture week. In the remaining quarters, this deadline is in the week before the lectures start. Furthermore, the Graduate School would like to encourage you to enroll on time for your courses, this is

mainly due to plannings issues in the past. This registration deadline is 15 days before the start of classes.

During the registration period, weeks, it is possible to withdraw from the course via OSIRIS yourself. Outside this period, it is not possible to withdraw from the *course*. You can withdraw from the *exam* by notifying the student administration through OSIRIS. Withdrawing from the exam is possible no later than five working days before the examination period.

Please note that the *course* you register for, determines the regulations you have to follow. If you take a Bachelor College course, Bachelor College regulations apply (even if you are a Graduate School student). This rule is of particular importance for pre-master students as well as students with prescribed/recommended homologation courses. You should consult OSIRIS and check whether the course you intend to take is a Bachelor College course or a Graduate School course. Please keep the following rules in mind:

- students that have successfully completed a pre-master program are not allowed to take Bachelor College courses as part of their master program;
- students desiring to take as part of their master program a Bachelor College courses, that have not been prescribed/recommended upon admission, should submit a motivated request to the examination committee.

Important, especially for Bachelor College graduates: Registration for a course does not constitute an automatic registration for the exam. You have to register for each exam separately via OSIRIS before the set deadlines. Note that if you are not registered for an exam, you cannot take part in it. (The lecturer has no authorization to register students for the exam.) For courses that are evaluated through assignments you do not need to register for the exam as there is no exam.

1.5 Examination and titles

In an examination at the end of the program the examination committee verifies and judges the final course results and the final master project grade. Completion of the program will lead to the title: *Master of Science* (MSc) with addition of the name of the program. Graduates are also entitled to use the Dutch title of *ingenieur* (ir).

1.6 Admissions

General and specific master program requirements are applicable to admissions. The specific requirements for admission to each of the master programs are described in the corresponding chapters.

1.6.1 General admissions requirements

To be eligible for admission to any of the master programs, a Bachelor of Science degree is required. This degree must be of an equivalent academic level and approximate scientific content as the corresponding Dutch BSc degrees. In addition, sufficient proficiency in the English language is required.

1.6.2 Admissions with deficiencies

For admitted students from other universities, it may be necessary to repair deficiencies due to differences in programs. The admission committee will point out those so-called homologation courses to the students directly or via the academic advisor.

1.6.3 Foreign students

The applications of students with a foreign university BSc degree will be evaluated by the admissions committee, taking into account both the academic level of the degree and the subjects studied by the applicant. Here too a homologation program may be required. In some special cases, relevant work experience may also be considered. The level of the degree is determined by the national organization EP-NUFFIC (https://www.epnuffic.nl).

1.6.4 Polytechnic graduates (HBO)

Students who have completed a polytechnic program may be eligible to participate in the pre-master programs of 30 EC. Completion of the pre-master program gives access to the corresponding master program. In Chapter 2 further details about admission for HBO students and the premaster program can be found.

It is not possible to follow additional homologation courses in a master program after a finished pre-master. For a deficiency that exceeds 30 EC, students are advised to enroll in the preparatory Bachelor's program.

1.6.5 Admissions procedure

The procedure to be followed depends on your particular situation. Detailed information on the application procedure can be found on the site of the Education and Student Service Center of the TU/e, https://www.tue.nl/en/education/. Foreign students must be aware that the admissions procedure, including visa application and other formalities, may take a considerable amount of time. In order to avoid delay in the start of your master study it is important to register and start the application procedure long in advance deadlines can be found at the link above.

1.7 Eindhoven and more

You might also consider including in your study program courses offered by other universities or taking an internship in a company or research institution. In general, any course offered at the master level by any Dutch university might be included **as long as it approved by the Examination Committee** (see Section 1.9).

1.7.1 International Experience

In normal circumstances, the TU/e strongly encourages students to get international experience. Due to the Corona Virus situation in 2020, this may be less feasible in academic year

2020-2021. If you are interested in studying abroad, please be sure to check the most up-to-date information about international travel online. Students who do not have a degree or certificate(s) for at least 15 EC obtained from a university in another country are encouraged to gain that experience during their master study. Several options are available:

- Take subjects at a university abroad (at least 15 EC)
- Do an internship abroad (at least 15 EC, which is roughly 3 months)
- Do (a part of) the graduation project abroad

Procedures related to obtaining an international experience are further detailed in the "International experience guide", available at https://educationguide.tue.nl/programs/graduate-school/masters-programs/ (choose your master program, "Internship and Exchange").

Organizing your stay abroad requires careful planning. It is therefore essential that you contact the faculty international office as early as possible: Exchange.MCS@tue.nl The international office can help you with the learning agreement, international insurances and scholarships. Every Monday, the departmental exchange coordinator organizes an open hour from 3 to 4 PM at MF5.150. You can come by without an appointment for questions regarding your international experience. For more information about grants, scholarships visa and insurance, you can also take a look on https://educationguide.tue.nl/broadening/exchange-programs-for-studying-abroad/. Since obtaining international experience is not a valid reason for not following mandatory or prescribed homologation courses, you are strongly encouraged to take those courses during the first year such that part of the second year can be spent abroad.

1.7.2 Internship

An internship takes 15 EC as part of the (free) electives and can be performed in the Netherlands or abroad, at a company or at a research institution. **Internship and graduation project should not be executed at the same company**.

Doing an internship requires approval from the academic advisor (see Section 10.1.7 for their office, email address and contact hours). This approval must be obtained *in advance*. The procedure consists of:

- the internship plan, a form to be handed in at CSA.MCS@TUE.nl;
- a request stating what is to be accomplished in the internship and why it is important for the coherence of your study program; (You may ask your mentor, graduation supervisor or the academic advisor for advice on internships and on the coherence of your program as a whole. These topics are also addressed in the Program and Examinations Regulations.)
- students requesting to perform an internship should also either have their study program been approved, or submit the study program form[1] together with the internship plan.

[1]Select the form corresponding to your program from the list available on the website.

1.8 Admission to seminars, capita selecta, master project

Capita selecta courses (5 EC) are occasional educational elements, often with a research flavor. They may be experimental courses, a lecture series given by a visitor, or a special individual assignment as a preparation on future research. As opposed to regular courses, Capita Selecta courses are by invitation only, i.e., while you can indicate your interest in following this course it is up to the lecturer to decide whether you are admitted or not. Students, hence, do not have a "right" to do these courses, but they may be granted the possibility.

The seminars, capita selecta, and master project are only open to students that are fully admitted. This means that they are not available for students that do not yet have their BSc diploma or students that did not yet complete the pre-master. Students are only allowed to take a seminar when they are at least in the fourth quarter of their study. Students that still have deficiencies (e.g. uncompleted homologation courses) are not allowed to start the master project. Each master program has additional specific rules regarding permission to start the master program and the allowed choices of graduation supervisor.

1.9 Approval of study program

The Examinations Committee must approve your program consisting of the mandatory courses and your choice of the electives (possibly including an internship). In order to obtain this approval you construct a program, possibly with the help of your mentor and academic advisor, fill out the program form, sign it, get it approved by your mentor or graduation supervisor and hand it to the student administration CSA.MCS@TUE.nl . To make sure you do not miss courses you should choose it is recommended to submit your study program around the start of Quarter 3 of your first year. If needed you can still make changes later and reapply for approval.

1.10 Honors programs

Two different honors programs are available for excellent students: Research CS Honors and Honors Academy. Students of all Master programs offered by the Computer Science division can apply. Both honors programs are extracurricular, i.e., done **on top** of the regular Master program, that is, the EC obtained do not count towards the 120 credits you need to accumulate for your Master program.

More information about the honors programs can be read below or obtained from the honors programs' coordinators dr. Kevin Buchin, e-mail k.a.buchin@TUE.nl and dr. Wouter Meulemans w.meulemans@TUE.nl .

1.10.1 CS Research Honors

The goal of the program is to give excellent students the opportunity to participate in and contribute to the research being done at the department. Concretely, the Honors program consists of:

- Two projects for 6 EC each, one in the third and fourth quartiles of the first year of the Master program and another one in the first and second quartiles of the second year. These projects can be research-oriented or design-oriented and are done in different research groups in the department. The exact contents of the projects is determined by the supervisor of the research group where the project is done, in consultation with the student. The expected outcome of the project is a paper (published as a technical report of the department, and possibly also elsewhere).
- Beside the projects, the student participates in other activities of the research group (for example in research seminars) and is encouraged to participate in activities organized by one of the national Dutch research schools (ASCI, IPA, or SIKS). The latter activities are typically short courses or conferences.

Students who successfully complete the Honors program will receive a certificate upon graduation.

Participating in the Honors program is especially useful if you are interested in taking a PhD later on, since it allows you to experience what it is like to do research in two different areas. But above all, the Honors program is challenging and fun.

The program is aimed at highly motivated excellent students (among the top 10% of the Master students in the department) who had outstanding grades in their Bachelor programs and scored high grades during the first semester of the Master program (average at least 8). For admission to the honors program, an application procedure applies. Detailed instructions for application and the deadline will be announced by e-mail to all students in February of each year.

1.10.2 Honors Academy

Honors Academy is the university-broad program. It consists of two interrelated components: personal leadership development (5 EC) and professional development (15 EC). Activities related to the personal leadership component target students of all master programs and are organized by the Graduate School. Professional development activities might be related to 'excellence for science', 'excellence for industry' and 'excellence for society'. Examples of such activities can be international or industrial internships, taking courses at other universities or designing a business plan.

You can apply by submitting an application letter to the the honors programs' coordinators dr. Kevin Buchin, e-mail k.a.buchin@TUE.nl and dr. Wouter Meulemans w.meulemans@TUE.nl . In this letter you should motivate why you want to join the honors academy and what makes you an excellent candidate for the professional development as well as personal leadership part. You need to enclose two appendices: (1) evidence of your past performance and (2) a tentative plan for your professional development: what do you want to achieve and how?

1.11 Internal quality assurance

After each semester the individual courses as well as the program are evaluated by the educational management and the study program committee. Based on this evaluation follow-up actions for improvement are defined if necessary. Input for the evaluation sessions are statistical data on the examination results, and the aggregated results from the semester

questionnaires for students. It is of vital importance that students cooperate in this respect since only questionnaires with a sufficient number of respondents are taken into consideration. Apart from that, the examination committee periodically carries out an investigation, in particular on the quality of the graduation projects and the quality of (partial) interim examinations.

The opinion of students on the quality of their graduation project and process is gathered by means of a graduation questionnaire, which is filled in after the assessment of the graduation project. These are collected and aggregated once a year. The results are discussed both in the study program committee and examination committee.

1.12 Individual support

Within the first few weeks of your study a *mentor* will be assigned to you. To allow us to assign you the mentor please register for one of the courses as indicated in the list below. The mentor will advise you with regards to the development of your professional skills and will help you in making the first choices for electives and in deciding which specialization best suits your interests.

At some point during your study your specialization will become clearer. You choice should be clear by the end of the first year of study. At that point, you may decide you want to switch mentors to someone who specializes in that field. The new mentor will then help you in selecting elective courses to prepare you for doing a master project in your area of interest and in selecting a trajectory for getting international experience (if needed).

For procedural aspects of your study such as obtaining approval of your study program and getting official permission to start your master project you should consult the academic advisor (see section 10.1.7). You can also discuss personal or study-related programs with the academic advisor; they can also refer you to student psychologists, should this be desired.

1.12.1 Mentoring

For the academic year 2020–2021 mentors will be assigned in the following Canvas courses.

- 2IMC96 Computer Science and Engineering, Software Science stream
- 2IMC94 Computer Science and Engineering, Systems Science stream
- 2IMC95 Computer Science and Engineering, Web Science stream
- 2IMC90 Data Science in Engineering
- 2IMC93 EIT Digital Data Science (entry)
- 2IMC98 EIT Digital Data Science (exit)
- 2IMC85 EIT Digital Embedded Systems (entry)
- 2IMC86 EIT Digital Embedded Systems (exit)
- 2IMC84 Embedded Systems, Cyber-Physical Systems stream
- 2IMC83 Embedded Systems, Embedded Networking stream
- 2IMC82 Embedded Systems, Embedded Software stream
- 2IMC81 Embedded Systems, Systems on Chip stream
- 2IMC99 Erasmus Mundus Big Data Management and Analytics

- Information Security Technology: dr. Nicola Zannone

1.13 Final project

The start of your master project is marked by submitting a completed graduation plan containing the necessary information on the project (name, place, period, supervisor, and so on), and stating the fact that you have completed your curricular part of the program (see Section 1.9). The form must be accompanied by a project description and signed by you and your supervisor, and then turned in to CSA.MCS@tue.nl for approval.

You do not need to register for the master project in OSIRIS.

1.13.1 Admission

During the master project, you should be able to work and concentrate on your project full-time. In practice, however, it turns out to be rather difficult to plan all your curricular activities and, especially, their success:

- If all courses have been completed, permission to start the master project will be granted.
- If more than two courses or 12 EC (whichever is lower) have not been completed, such permission will not be granted.
- In other cases (no more than two courses or 12 EC not yet completed) it depends on the status of the uncompleted courses whether permission to start the master project will be granted, and if so, whether it is feasible to work on the project full time.

Courses that are to be taken as homologation units must be completed and passed before you are allowed to start the master project. Also, be aware that you are not allowed to finish your project (with presentation and defense) before you have completed all your courses. For more information, please contact the academic advisor, Academic.Advisor.MCS@tue.nl.

1.13.2 Planning

Together with your supervisor, you decide on a description of your topic and a global planning. You also arrange the supervision method, including how often you and your supervisor will meet to discuss progress. The project is concluded with a thesis and a presentation followed by a defense.

In general, the master project should be completed within 6 months from the start. An extension to 9 months is possible by discussion with your graduation supervisor. In case of the supervisor's approval no further approval is needed for an extension up to 9 months.In exceptional cases, and only if it is clear that the project can be finished, the exam committee may allow for an additional 3 months period. It is important to note that the project must be finished within 1 year. A project not finished within 1 year is automatically cancelled and graded as "fail". You then have to start a new project with a different supervisor. The complete examination regulations can be found on the website.

1.13.3 Confidentiality of MSc thesis

Please visit the Intranet website for information on the confidentiality period of your MSc thesis.

There are the following three options:

- the thesis is *public*. This is the preferred option. Only public theses can be nominated for university-broad or national thesis awards, such as KNVI Thesis Prize for Informatics and Information Science or VERSEN MSc thesis award.
- the thesis *confidential for two years*. This option is possible for company-based projects only.
- the thesis is *confidential for five years*. This option is also possible for company-based projects only and requires approval of the Graduate program director. Graduation supervisor should submit a motivated request why the extended confidentiality period is required.

Confidentiality period should be discussed with the company in the beginning of the graduation project. This can prevent unexpected surprises during the project or extra work incurred on the student due to the need to adjust or rewrite significant parts of the thesis.

1.13.4 Final presentation and defense

The final presentation is public and is held in buildings of Eindhoven University of Technology or via video call due to Corona pandemic. Please check with your supervisor to see which option(s) is/are allowed at the time of your defense and best for your committee members. It is customary that the final presentation takes ca. 30 minutes. The defense following the presentation, however, is not public; only the student and the assessment committee (see below) are present unless both parties have no objection to the presence of others.

1.13.5 Assessment

Your final project is graded by an assessment committee. The committee usually consists of your supervisor, a staff member from your specialization area, and a staff member from one of the other CS research groups. The supervisor is responsible for forming this committee at least one month before graduation.

The assessment committee takes the following criteria into account:

Results:	Significance of the results versus difficulty of the problem or project goals.
Report:	Structure, completeness, correctness, readability, argumentation.
Graduation presentation:	Structure, contents, clarity, contact with audience.
Defense:	Argumentation, demonstration of knowledge, competency in discerning main aspects from details of the project.
Execution of the project:	Level of independence, planning, organization, handling deadlines and setbacks, level of own contribution.

The actual assessment form used by the committee has a more fine-grained list of criteria for evaluating the work. Not all criteria are equally important. The assessment committee

decides the relative importance of each criterion to arrive at a final grade. The motivation for the grade is documented in an assessment report, see the MSc assessment form.

1.13.6 Cum laude regulations

The Examination Committee may award the classification "cum laude" to students who started their degree programs on or after September 1, 2019 under the following conditions:

- they achieve a weighted mathematical average (based on credits) that is a unrounded 8.0 or higher in relation to the study components takes by students that belong to the program of examinations, with exception of the graduation project,
- they have a grade of 9.0 or higher for the graduation project, and
- none of their study components belonging to the program of examinations has a final grade lower than a 6 and
- they must finish the final examination within 32 months of the commencement of the degree program. The examination committee may deviate from this latter requirement in special cases.

The Examination Committee may award the classification "cum laude" to students who started their degree programs before September 1, 2019 under the following conditions:

- they achieve an mathematical average of 8.0 or higher for the assessments of study components that belong to the program of examinations, and
- a grade of 9.0 or higher for the graduation project, and
- none of the study components belonging to the degree program may have a grade lower than a 6.0.

1.13.7 Checklist

The graduation checklist summarizes all the steps required starting with getting your study program approved and ending with the graduation ceremony.

1.14 After graduation

As an MSc graduate from the Computer Science Graduate Program, you are optimally prepared for a broad range of ICT-related jobs. However, you might consider to qualify yourself further for special jobs like system or software architect or for an academic career. In the latter case, the department of Mathematics and Computer Science offers the following opportunities.

1.14.1 Software Technology PDEng degree program

The Professional Doctorate in Engineering (PDEng) degree program in Software Technology is provided in the context of the 3TU School for Technological Design, the Stan Ackermans Institute.

It is an accredited and challenging two-year post-graduate-level engineering degree program during which its trainees focus on strengthening their technical and non-technical

competences related to the effective and efficient design and development of software-intensive systems, such as real-time embedded systems, in an industrial setting. The emphasis is on large-scale project-based design and development of this kind of software.

The various parts of the PDEng degree program aid to develop the capability of individuals to work within a professional context. It advocates a scientific research-based approach to solving problems, a systematic way of collecting evidence and a critical, reflective, and independent mind for the analysis and interpretation of evidence.

It adds an additional dimension to a full MSc. program by extending it and integrating it with new elements. The emphasis is on developing and strengthening (exercising) the competencies necessary for finding complex technical solutions. For finding such solutions, an effective collaboration with representatives of different domains is inevitable, and this is practiced during the program. During the program, the PDEng trainees focus on multi-disciplinary systems architecting and designing software for software-intensive systems in multiple application domains for the High Tech Industry.

After successfully completing all requirements, trainees are awarded a Professional Doctorate in Engineering degree. More information can be found on: https://www.tue.nl/softwaretechnology

1.14.2 PhD programs

While obtaining a PhD is the first step in the academic career, numerous PhDs develop successful careers in industry, government and non-academic education.

A PhD program is an individual four year program, dedicated to sharpening your research and professional skills. You are typically hired on a specific research project and become part of the scientific staff of the research group in which the project takes place. Your main task is to perform research under the guidance of and in collaboration with the supervisor(s) appointed by the Department. At the end of the four-year period, a PhD thesis is written on the research results. You do not only perform research, but also receive scientific training and training related to professional skills and personal development. Moreover, some PhD students are involved in teaching and supervision of Master students.

More information about PhD programs can be found on: https://www.tue.nl/en/education/tue-graduate-school/phd-programs/

2 Pre-master programs

2.1 General rules

- The pre-master programs have only one starting moment (September).
- Students that have successfully completed a large part of their pre-master program during the first half-year of their studies and would be at a demonstrable disadvantage should they be required to wait for the completion of the pre-master prior to joining the master program, can apply for a special permission of the Examinations Committee to follow master study's components:
  - Students should have to pass all courses during the first half year to be eligible for this exception.
  - Students following a 30 EC pre-master program that can be followed within half a year are not eligible.
  - Maximum of 15 EC of master study's components can be approved.
  - The eligible courses have to be determined in advance.
  - The application should be discussed with and submitted to the academic advisor (see below).
- Please note that the *course* you register for, determines the regulations you have to follow (see Section 1.4). You should consult OSIRIS and check whether the course you intend to take is a Bachelor College course or a Graduate School course.
- Successful completion of the pre-master program grants admission to the *corresponding* master program. Pre-master graduates cannot be admitted to international programs (EIT Embedded Systems, EIT Data Science, Erasmus Joint Master Degree: Big Data Management and Analytics).

It is not possible to follow additional homologation courses in a master program after a finished pre-master. For a deficiency that exceeds 30 EC, students are advised to enroll in the preparatory Bachelor's program.

2.2 Computer Science and Engineering

The pre-master program for a student with a completed polytechnic program in computer science totals to 30 EC and consists of the following units:

Quarter	Code	Unit	ECTS
1	2WBB0	Calculus	5
1	2IT60	Logic and set theory	5
1	2IHA10	Algorithms and data structures	5
2	2ID50	Data modeling and databases	5
2	2DE29	Basic linear algebra	5
2/3	2ITS90	Automata, language theory and complexity	5

2.3 Data Science in Engineering

The pre-master program for a student with a completed polytechnic program in computer science totals to 30 EC and consists of the following units:

Quarter	Code	Unit	ECTS
1	2DL10	Premaster calculus and probability	5
1	2IT60	Logic and set theory	5
1	2IHA10	Algorithms and data structures	5
2	2ID50	Data modeling and databases	5
2	JBM010	Data Statistics	5
3	2DE20	Mathematics 1	5

Furthermore the pre-master program will be expanded with the study component 2IMV20 Visualization.

2.4 Information Security Technology

The pre-master program for a student with a completed polytechnic program in computer science totals to 25 EC and consists of the following units:

Quarter	Code	Unit	ECTS
1	2WBB0	Calculus	5
1	2IT60	Logic and set theory	5
2	2WF80	Introduction to cryptology	5
4	2IC80	Lab on offensive computer security	5
4	2IC60	Computer networks and security	5

It is recommended to follow also 2WF90 Algebra for security

2.5 Embedded Systems

The pre-master program for a student with a completed polytechnic program in computer science or similar totals to 30 EC and consists of the following units:

Quarter	Code	Unit	ECTS
1	2DL10	Premaster calculus and probability	5
1	5ECA0	Circuits	5
1	2IT60	Logic and set theory	5
2	5LIU0	Premaster Linear Systems, Signals and Control	5
3	2DE20	Mathematics I	5
4	5XIE0	Computational modeling	5

The pre-master program for a student with a completed polytechnic program in electrical engineering or similar totals to 30 EC and consists of the following units:

Quarter	Code	Unit	ECTS
1	2DL10	Premaster calculus and probability	5
1	2IT60	Logic and set theory	5
2	2INC0	Operating systems	5
2	5LIU0	Premaster Linear Systems, Signals and Control	5
3	2DE20	Mathematics I	5
4	5XIE0	Computational modeling	5

Part II

Master Programs

3 Computer Science and Engineering

The Master program in Computer Science and Engineering (CSE) gives a broad view of computer science from both a scientific and an engineering perspective, and provides ample opportunities for specialization. The program offers three different streams: Software Science, Systems Science, and Web Science and the possibility to follow a program partly outside these streams, for instance to prepare for getting a teaching degree. Each stream has a core program of five courses. There is a large list of stream electives from which you should choose some courses to prepare for your master project. There is also ample room in the program to choose electives from outside your stream. Apart from the three streams there are also two special tracks: Data Science in Engineering and Information Security Technology. These are described in separate chapters in this document.

3.1 Admission

A Bachelor degree in Computer Science obtained at a Dutch university provides direct admission to the CSE program. Students with a different degree and from foreign universities have to apply for admission via the admission committee on Studielink. Dutch HBO graduates have to take a pre-master program before they can be admitted, see Section 2.2.

The admission procedure is described on https://www.tue.nl/en/education/become-a-tue-student/admission-and-enrollment/, and the requirements are listed in the Program and Examination Regulations (see Appendix A.1).

3.2 Learning outcomes

A graduate from the master program

- is qualified to degree level within the domain of 'science engineering & technology';
- is competent in Computer Science and Engineering at the scientific Master's degree level;
- is able to conduct research and design independently;

- has the ability and attitude to include other disciplines in their research, where necessary;
- has a scientific approach to complex problems and ideas;
- possesses intellectual skills that enable them to reflect critically, reason and form opinions;
- has the ability to communicate the results of their learning, thinking and decision-making processes at an international level;
- is aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in their scientific work;
- in addition to a recognizable domain-specific profile, possesses a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context. In this context, multidisciplinary means being focused on other relevant disciplines needed to solve the design or research problem in question;
- has the ability and attitude to seek new potential applications, taking the social context into consideration.

In addition to these general learning outcomes, CSE graduates should also be experts in the subarea of computer science that they specialize in.

3.3 Curriculum

The Master program Computer Science and Engineering is a two-year program of 120 ECTS in total. The academic year is subdivided into two semesters, the fall semester starting in September, and the spring semester starting in February. It is possible to enter the program at the start of either semester; however, starting in September is preferred. The program is only offered as a full time study program.

The CSE curriculum is structured in *streams*, which provide an organized set of courses in particular subject areas within computer science. The streams provide guidance for the directions in which you can specialize, and ensure that you choose a comprehensive and coherent set of courses. When you enroll to the CSE master you should choose a stream right away because this determines the list of mandatory courses and the assignment of a mentor. The streams are:

- Software science (Section 3.3.1)
- Web science (Section 3.3.2)
- Systems science (Section 3.3.3)

Each stream has the same structure, as summarized in the following table.

Units	ECTS
CSE mandatory course	5
Stream mandatory courses	15 or 20
Stream elective courses	25 or 20
Free electives	40
Seminar	5
Master project	30

Each stream has a number of mandatory courses, and a selected set of elective courses from which at least 20 or 25 EC should be chosen. There is great flexibility in defining the remaining part of your individual study program from all courses that are offered by the computer science department (40 credit points). Within this remaining part you might choose to include 15 credit points in international experience if you do not have it yet and are not doing your master project abroad. To prepare for the master project, you take a seminar course from one of the computer science research groups. In the following sections, more details for each of the streams are given.

3.3.1 Software Science stream

Innovative software systems are the driving force behind many exciting developments in society, industry, and science. However, designing software systems that function correctly, efficiently and securely, is far from easy. The CSE stream Software Science focuses on the formal techniques and technology you need for this. You learn model-driven engineering techniques to increase the quality of computer programs. As a graduate of the stream Software Science, you

- have in-depth knowledge of techniques needed to model and design efficient and reliable software
- understand the strengths and weaknesses of these techniques and can apply them in the appropriate situation, taking limitations of cost, time, and other resources into account
- can analyze existing software systems and understand the fundamental issues involved in software maintenance

Prior to the beginning of the academic year you should register for 2IMC96. For further information about mentoring please consult Section 1.12.1.

The following table lists the mandatory courses and stream electives.

Quarter	Code	Unit	EC	Total
CSE mandatory course				***5***
1	2IMA10	Advanced algorithms	5	
Stream mandatory courses				***15***
2	2IMP10	Program verification techniques	5	
3	2IMP25	Software evolution	5	
3	2IMD10	Engineering Data-Intensive Systems	5	
Stream electives [1]				***25***
1, 2, 3 or 4	SFC640	Academic Writing in English[2]	5	
1	2AMM20	Foundations of data-mining	5	
1	2AMI10	Foundations of process mining	5	
2	2IMA15	Geometric algorithms	5	
2	2IMP20	Generic language technology	5	
3	2IMF15	Proving with computer assistance	5	
4	2IMF10	Process algebra	5	
4	2AMD15	Big Data Management	5	
4	2IMV15	Simulation in computer graphics	5	
5	2IMG15	Algorithms for geographic data	5	

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Quarter	Code	Unit	EC	Total
Free electives (possibly including internship)				***40***
Seminar and master project)				***35***
4 or 6		**Seminar** [3]	5	
7 and 8	2IMC00	**Master project** [4]	30	

[1] *You have to choose at least 25 credit points from this list.*

[2] *Before registering for the SFC640, you must first complete the SFC600 English Placement Test on Canvas to assess your current level of English. Complete SFC600 at least SIX working days before the registration deadline. Only if you have positive advice from SFC600 will you be accepted in SFC640. 90% attendance is required.*

[3] *Seminars must be taken from the fourth quarter of your study program onwards. This means that if you enroll in September, you cannot take the seminars in quarter 2 in your first year, but that you have to wait until you have entered the second year. If you enroll in February, the seminars are effectively in the fourth quarter of your study.*

[4] *You can only start the master project if your individual study program has been approved by the Examinations Committee, and if all homologation units (if any) have been completed successfully, see also Section 1.13.*

3.3.2 Web Science stream

Over the past decade the use of web-based systems has exploded. Buying clothes, books, booking hotels, checking the weather forecast, contacting your friends: all of this is done on the internet, and novel web-based applications are developed every day. The CSE stream Web Science focuses on the technology behind these developments. In the stream you learn techniques needed to design intelligent and reliable web-based systems, their role in on-line business and you learn to analyze the use of such systems. As a graduate of the Web Science stream you

- have knowledge of the principles and technologies that drive the Web
- have the skills to design effective web-based systems, and to analyze existing web-based systems and the data generated through their use
- can design intelligent information services using semantic-web technology or machine-learning techniques
- have insight into business, privacy and security issues related to web-based systems

If you want to specialize more in the data-analysis aspect of Web Science you should consider the special track on Data Science in Engineering.

Prior to the beginning of the academic year you should register for 2IMC95. For further information about mentoring please consult Section 1.12.1.

The following table lists the mandatory courses.

Quarter	Code	Unit	EC	Total
CSE mandatory course				***5***
1	2IMA10	Advanced algorithms	5	
Stream mandatory courses				***20***
1	2AMM20	Foundations of data mining	5	
2	2IMV20	Visualization[1]	5	

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Quarter	Code	Unit	EC	Total
4	2AMM10	Deep learning	5	
4	2AMD15	Big Data Management	5	
Stream electives [2]				***20***
1, 2, 3 or 4	SFC640	Academic Writing in English[3]	5	
1	2IMV25	Interactive virtual environments	5	
1	2IMS25	Principles of data protection	5	
2	2IMS20	Cyberattacks Crime and Defenses	5	
3	2AMM15	Machine Learning Engineering	5	
3	2MMD30	Graphs and algorithms	5	
3	2IMV10	Visual computing project	5	
4	0EM190	Infonomics	5	
Free electives (possibly including internship)				***40***
Seminar and master project)				***35***
4 or 6		**Seminar** [4]	5	
7 and 8	2IMC00	**Master project** [5]	30	

[1] *Students that took JBI100 are not allowed to follow this course due to overlap. They have to take 2AMV10 Visual Analytics instead.*

[2] *You have to choose at least 20 credit points from this list.*

[3] *Before registering for the SFC640, you must first complete the SFC600 English Placement Test on Canvas to assess your current level of English. Complete SFC600 at least SIX working days before the registration deadline. Only if you have positive advice from SFC600 will you be accepted in SFC640. 90% attendance is required.*

[4] *Seminars must be taken from the fourth quarter of your study program onwards. This means that if you enroll in September, you cannot take the seminars in quarter 2 in your first year, but that you have to wait until you have entered the second year. If you enroll in February, the seminars are effectively in the fourth quarter of your study.*

[5] *You can only start the master project if your individual study program has been approved by the Examinations Committee, and if all homologation units (if any) have been completed successfully, see also Section 1.13.*

3.3.3 Systems Science stream

High-tech systems are defined by a tight interaction between physical systems and computing systems. They are often called "Cyber-Physical Systems". They are characterized by complex architectures and complex interactions between physical sensors and actuators control, computation, and communication. In the CSE stream Systems Science you study these new technologies and the process to develop them. Protocols, interfaces and algorithms need to be designed to improve (energy) efficiency and automation. Larger systems are never built from scratch anymore, but composed from existing building blocks. An understanding of the essential structures and behaviors of a system - the architecture, laid down in models - is therefore essential. Models are further used to validate—often using mathematically based methods—and monitor required qualities (reliability, robustness, safety, security and privacy), and to drive the implementation. Experimentation and online methods (like self-monitoring) are essential ingredients. As a student graduating in the stream Systems Science you

- are familiar with the architectures and architectural principles of large-scale software systems

- are capable to apply complex model-based methods required for the rigorous functional and quantitative analysis of system behaviors
- understand the role of software—foundations as well as processes and tools—in its interaction with hardware and sensors in large-scale software-intensive systems.

Prior to the beginning of the academic year you should register for 2IMC94. For further information about mentoring please consult Section 1.12.1.

The following table lists the mandatory courses.

Quarter	Code	Unit	EC	Total
CSE mandatory course				***5***
1	2IMA10	Advanced algorithms	5	
Stream mandatory courses				***20***
1	2IMF30	System validation	5	
1	2IMF25	Automated reasoning	5	
2	2IMN15	Internet of Things	5	
3	2IMN20	Real-time systems	5	
Stream electives [1]				***20***
1, 2, 3 or 4	SFC640	Academic Writing in English[2]	5	
1	2IMN10	Architecture of distributed systems	5	
2	2IMN25	Quantitative evaluation of embedded systems	5	
3	2IMF35	Algorithms for model checking	5	
3	2IMS15	Verification of security protocols	5	
3	2IMD10	Engineering Data-Intensive Systems	5	
4	2IMN35	VLSI Programming	5	
4	2IMP30	System design engineering	5	
Free electives (possibly including internship)				***40***
Seminar and master project)				***35***
4 or 6		**Seminar** [3]	5	
7 and 8	2IMC00	**Master project** [4]	30	

[1] *You have to choose at least 20 credit points from this list.*

[2] *Before registering for the SFC640, you must first complete the SFC600 English Placement Test on Canvas to assess your current level of English. Complete SFC600 at least SIX working days before the registration deadline. Only if you have positive advice from SFC600 will you be accepted in SFC640. 90% attendance is required.*

[3] *Seminars must be taken from the fourth quarter of your study program onwards. This means that if you enroll in September, you cannot take the seminars in quarter 2 in your first year, but that you have to wait until you have entered the second year. If you enroll in February, the seminars are effectively in the fourth quarter of your study.*

[4] *You can only start the master project if your individual study program has been approved by the Examinations Committee, and if all homologation units (if any) have been completed successfully, see also Section 1.13.*

3.3.4 Free stream

The streams have been set up such that they provide a structured set of courses related to important topics in computer science. The "free stream" enables you to follow a different program. In any case you have to take the CSE mandatory course together with the four mandatory courses from one of the predefined streams (Software Science, Web Science or

Systems Science) but then take a set of electives that does not contain 20 EC from the stream electives of that stream. You have to ask permission to the Examinations Committee, and motivate why you cannot set up a desired individual study program that falls within one of the streams.

A commonly accepted reason for choosing the free stream is to follow a teacher-training program with courses and other credits from the Eindhoven School of Education (ESoE) aimed at obtaining a teaching degree (with or without going for a double degree). Instead of 20 EC in stream electives plus 40 EC in free electives you then take only 15 EC in electives from your chosen stream plus 45 EC as teacher training program.

3.3.5 Free electives

This section provides a list of courses that are generally recommended for the free electives space in the curriculum. The list applies to all streams. In principle all master courses offered at the TU/e can be chosen as free electives so you are not restricted to this list.

Your complete study program including the free electives always requires approval by the examinations committee by submitting your Study Program form to CSA.MCS@tue.nl. Study Programs that deviate from the standard should include a motivation. Your mentor will help you to compose a balanced program that is very likely to be approved.

If you do not (yet) have a degree from another country or at least 15 credit points in international experience you are encouraged to reserve 15 credits from the room for free electives to take courses abroad or to do an internship of 15 credits abroad, see Section 1.7.2. (This does not apply to students taking the teacher training.)

Quarter	Code	Unit	EC
1	2IMM20	Foundations of data-mining	5
1	2IMN10	Architecture of distributed systems	5
1	2IMA10	Advanced algorithms	5
1	2IMV25	Interactive virtual environments	5
1	2IMF25	Automated reasoning	5
1	2IMF30	System validation	5
1	2IMS25	Principles of data protection	5
2	2IMS20	Cyberattacks Crime and Defenses	5
2	2IMP10	Program verification techniques	5
2	2IMA15	Geometric algorithms	5
2	2IMN15	Internet of things	5
2	2AMI20	Advanced process mining	5
2	2IMN25	Quantitative evaluation of embedded systems	5
2	2IMV20	Visualization [1]	5
2	2IMP20	Generic language technology	5
2	2DMT00	Applied statistics	5
3	2IMA25	Exact Algorithms for NP-hard Problems	5
3	2IMM15	Web information retrieval and data mining	5
3	2IMF15	Proving with computer assistance	5
3	2IMN20	Real-time systems	5
3	2IMP25	Software evolution	5
3	2IMV10	Visual computing project	5
3	2IMF35	Algorithms for model checking	5

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Quarter	Code	Unit	EC
3	2IMS15	Verification of security protocols	5
3	2IMD10	Engineering Data-Intensive Systems	5
3	2MMD30	Graphs and algorithms	5
3	2DI70	Statistical learning theory	5
4	2IMM10	Deep learning	5
4	2IMD15	Big Data Management	5
4	2IMF10	Process algebra	5
4	2IMG10	Topological data analysis	5
4	2IMN35	VLSI programming	5
4	2IMP15	Software project management	5
4	2IMP30	System design engineering	5
4	2IMV15	Simulation in computer graphics	5
4	2IMNT2	Real-time software development	5
4	2DD23	Time-series analysis & forecasting	5
5	2IMS10	Physical aspects of digital security	5
5	2IMG15	Algorithms for geographic data	5
		Seminars[2]	
4	2IMS00	Seminar information security technology	5
4	2IMA00	Seminar algorithms	5
6	2IMG00	Seminar applied geometric algorithms	5
6	2IMM00	Seminar data mining	5
6	2IMI00	Seminar analytics for information systems	5
6	2IMD00	Seminar databases	5
6	2IMN00	Seminar systems architecture and networking	5
6	2IMP00	Seminar software engineering and technology	5
6	2IMV00	Seminar visualization	5
6	2IMF00	Seminar formal system analysis	5
		Capita selecta courses/internship[3,4]	
	2IMF05	Capita selecta formal system analysis	5
	2IMP05	Capita selecta software engineering and technology	5
	2IMS05	Capita selecta security	5
	2IMA05	Capita selecta algorithms	5
	2IMG05	Capita selecta applied geometric algorithms	5
	2IMM05	Capita selecta data mining	5
	2IMN05	Capita selecta systems architecture and networking	5
	2IMV05	Capita selecta visualization	5
	2IMD05	Capita selecta databases	5
	2IMI05	Capita selecta analytics for information systems	5
	2IMC10	Internship[3]	15

[1] *Students that took JBI100 are not allowed to follow this course due to overlap.*

[2] *Seminars can be taken from the fourth quarter of your study program onwards. This means that if you enroll in September, you cannot take the seminars in quarter 2 in your first year, but that you have to wait until you have entered the second year. Similarly, if you enroll in February, the seminars in quarter 4 can only be followed in your second year.*

[3] *Capita selecta can only be taken with permission of the responsible lecturer. They can be taken at any time but typically during the second year of your master study.*

[4] *The internship can be followed only after having obtained permission of the internship coordinator (see Section 1.7.2).*

3.3.6 Homologation courses

Some courses may be prescribed or recommended as homologation courses (up to 15 EC) to make up for deficiencies in former education. This prescription/recommendation is part of the admission decision.

Upon discussion with your mentor and/or academic advisor and approval by the exam committee, you might include up to 15 EC of bachelor-level units as part of the free electives. It is not possible to follow additional homologation courses in a master program after a finished pre-master.

3.4 Final project

The final project of 30 credit points can be completed in any of the research groups in the CS-division. The practical execution may be performed in industry or a research institute, in the Netherlands or abroad, as long as a CS staff member is supervising it. See for more details on the final project Section 1.13.

3.5 Double degree program CSE and SEC

The qualification to teach computer science to senior secondary school pupils is coupled to the 3TU master program Science Education and Communication (SEC). This program encompasses 120 credits. In Eindhoven it is offered by the Eindhoven School of Education (ESoE). In the Education track of the SEC program, a student specializes in one of four disciplines: maths, physics, chemistry or computer science. Please note that the SEC program is completely lectured in Dutch!

BSc graduates in computer science are directly admitted to the SEC-program. So are MSc graduates from a computer science oriented program; their SEC-program is reduced to 60 credits because of exemptions. For this last category an even shorter route is available by taking the double degree program, which amounts up to 150 credits. Enrollment is required for both master programs (one main enrollment and a second enrollment). Certificates will be granted after completion of the whole program.

Details about the curriculum are available at the ESoE website: `https://www.tue.nl/esoe/`.

It is possible to take 45 credits worth of components of the SEC program within the CSE master. The TU/e strives to have this become sufficient to obtain a teaching qualification without doing a double degree CSE and SEC master.

4 Data Science in Engineering

A Master of Science in Data Science in Engineering (DSIE) is a multidisciplinary academic expert in many aspects of handling data and information. Growing amounts of data will significantly change the jobs of (future) engineers. A data scientist understands how to transform data into actionable information that can be used to influence operational processes, e.g. reducing waiting times in care processes, improving compliance in banks and making high-tech systems more robust. To this end the DSIE master combines topics from computer science, mathematics and industrial engineering.

The DSIE master is embedded as a special track within the Computer Science and Engineering (CSE) master.

After taking some courses, you will probably have a more clear picture of the academic direction you want to pursue in your studies. If not, you may want to talk to several staff members or the academic advisor. In the specialization for your subject, there are people that you may want to be involved with for your final master project (see Section 4.4). In order to compose a well-balanced program that provides adequate prerequisites for this project, it is advisable to first choose and consult a project supervisor in the specialization of your interest before choosing elective courses. As a rule of thumb, you should start your search for a supervisor and the construction of your individual program no later than at the end of your first year.

4.1 Admission

A Bachelor degree in Computer Science obtained at a Dutch university provides direct admission to the DSIE program. Students with a different degree and from foreign universities have to apply for admission via the admission committee. Dutch HBO graduates have to take a pre-master program before they can be admitted, see Section 2.3.

Admissions to the DSiE requires basic working knowledge and skills in the following subjects, as acquired in approved Bachelors level coursework: logic and set theory (2IT60), linear algebra (2DE29 or 2DBI00), data modeling and databases (2ID50), calculus-based statistics and probability (2DI90), and data structures and algorithms (2IL50 and 2ILC0).

Note that these courses themselves have mandatory prerequisites. Lack of knowledge in up to three of the indicated subjects can be compensated for during the Masters program.

The admission procedure is described in Section 1.6, and the requirements are listed in the Teaching and Examination Regulations (see Appendix A.1).

4.2 Learning outcomes

A graduate from the master program

- is qualified to degree level in the domain of science, engineering and technology;
- is competent in the relevant domain-specific discipline, namely computer science and engineering;
- is capable of acquiring knowledge independently;
- approaches computer-science problems in a thorough and scientifically founded manner;
- is capable of critical thinking, can reason logically and form opinions;
- has design skills, presentation skills, and communication skills;
- has insight into the role of computer science in industry, society, and science;
- and, in addition to a recognizable domain-specific profile, possesses a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context.

In addition to these general learning outcomes, a graduate from DSIE

- has a broad view of data science;
- should be able to understand and develop technology for handling structured and semi-structured and possibly distributed big data;
- should be able to analyse data to draw meaningful conclusions from data, effectively turning data into value;
- should understand the role of data in organisations, enabling the shift towards data-driven decision making in industry;
- should understand legal and social aspects of collecting, owning and manipulating data.

4.3 Curriculum

The Master track Data Science in Engineering is a two-year program of 120 EC in total. The academic year is subdivided into two semesters, the fall semester starting in September, and the spring semester starting in February. It is possible to enter the program at the start of either semester; however, starting in September is preferred. The program is only offered as a full time study program.

The DSIE curriculum contains courses from computer science and mathematics and electives from industrial engineering. It is structured similarly to other streams of the Master program Computer Science and Engineering (Section 3.3).

Units	ECTS
CSE mandatory course	5
Stream mandatory courses	25
Stream elective courses	20
Free electives	35
Seminar	5
Master project	30

The following table lists the mandatory courses and stream electives.

Quarter	Code	Unit	EC	Total
CSE mandatory course				***5***
1	2IMA10	Advanced algorithms	5	
Stream mandatory courses				***25***
2	2DMT00	Applied statistics	5	
2	2AMI20	Advanced process mining	5	
2	2IMV20	Visualization[1]	5	
3	2DI70	Statistical learning theory	5	
4	2AMD15	Big Data Management	5	
Stream electives [1]				***20***
1, 2, 3 or 4	SFC640	Academic Writing in English[3]	5	
1	2AMI10	Foundations of process mining	5	
1	2IMS25	Principles of data protection	5	
1	2AMM20	Foundations of data mining	5	
1	2AMS10	Longitudinal data analysis	5	
2	0LM190	Philosophy and Ethics of AI	5	
2	2IMP40	Applications of data science for software engineering	5	
3	2AMM15	Machine Learning Engineering	5	
3	2AMV10	Visual Analytics	5	
3	2IMD10	Engineering Data-Intensive Systems	5	
4	2DD23	Time-series analysis and forecasting	5	
4	2AMM10	Deep learning	5	
4	2AMS20	Statistic for big data	5	
4	2AMU20	Generative AI Models	5	
5	2IMG15	Algorithms for geographic data	5	
Free electives (possibly including internship)				***35***
Seminar and master project				***35***
4 or 6		**Seminar** [4]	5	
7 and 8	2IMC00	**Master project** [5]	30	

[1] *Students that took JBI100 are not allowed to follow this course due to overlap. They have to take 2AMV10 Visual Analytics instead.*

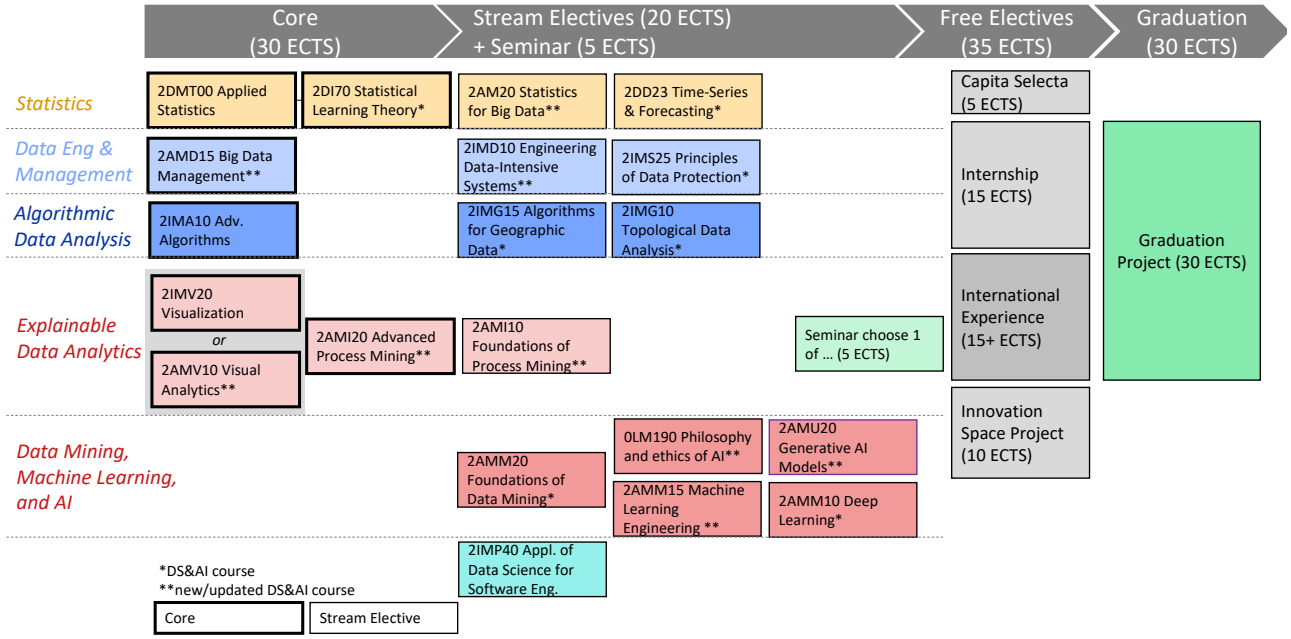
[2] *You have to choose at least 20 credit points from this list.*

[3] *Before registering for the SFC640, you must first complete the SFC600 English Placement Test on Canvas to assess your current level of English. Complete SFC600 at least SIX working days before the registration deadline. Only if you have positive advice from SFC600 will you be accepted in SFC640. 90% attendance is required.*

[4] *Seminars must be taken from the fourth quarter of your study program onwards. This means that if you enroll in September, you cannot take the seminars in quarter 2 in your first year, but that you have to wait until you have entered the second year. If you enroll in February, the seminars are effectively in the fourth quarter of your study.*

[5] *You can only start the master project if your individual study program has been approved by the Examinations Committee, and if all homologation units (if any) have been completed successfully, see also Section 1.13.*

The mandatory core courses and stream elective courses of DSIE belong to specialization areas within Data Science and Artificial Intelligence. The overview below shows to which specialization area each course belongs (see table above for when each course is scheduled).



Through the core program, you obtain foundations in 4 specialization areas (Statistics, Data Engineering and Management, Algorithmic Data Analysis, and Explainable Data Analytics). Through your electives, you can explore and dive deeper into specific specialization areas.[1]

You can consult mentors when you have questions about picking the right specialization for your own study program. Prior to the beginning of the academic year you should register for 2IMC90; registering for 2IMC90 gives you access to further program specific information, mentoring advice, and we can reach you for program-related announcements. For further information about mentoring please consult Section 1.12.1.

[1]The overview also shows which subjects have been introduced as new subjects or are being redesigned in relation to the planned Master program of Data Science and Artificial Intelligence (DS&AI). The DS&AI Master program builds on extends these specialization area. For more information about the planned Master program please consult Master Data Science and Artificial Intelligence

4.3.1 Alternative for teacher training stream

Like in the standard CSE program you can reduce the electives from the above list to 10 credits to make room for a 45 credit teacher training program offered by the Eindhoven School of Education (ESoE).

4.3.2 Free electives

In principle all master courses offered at the TU/e can be chosen as free electives.

- Stream electives can be chosen under free electives as well and we do recommend to take more than the required minimum number of stream electives.
- In addition, other courses from the CSE program (Chapter 3; course codes starting with 2IM...and 2AM...) as well as courses from the Operations Management and Logistics program (course codes starting with 1B... and 1C) are recommended. Taking courses from these programs as free electives gives you a profile as a Data Science "generalist".
- If you have a prior degree or specialization in a different domain, e.g., Physics, Bio-Technology, HTI, Mathematics, etc., you may consider courses from these programs as a free elective. Taking courses from these programs as free electives gives you a profile as a Data Science "specialist".

Your complete study program including the free electives always requires approval by the examinations committee by submitting your Study Program form to CSA.MCS@tue.nl. Study Programs that deviate from the standard should include a motivation. Your mentor will help you to compose a balanced program that is very likely to be approved.

If you do not (yet) have a degree from another country or at least 15 credit points in international experience you are strongly encouraged to reserve 15 credits from the room for free electives to take courses abroad or to do an internship of 15 credits abroad, see Section 1.7.2. (This does not apply to students taking the teacher training.)

4.3.3 Homologation courses

Some courses may be prescribed or recommended as homologation courses (up to 15 EC) to make up for deficiencies in former education. This prescription/recommendation is part of the admission decision. Upon discussion with your mentor and/or academic advisor and approval by the exam committee, you might include not more than 15 EC of bachelor-level units as part of the free electives.

It is not possible to follow additional homologation courses in a master program after a finished pre-master.

4.4 Final project

Prior to starting the final project you should first choose and consult the intended final project supervisor. As final project supervisors can act assistant professors, associate professors and full professors from the Computer Science sub-department within the Mathematics and Computer Science department. Furthermore, as final project supervisors of DSiE students can act assistant professors, associate professors and full professors from the Statistics

group of the Mathematics sub-department within the Mathematics and Computer Science department. If you are in doubt how to choose the graduation supervisor please consider contacting your mentor.

See for more details on the final project Section 1.13.

4.5 Double degree program DSIE and SEC

The qualification to teach computer science to senior secondary school pupils is coupled to the 3TU master program Science Education and Communication (SEC). This program encompasses 120 credits. In Eindhoven it is offered by the Eindhoven School of Education (ESoE). In the Education track of the SEC program, a student specializes in one of four disciplines: maths, physics, chemistry or computer science. Please note that the SEC program is completely lectured in Dutch!

BSc graduates in computer science are directly admitted to the SEC-program. So are MSc graduates from a computer science oriented program; their SEC-program is reduced to 60 credits because of exemptions. For this last category an even shorter route is available by taking the double degree program, which amounts up to 150 credits. Enrollment is required for both master programs (one main enrollment and a second enrollment). Certificates will be granted after completion of the whole program.

Details about the curriculum are available at the ESoE website: `https://www.tue.nl/esoe/`.

It is possible to take 45 credits worth of components of the SEC program within the DSIE master. The TU/e strives to have this become sufficient to obtain a teaching qualification without doing a double degree DSIE and SEC master.

5 Information Security Technology

A Master of Science in Information Security Technology (IST) is an academic expert in the area of digital communication in general, and in information security technology in particular. Information security technology protects data that are stored, transmitted, accessed, or modified against all kinds of threats. This can vary from unauthorized access to malicious manipulations. Information security technology is essential for secure communication and data protection in many situations.

The IST track is offered in collaboration with Radboud University (RU). These universities have joined their forces with respect to security education. This master track is called the "TRU/e Master in Cyber Security" (see https://true-security.nl).

Each of the mandatory and special elective courses is taught at only one of these universities. This implies that students have to travel to other sites for part of their education. The program is set up in such a way that averaged over the two years of their master's studies students will have to travel one day per week to another university.

After taking some courses, you will probably have a more clear picture of the academic direction you want to pursue in your studies. If not, you may want to talk to several staff members or the academic advisor. In the specialization for your subject, there are people that you may want to be involved with for your final master project (see Section 5.4). In order to compose a well-balanced program that provides adequate prerequisites for this project, it is advisable to first choose and consult a project supervisor in the specialization of your interest before choosing elective courses. As a rule of thumb, you should start your search for a supervisor and the construction of your individual program not later than at the end of your first year.

A Master of Science in Information Security Technology can become involved in cryptographic primitives, security protocols, data storage, communication, or information security management. Additionally, the graduate can act as internal or external consultant, regarding the security of information systems and networks, or regarding the security policy of an organization. A Master of Science in Information Security Technology can enter a job in the following institutions: research laboratories and academic institutes (both for theoretical and applied work); applied R&D in industry; the financial world; governmental agencies; consultancy agencies (all with respect to security in the area of information systems and

relevant policymaking).

5.1 Admission

A Bachelor degree in Computer Science obtained at a Dutch university provides direct admission to the CSE program. Students with a different degree and from foreign universities have to apply for admission via the admission committee. Dutch HBO graduates have to take a pre-master program before they can be admitted, see Section 2.4.

The admission procedure is described in Section 1.6, and the requirements are listed in the Teaching and Examination Regulations (see Appendix A.1).

5.2 Learning outcomes

The goal of the program is to transform Bachelors in Computer Science and Mathematics into academic experts in the area of digital communication in general and in information security in particular. Alumni will be able to function as researcher or as system developer in university or society. They will be well aware of the state-of-the-art in information security technology at the master level. They will be able to analyze complex security situations and to reduce them to solvable problems.

A graduate from the master program

- is qualified to degree level in the domain of science, engineering and technology;
- is competent in the relevant domain-specific discipline, namely computer science and engineering;
- is capable of acquiring knowledge independently;
- approaches computer-science problems in a thorough and scientifically founded manner;
- is capable of critical thinking, can reason logically and form opinions;
- has design skills, presentation skills, and communication skills;
- has insight into the role of computer science in industry, society, and science;
- and, in addition to a recognizable domain-specific profile, possesses a sufficiently broad basis to be able to work in an interdisciplinary and multidisciplinary context.

In addition to these general learning outcomes, a graduate from IST

- has a broad view of information security;
- should be able to evaluate existing and newly designed security systems;
- should be able to list relevant security requirements in an application and to select the right techniques to address these issues;
- is an expert in at least one subarea of information security;
- can contribute to discussions about the role of information security in our society;
- has experience in the process of specifying, designing, and realization of an application in which security plays an important role.

5.3 Curriculum

The Master track Information Security Technology is a two-year program of 120 ECTS in total. The academic year is subdivided into two semesters, the fall semester starting in September, and the spring semester starting in February. The program is only offered as a full time study program. The curriculum contains both computer science courses and mathematics courses, and consists of a mandatory core program and elective courses.

The IST master has the following structure:

Units	ECTS
Mandatory courses	30
IST electives	15
Free electives	40
Seminar	5
Master project	30

Prior to the beginning of the academic year you should register for 2IMC91. For further information about mentoring please consult Section 1.12.1.

5.3.1 Core program

The mandatory part of the program contains the following courses:

Quarter	Code	Unit	EC	Location
1	2MMC10	Cryptology	5	Eindhoven
1	2IMS25	Principles of Data Protection	5	Eindhoven
1-2	2IRU15	Software security	5	Nijmegen
1-2	2IRU20	Security in organizations	5	Nijmegen
3	2IMS15	Verification of security protocols	5	Eindhoven
3-4	2IRU25	Advanced network security	5	Nijmegen
3-4	2IRU30	Privacy seminar[1]	6	Nijmegen
4	2IMS00	Seminar Information Security Technology[1]	5	Eindhoven
7-8	2IMC00	Master project[2]	30	

[1] *Either 2IRU30 or 2IMS00 should be followed but not both.* [2] *In case the master project is done within the Mathematics Division the code is 2MMR30.*

5.3.2 IST Electives

The list below contains the preferred electives for the IST program. At least 15 EC must be taken from this list. Note that courses in quarters 1 and 2 can be taken in the second year in quarters 5 or 6.

Quarter	Code	Unit	EC	Location
1, 2, 3 or 4	SFC640	Academic Writing in English[1]	5	Eindhoven
1-2	2IRU35	Law in cyberspace	6	Nijmegen
2	2IMS20	Cyberattacks Crime and Defenses	5	Eindhoven
2	2DMI10	Applied cryptography	5	Eindhoven

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Quarter	Code	Unit	EC	Location
3	2DMI00	Cryptographic protocols	5	Eindhoven
3-4	2IRU10	Hardware security	6	Nijmegen
3-4	2IRU40	Cryptographic Engineering	6	Nijmegen
5	2IMS10	Physical aspects of digital security	5	Eindhoven

[1] *Before registering for the SFC640, you must first complete the SFC600 English Placement Test on Canvas to assess your current level of English. Complete SFC600 at least SIX working days before the registration deadline. Only if you have positive advice from SFC600 will you be accepted in SFC640. 90% attendance is required.*

5.3.3 Free electives

In principle all master courses offered at the TU/e can be chosen as free electives. We do recommend to take more than the required minimum number of courses from the above lists. Other mathematics and computer science related courses from the TU/e and RU are also recommended, as well as security-related courses from other universities (provided their topics do not overlap with the TU/e and RU courses you already take).

Your complete study program including the free electives always requires approval by the examinations committee by submitting your Study Program form to CSA.MCS@tue.nl. Study Programs that deviate from the standard should include a motivation. Your mentor will help you to compose a balanced program that is very likely to be approved.

If you do not (yet) have a degree from another country or at least 15 EC in international experience you should reserve 15 EC from the room for free electives to take courses abroad or to do an internship of 15 EC abroad, see Section 1.7.2. (This does not apply to students taking the teacher training.)

5.3.4 Homologation courses

Some courses may be prescribed or recommended as homologation courses (up to 15 EC) to make up for deficiencies in former education. This prescription/recommendation is part of the admission decision. Upon discussion with your mentor and/or academic advisor and approval by the exam committee, you might include not more than 15 EC of bachelor-level units as part of the free electives.

It is not possible to follow additional homologation courses in a master program after a finished pre-master.

5.4 Final project

Prior to starting the final project you should first choose and consult the intended final project supervisor. As final project supervisors can act assistant professors, associate professors and full professors from the Computer Science sub-department within the Mathematics and Computer Science department, or from the Coding Theory and Cryptology section within the Mathematics and Computer Science department. If you are in doubt how to choose the graduation supervisor please consider contacting your mentor.

See for more details on the final project Section 1.13.

5.4.1 Checklist

The graduation checklist summarizes all the steps required starting with getting your study program approved and ending with the graduation ceremony.

6 Embedded Systems

The design of innovative software and hardware is the core of technological and industrial progress. Both the departments of Mathematics and Computer Science and Electrical Engineering play an active role in the development of new, innovative technology. The Master of Science program in Embedded Systems at the TU/e is illustrative of this active role, as it is a co-production of these two departments, awaiting students with a background in computer science, as well as graduates from the field of electrical engineering.

The program rests on a sound theoretical foundation, with an emphasis on the design of quality embedded systems. As a graduate of this program, you will have developed a scientific attitude and an engineering approach to the field. Your position will be the design of embedded systems from a high-level architecture viewpoint, via requirements and behavioral specifications and using platforms, hardware and silicon. You will be able to play a leading role in the development of embedded systems, either in scientific research, in industry or governmental organizations.

The Embedded Systems program focuses on the design of efficient and reliable systems. For this you need knowledge of algorithms, performance, software-hardware integration, methods of design, validation, testing and documentation, and an insight into the variability and maintainability of these protocols. All these aspects are addressed in the compulsory part of the program. The Embedded Systems program at the TU/e is offered in close collaboration with Delft University of Technology (TUD) and the University of Twente (UT) in the context of the 4TU federation: the programs at the three locations share a mandatory common core of 25 EC and jointly offer specialisation courses and homologation modules through online facilities.

6.1 Admission

A Bachelor degree in Computer Science or in Electrical Engineering obtained at a Dutch university provides direct admission to the ES program. Students with a different degree and from foreign universities have to apply for admission via the admission committee. Dutch HBO graduates have to take a pre-master program before they can be admitted, see Section 2.5.

The admission procedure is described in Section 1.6, and the requirements are listed in the Program and Examination Regulations (see Appendix A.2).

6.2 Learning outcomes

Intended learning outcomes of the program:

1. The graduate has an all-embracing view on embedded systems, their design and their application in systems of various sizes (e.g. from small robots to cyber physical and networked systems) including their evolution over time, demonstrated by an integration approach in system design.

2. The graduate is capable of analysing the functional behaviour of complex embedded systems in a structural way using appropriate abstractions.

3. The graduate is able to describe and study the non-functional aspects of embedded systems, e.g. resource boundedness and dependability.

4. The graduate has a thorough knowledge of state-of-the-art methods and techniques for embedded systems design such as requirements engineering, hardware-software integration, performance modelling and analysis, validation and testing.

5. The graduate is able to design embedded systems that satisfy the functional and non-functional requirements, taking into account the performance of the system during its lifetime. The graduate is also aware of costs and environmental issues making optimal use of the available resources.

6. The graduate has the ability and attitude to include other disciplines or involve practitioners of these disciplines in their work, where necessary. As an engineer the graduate is therefore able to work in a multidisciplinary setting.

7. The graduate is able to conduct research and design independently and has a scientific approach to complex problems and ideas.

8. The graduate possesses intellectual skills that enable critical reflection, reasoning and forming opinions.

9. The graduate has the ability to communicate the results of their learning, thinking and decision-making processes at an international level.

10. The graduate is aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in the scientific work.

6.3 Curriculum

The master program on Embedded Systems is a two-year program of 120 ECTS in total. The curriculum consists of courses offered by the Computer Science division of the department Mathematics and Computer Science and the department of Electrical Engineering.

The curriculum has a core of 25 EC consisting of five courses that are mandatory for all Embedded Systems students (see Section 6.3.1). The curriculum is further structured into four steams:

- Systems on Chip (Section 6.3.2)
- Embedded Software (Section 6.3.3)
- Embedded Networking (Section 6.3.4)
- Cyber-Physical Systems (Section 6.3.5)

The purpose of the streams is, on the one hand, to provide guidance to students in composing coherent individual study programs, and on the other hand, to preserve the multidisciplinary nature of each individual Embedded Systems study program. Associated with every stream is a mandatory part of 15 EC and an elective part of 15 EC; the elective part should be composed of courses selected from a list of stream electives associated with the stream. The graduation project of the Embedded Systems program consists of a 10 EC preparation phase and a 30 EC master project. The remaining 25 EC of the program may be composed of free electives (see some recommendations in Section 6.3.6), homologation units (at most 15 EC), and (optionally) an internship (15 EC).

We strongly encourage you to include 15 credit points contributing to your international experience in your study program. This experience is particularly valuable to students that do not yet have international experience and are not intending on doing their master project abroad. To prepare for the master project, you start with a master thesis preparation, followed by the master project. Students usually start the preparation phase in quarter 5 or quarter 6, followed by the master project in quarters 7 and 8 The Preparation graduation project ES has to be completed before the start of the master project. If homologation units are chosen then they must be completed before the start of the preparation project. In the following sections, more details for each of the streams are given.

6.3.1 Mandatory program elements

The mandatory program elements for all students are listed below:

Quarter	Code	Unit	EC
1	2IMF30	System Validation	5
2	5SIA0	Embedded Computer Architecture	5
2	2IMN25	Quantitative Evaluation of Embedded Systems	5
3	2IMN20	Real-time Systems	5
4	5LIB0	Embedded Systems Laboratory	5
5-6	2IMC05/5T514	**Preparation graduation project ES**[1]	10
7-8		**Master thesis project**	30

[1] *Preparation for graduation project ES consists of a literature survey and feasibility study for the graduation project.The course Preparation graduation project ES (2IMC05/5T514) has to be completed and assessed before the start of the Master graduation project (2IMC00/5T746).*

6.3.2 Systems on Chip stream

Modern chips are rapidly evolving into complete Systems on Chip (SoCs). The emergence of SoCs leads to new challenges in VLSI design, design automation, programming and code generation, task and communication mapping and scheduling, memory management, and model-driven design-space exploration. This stream addresses the design of SoCs with special attention for the various design trade-offs and formal verification techniques to support correct design.

Prior to the beginning of the academic year you should register for 2IMC81. For further information about mentoring please consult Section 1.12.1.

Quarter	Code	Unit	ECTS	Total
Stream mandatory courses				***15***
1	2IMF25	Automated reasoning	5	
2	5LIH0	Digital integrated circuit design	5	
4	5LID0	Systems on silicon	5	
Stream electives [2]				***15***
1	5LIN0	Video processing	5	
1	5CCA0	Semiconductor physics and materials	5	
2	5LIF0	Advanced digital circuit design	5	
2	2IMNT1	Embedded computer architectures 2[4]	5	
2	5LIG0	Applied combinatorial algorithms	5	
3	5LIL0	Intelligent architectures	5	
3	5LIM0	Parallelization, compilers and platforms	5	
3	5SIB0	Electronic design automation	5	
3	5LIJ0	Embedded control systems	5	
3	5LIE0	Multiprocessors	5	
3-4	2IRU10	Hardware security[5]	6	
4	2IMN35	VLSI programming	5	
4	5LIA0	Embedded visual control	5	
6	2IMF00	Seminar formal system analysis[6]	5	

[2] *You have to choose at least 15 credit points from this list.*

[4] *Lectures for this course are taught at the University of Twente; a secondary registration with the University of Twente is required. Students can also follow the lectures by watching a live stream that will be broadcast via the internet. Recordings of the live streams will be made available. More information about the live streaming and the recordings will be made available via Canvas at the start of the course.*

[5] *The course is offered by Radboud University. The classes will take place in Nijmegen. To attend the course students need to have a secondary registration at Radboud University.*

[6] *A seminar may be followed starting from the fourth quarter of the program. For students starting in the first semester, this implies that the seminar may be followed in the second quarter of the second year*

6.3.3 Embedded Software stream

The behaviour and functionality of embedded systems is largely determined by the software that it runs. This stream focusses on the development of embedded software addressing aspects such as model-driven design, domain specific languages, code generation techniques, and formal techniques to solve scheduling problems.

Prior to the beginning of the academic year you should register for 2IMC82. For further information about mentoring please consult Section 1.12.1.

Quarter	Code	Unit	EC	Total
Stream mandatory courses				***15***
1	2IMF25	Automated reasoning	5	
3	5LIM0	Parallelization, compilers and platforms	5	
4	2IMP30	System design engineering	5	
Stream electives [2]				***15***
1	5LIN0	Video processing	5	
1	2IMN10	Architecture of distributed systems	5	
1-2	2IRU15	Software security[3]	5	
2	2IMP10	Program verification techniques	5	
2	5LIG0	Applied combinatorial algorithms	5	
2	2IMP20	Generic language technology	5	
2	2IMF35	Algorithms for model checking	5	
3	2IMP25	Software evolution	5	
3	5LIE0	Multiprocessors	5	
3	5LIJ0	Embedded control systems	5	
3	5LIL0	Intelligent architectures	5	
4	2IMN35	VLSI programming	5	
4	5LIK0	Embedded signal processing systems	5	
6	2IMF00	Seminar formal system analysis[4]	5	
6	2IMN00	Seminar systems architecture and networking[4]	5	
6	2IMP00	Seminar software engineering and technology[4]	5	

[2] *You have to choose at least 15 credit points from this list.*
[3] *The course is offered by and at the Radboud Universiteit in Nijmegen. Secondary enrollment at the Radboud University is required. Students should have basic knowledge of network security comparable to the bachelor course 2IC60 Computer Networks and Security.*
[4] *A seminar may be followed starting from the fourth quarter of the program. For students starting in the first semester, this implies that the seminar may be followed in the second quarter of the second year.*

6.3.4 Embedded Networking stream

Embedded Networking (EN) refers to the powerful trend of the last twenty years of connecting embedded systems into networks. For electronic systems in automotive, for example, the network is often the point of integration. More recently we have seen the concept of the Internet of Things, the vision that everyday objects get enriched with embedded electronics, that these objects are uniquely identified and communicate using a unified protocol and naming scheme. EN includes the fields of sensor networks, but also networked systems that represent a platform and are not identical to the application. From the sensor network domain, concerns of effective resource management (like size, energy, memory, communication bandwidth) are derived. Quality metrics for EN include performance (latency, throughput), dependability (quality of service) and scalability. Besides these, EN challenges lie in the architecture of system and software, in management and sharing of distributed resources, in interoperability and semantics, in security and privacy, and in application development. While it is fairly easy to sketch advanced applications, it is not straightforward

to realize these in a cost-effective manner. Relevant topics for this stream are: distributed systems (architecture and protocols), networked systems, data semantics, network security, system correctness, and resource management.

Prior to the beginning of the academic year you should register for 2IMC83. For further information about mentoring please consult Section 1.12.1.

Quarter	Code	Unit	ECTS	Total
Stream mandatory courses				***15***
1	2IMN10	Architecture of distributed systems	5	
1	5LIC0	Networked embedded systems	5	
2	2IMN15	Internet of things	5	
Stream electives [2]				***15***
1	2IMF25	Automated reasoning	5	
2	5LIH0	Digital integrated circuit design	5	
2	5LIF0	Advanced digital circuit design	5	
2	2IMS20	Cyberattacks crime and defenses	5	
3	5SIB0	Electronic design automation	5	
3	2IMS15	Verification of security protocols	5	
3-4	2IRU25	Advanced network security[3]	5	
4	5LIA0	Embedded visual control	5	
4	5LID0	Systems on silicon	5	
4	5LIK0	Embedded signal processing systems	5	
4	2IMP30	System design engineering	5	
6	2IMF00	Seminar formal system analysis[3]	5	
6	2IMN00	Seminar systems architecture and networking[4]	5	

[2] *You have to choose at least 15 credit points from this list.*

[3] *The course is offered by and at the Radboud Universiteit in Nijmegen. Secondary enrollment at the Radboud University is required. Students should have basic knowledge of network security comparable to the bachelor course 2IC60 Computer Networks and Security.*

[4] *A seminar may be followed starting from the fourth quarter of the program. For students starting in the first semester, this implies that the seminar may be followed in the second quarter of the second year.*

6.3.5 Cyber-Physical Systems stream

Cyber-Physical Systems are characterised by a tight coupling between embedded computer (cyber) systems and physical processes, monitored and controlled by those computer systems. Cyber-physical systems require integral, multidisciplinary design, involving computer engineering, control, mechatronics, networking, signal processing, and mathematical modelling. The stream focusses on the control and signal processing aspects of cyber-physical systems.

Prior to the beginning of the academic year you should register for 2IMC84. For further information about mentoring please consult Section 1.12.1.

Quarter	Code	Unit	ECTS	Total
Stream mandatory courses				***15***
2	2IMN15	Internet of things	5	

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Quarter	Code	Unit	ECTS	Total
3	5LIJ0	Embedded control systems	5	
4	5LIK0	Embedded signal processing systems	5	
Stream electives [2]				***15***
1	2IMN10	Architecture of distributed systems	5	
1	5CSA0	Modeling dynamics	5	
1	5LIC0	Networked embedded systems	5	
2	5LIF0	Advanced digital circuit design	5	
2	5LIV0	Video Health Monitoring	5	
2	2IMP20	Generic language technology	5	
2	5LIG0	Applied combinatorial algorithms	5	
3	2IMP25	Software evolution	5	
3	5LIE0	Multiprocessors	5	
3	5LIL0	Intelligent architectures	5	
3	5LIM0	Parallelization, compilers and platforms	5	
3	5SIB0	Electronic design automation	5	
4	5LIA0	Embedded visual control	5	
4	2IMN35	VLSI programming	5	
4	2IMP30	System Design Engineering	5	

[2] *You have to choose at least 15 credit points from this list.*

6.3.6 Free Electives

In principle all master courses offered at the TU/e can be chosen as free electives. In particular, we would like to encourage you to include SFC640 *Academic Writing in English* as one of the free electives.

Also courses from the Embedded Systems programs of TU Delft and the University of Twente may qualify as suitable free electives, provided that there is no content-wise overlap with other courses in your individual study program. You need to obtain permission from the academic advisor before enrolling in courses from Delft or Twente to confirm there is no overlap issue.

Your complete study program including the free electives always requires approval by the examinations committee. Your mentor will help you to compose a balanced program that is very likely to be approved.

Some courses may be recommended as homologation courses (up to 15 credits) to make up for deficiencies in former education (see Section 6.3.7). This recommendation is then part of the admission decision. Following the recommendation is not mandatory. You are yourself responsible for making sure that you satisfy the prerequisites of courses.

If you do not (yet) have at least 15 credit points in international experience you are strongly encouraged reserve 15 credits from the room for free electives to take courses abroad or to do an internship of 15 credits abroad, see Section 1.7.2.

6.3.7 Homologation units

Students entering the Embedded Systems master program have very diverse backgrounds and consequently most students do not satisfy all BSc-level knowledge and skills required for the master program. Students should evaluate themselves to what extent they satisfy

the prerequisites of courses of the Embedded Systems program. At least, they should make sure that they satisfy the prerequisite knowledge and skills of the mandatory courses of the program and the mandatory stream courses. There is a homologation recommendation tool (see https://homrec-test.mdsetechnology.org) to help you determine whether this is the case. To allow students to repair deficiencies, the Embedded Systems master program offers the homologation modules below, specially designed to repair deficiencies.

Homologation modules must be completed before start of the Preparation graduation project (see Section 6.4).

If you feel that you lack knowledge and skills not addressed by one of the homologation modules above, then contact the academic advisor. Master students are also allowed to include bachelor courses in their program subject to approval of the academic advisor. Bachelor courses, including homologation modules, are considered to be free electives and should constitute not more than 15 EC. It is not possible to follow additional bachelor courses in a master program after a finished pre-master.

Quarter	Code	Unit	ECTS
1	5LFK0	Circuit analysis	2.5
1	5LIS0	Computer architecture and C programming	2.5
1	2IHT10	Logic and set theory	2.5
2	5LIQ0	Linear Systems, signals and control	2.5
2	5LIR0	Linear Systems, signals and control (DBL)	2.5

In some cases, these homologation modules are offered as self-study courses, based on online course material, with some guidance by a responsible lecturer. In other cases, the homologation modules are associated with existing bachelor courses, with regular lectures, tutorials and lab sessions.

6.3.8 Internship

Especially when the master project will be performed in an industrial environment, it is usually advised to spend the rest of the study program on regular courses. In some cases, however, an internship (code 2IMC10 or 5L990) may be a valuable addition to the program, provided that it enhances practical experience, provides deepening of knowledge, contributes to the specialization, and perhaps provides international experience. See Section 1.7.2 for details on internships.

6.4 Final project

Prior to starting the final project you should first choose and consult the intended final project supervisor. The project can be completed in any of the specializations listed in Section 9.1 and Section 9.2, provided that a staff member of the associated group has the supervision. In case the project is carried out under supervision of a staff member of the Mathematics and Computer Science department, the course code is 2IMC00. In case the supervisor is from the Electrical Engineering department, the code is 5T746. If you are in doubt how to choose the graduation supervisor please consider contacting your mentor.

To prepare for the master project, you start with a master thesis preparation followed by the master project itself. Preparation for Graduation Project ES (2IMC05/5T514) has to be completed before the start of the master project

You do not need to register for the Preparation for Graduation project ES or for the master project in OSIRIS.

6.4.1 Checklist

The graduation checklist summarizes all the steps required from having your study program approved to the graduation ceremony.

7 EIT Tracks

EIT Digital Master School offers an international Master program on *ICT Innovation*, combining and integrating technical majors with a fully standardized minor on Innovation and Entrepreneurship. As a student in the EIT digital Master School you not only get fundamental knowledge and skills on a technical topic, but also learn how to drive your innovative ideas to the market.

Mobility

A distinctive feature of the ICT Innovation program is geographic mobility: you will study at two top-notch universities in two different European countries. When you apply for admission to the two-year program, you select an entry point (the university at which you do the first year of the program), and an exit point (the university at which you do the second year of the program). You will also travel to a kick-off event, summer and winter schools to meet other students, business partners and professionals. Learning about cultural and language differences enables our students to become experts in their technical field and also succeed as managers in global markets.

Double Degrees and the EIT digital certificate

When you successfully complete the program you will receive a double degree from your entry point university and your exit point university. In addition, you will get the EIT digital certificate, documenting the EIT digital specific learning outcomes on Innovation and Entrepreneurship.

Tracks

Eindhoven University of Technology offers the following tracks in the context of the ICT Innovation program:

Data Science: This program will provide the mathematical and computer science competences for analyzing big data and the entrepreneurial skills to successfully apply these in a corporate environment.

	At the TU/e this track leads to a degree in Computer Science and Engineering.
Embedded Systems:	This program equips engineers of tomorrow to specify, design, and implement computer systems that are widely used in a variety of personal and industrial devices in e.g. transportation and health-care. At the TU/e this track leads to a degree in Embedded Systems.

7.1 Embedded Systems

The term embedded system refers to electronic components (which almost invariably include one or more software programmable parts) of a wide variety of personal and industrial devices, e.g., transportation systems, health-care equipments as well as equipments in the construction industry. In all these areas, embedded systems confer added value to the products by either extending the range of the delivered functionalities or by enhancing the quality of a "traditional" functionality that is rendered to the user.

The graduates of this program will have a holistic view on the specification, design, and implementation of complex embedded systems, taking issues such as resource-constraints, budget and development time into account. In addition to the technical skills, the EIT program offers insights on the elements of business and developing innovations into successful business ideas.

A distinctive feature of the program is that you study at two universities in two different institutions and in two different countries: you spend one year at the entry point taking the common base courses and part of your innovation and entrepreneurship module and then you move to the exit point for your specialization courses and your graduation project as well as the rest of the innovation and entrepreneurship module.

Prior to the beginning of the academic year you should register for 2IMC85 (entry) or 2IMC86 (exit). For further information about mentoring please consult Section 1.12.1.

Graduation options

The EIT Digital Embedded Systems program requires mobility among six renowned European universities, listed below:

- Budapest University of Technology and Economics (BME), Hungary
- Royal Institute of Technology (KTH), Sweden
- Technische Universität Berlin (TU Berlin), Germany
- 3TU.Federation (3TU), represented by TU/e, The Netherlands
- Turku Centre for Computer Science (TUCS), Finland
- University of Trento (UNITN), Italy.

After being admitted to one of the entry points (KTH, TU Berlin or TU/e), during your second year, you will have the option of specializing in one of the following areas offered at the exit points:

- UNITN: Real-Time Embedded Systems

- TU/e: Embedded Networking
- KTH: Embedded Platforms
- TUCS: Energy Efficient Computing
- BME: Critical Embedded Systems
- TU Berlin: Embedded Multicore Processing

7.1.1 Goals

The general learning outcomes of the programme are:

- The graduate has an all-embracing view on embedded systems, their design and their application in systems of various sizes (e.g. from small robots to cyber physical and networked systems) including their evolution over time, demonstrated by an integration approach in system design.
- The graduate is capable of analysing the functional behaviour of complex embedded systems in a structural way using appropriate abstractions.
- The graduate is able to describe and study the non-functional aspects of embedded systems, e.g. resource boundedness and dependability.
- The graduate has a thorough knowledge of state-of-the-art methods and techniques for embedded systems design such as requirements engineering, hardware-software integration, performance modelling and analysis, validation and testing.
- The graduate is able to design embedded systems that satisfy the functional and non-functional requirements, taking into account the performance of the system during its lifetime. The graduate is also aware of costs and environmental issues making optimal use of the available resources.
- The graduate has the ability and attitude to include other disciplines or involve practitioners of these disciplines in their work, where necessary. As an engineer the graduate is therefore able to work in a multidisciplinary setting.
- The graduate is able to conduct research and design independently and has a scientific approach to complex problems and ideas.
- The graduate possesses intellectual skills that enable critical reflection, reasoning and forming opinions.
- The graduate has the ability to communicate the results of their learning, thinking and decision-making processes at an international level.
- The graduate is aware of the temporal and social context of science and technology (comprehension and analysis) and can integrate this context in the scientific work.
- The graduate has an understanding how technological innovations can be developed into successful business ideas. The graduate is aware of the basic concepts of business organisation, product development, entrepreneurial finance, and market dynamics. The graduate is also able to start up and manage a technology-based company and understands how to develop and lead human resources of such a company.

7.1.2 Entry point program

KTH, TU Berlin, and TU/e offer an entry-point programme for the ES technical major. It consists of a *Technical Common Base*, an *(entry point) I&E module*, and *Electives*. The following table summarises the TU/e entry-point programme:

Quarter	Code	Unit	ECTS
Technical common base			
1	2IMF30	System validation	5
2	5SIA0	Embedded computer architecture	5
2	2IMN25	Quantitative evaluation of embedded systems	5
3	2IMN20	Real-time systems	5
4	5LIB0	Embedded systems laboratory	5
Innovation & entrepreneurship module			
2	1ZM20	Technology entrepreneurship	5
3-4	1ZM150	Innovation Space project	10
3-4	2IEIT0	Winter school	1
	2IEIT5	Summer school	4
Electives Embedded Systems			10
Electives Innovation & entrepreneurship			5

Electives Innovation & entrepreneurship should be selected from the following list:

Quarter	Code	Unit	ECTS
2	1ZM120	Entrepreneurial Marketing	5
2	0HM220	Network Society	5
2	1ZM140	Strategy and Technology Management	5
3	1CM22	Integrated Finance & Operations Management	5
3	1ZM65	System Dynamics	5
4	1ZM90	Open Innovation	5
4	0LM150	Entrepreneurship and corporate social responsibility	5
4	1CM15	Project & process management	5
4	1ZM70	Entrepreneurial Finance	5

7.1.3 Exit point program

The TU/e offers an exit-point program with a specialisation in Embedded Networking. The following table summarises the programme:

Quarter	Code	Unit	ECTS
1	2IMN10	Architecture of distributed systems	5
1	5LIC0	Networked embedded systems	5
2	2IMN15	Internet of things	5
		Electives	10

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Quarter	Code	Unit	ECTS
1–2	1ZS30	**Innovation and entrepreneurship study**	6
3–4	2IMC00/5T746	**Master project**[2]	30

[2] The student is allowed to start with the graduation project only after the Master's study program has been approved by the examinations committee. See Section 6.4 for further details on planning and assessment of the Master project.

Electives

The courses listed in Section 6.3.6 and in the different streams of the regular Embedded Systems program are suitable as electives.

7.2 Data Science

The EIT Digital technical programs involve a 2-year master program (120 ECTS) that includes a common technical competence base, which constitutes the curriculum for the first study year, and a specialisation that will be the starting point for the thesis work during the second year. In all, this compiles 90 ECTS. In addition, a Minor in Innovation & Entrepreneurship will provide you with valuable knowledge on how to drive your innovations to the market. Note that it is compulsory for students that the first year program at the entry point university is followed by a second year program at a different university (exit point university). The students will obtain a degree of both the entry and exit university and an EIT digital certificate.

Prior to the beginning of the academic year you should register for 2IMC93 (entry) or 2IMC98 (exit). For further information about mentoring please consult Section 1.12.1.

Graduation options

The EIT Data Science program requires mobility among twelve renowned European universities, listed below:

- Royal Institute of Technology (KTH), Sweden
- Aalto University (Aalto), Finland
- Eindhoven University of Technology (TU/e), The Netherlands
- Technical University of Madrid (UPM), Spain
- Polytechnic University of Milan (POLIMI), Italy
- Université Côte d'Azur (UCA), France
- University Paris-Sud (UPS), France
- Eötvös Loránd University (ELTE), Hungary
- University Rennes 1 (UR1), France
- University of Twente (UT), The Netherlands
- Technical University of Berlin (TUB), Germany
- University of Trento (UNITN), Italy

After being admitted to one of the entry points (TU/e, KTH, Aalto, UPM, POLIMI, UCA, UPS, ELTE, UR1, UT), during your second year, you will have the option of specializing in one of the following areas offered at the exit points:

- KTH Stockholm: Distributed Systems and Data Mining for Really Big Data
- TUB Berlin: Design, Implementation and Usage of Data Science Instruments
- TU/e Eindhoven: Business Process Intelligence
- UPM Madrid: Infrastructures for Large Scale Data Management and Analysis
- Aalto: Machine Learning, Big Data Management, and Business Analytics
- Université Côte d'Azur (UCA): Multimedia and Web Science for Big Data
- University Paris-Sud (UPS): Natural Language Processing
- Eötvös Loránd University (ELTE): Real-time Data Analytics
- University of Trento (UNITN): Big Data Variety and Veracity

7.2.1 Goals

The general learning outcomes of the programme are:

- The graduate has a broad view of data science as a specialization of computer science, engineering and technology;
- The graduate should be able to understand and develop technology for handling structured and semi-structured and possibly distributed big data;
- The graduate should be able to analyse data to draw meaningful conclusions from data, effectively turning data into value;
- The graduate should understand the role of data in organisations, enabling the shift towards data-driven decision making in industry;
- The graduate should understand legal and social aspects of collecting, owning and manipulating data.

7.2.2 Entry point program

The entry-point programme consists of a set of *Common Core Competences*, a bases in Entrepreneurship and Electives. The following table summarises the TU/e entry-point programme:

Quarter	Code	Unit	ECTS
Technical common base			
1	2AMI10	Foundations of process mining[2]	5
1	2IMM20	Foundations of data mining	5
1	2IMA10	Advanced Algorithms	5
2	2IMV20	Visualization [3]	5
2	2DMT00	Applied statistics	5
Electives (2 out of 5)			
2	2IMA15	Geometric algorithms[4]	5
3	2IMV10	Visual computing project	5

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Quarter	Code	Unit	ECTS
3	2DI70	Statistical learning theory	5
3	2AMM15	Machine Learning Engineering	5
4	2AMD15	Big Data Management	5
Innovation & entrepreneurship module			
2	1ZM20	Technology entrepreneurship	5
3-4	1ZM150	Innovation Space project	10
3-4	2IEIT0	Winter school	1
	2IEIT5	Summer school	4
4	0LM150	Entrepreneurship and corporate social responsibility	5

[2] *Students who took the course 2IIE0 Business process intelligence in their bachelor are not allowed to take 2IMI35 or 2AMI10 due to the overlap.*

[3] *Students that took JBI100 are not allowed to follow this course due to overlap. They have to take 2AMV10 Visual Analytics instead.*

[4] *Students should be advised that due to three other mandatory courses in this quarter, selecting this course implies that you need to* follow *four courses in the same quarter.*

7.2.3 Exit point program

The TU/e offers an exit-point program with a specialisation in Process Mining. The following table summarises the programme:

Quarter	Code	Unit	ECTS
1	2AMI10	Foundations of process mining[2]	5
1	2IMS25	Principles of Data Protection	5
1	1ZS30	**Innovation and entrepreneurship study**	6
2	2IMV20	Visualization	5
2	2AMI20	Advanced process mining	5
2	2IMI00	Seminar analytics for information systems [3]	5
2	2IMD00	Seminar databases [3]	5
2	2IMM00	Seminar data mining [3]	5
3–4	2IMC00	**Master project** [4]	30

[2] *Students who took the course 2IIE0 Business process intelligence in their bachelor are not allowed to take this course due to the overlap and should replace this course with 2IMA10 Advanced algorithms.*

[3] *One of these three seminars has to be chosen.*

[4] *The student is allowed to start with the graduation project only after the Master's study program has been approved by the examinations committee. See Section 1.13 for further details on admission, planning and assessment of the Master project.*

8

Erasmus Mundus Joint Master Degree: Big Data Management and Analytics

Today, public and private organizations in all sectors face an avalanche of data. Business Intelligence (BI) enables an organization to collect and analyze internal and external data to generate knowledge that support the decision-making processes. Encouraged by the success of Business Intelligence, Big Data expands the analytical capabilities of organizations to the extent that any piece of relevant data must be gathered, processed, and analyzed. Big Data implies the complete digitalization of the organizations' internal processes and the incorporation of external data from any available relevant source. The Erasmus Mundus Joint Master Degree in "Big Data Management and Analytics" (BDMA) is designed to provide understanding, knowledge, and skills in the broad scope of fields underlying business intelligence and big data. Its main objective is to train computer scientists who have an in-depth understanding of the stakes, challenges, and open issues of gathering and analyzing large amounts of heterogeneous data for decision-making purposes. The program will prepare the graduates to answer the professional challenges of our data-driven society through a strong connection with industry, but also to pursue their studies into doctorate programs through a strong connection with research and innovation.

The curriculum is jointly delivered by Université libre de Bruxelles (ULB), Belgium, Universitat Politècnica de Catalunya (UPC), Spain, Technische Universit´at Berlin (TUB), Germany, Eindhoven University of Technology (TU/e), the Netherlands, and CentraleSupelec (CS), France. Academic partners around the world and partners from leading industries in business intelligence and big data, private research&development companies, excellence centers, service companies, start-up incubators, public research institutes, and public authorities will contribute to the program by giving lectures, training students, providing software, course material, and internships or job placements.

Big Data Management and Analytics is a 2-year (120 ECTS) program. The first two semesters are devoted to fundamentals on business intelligence (ULB) and big data (UPC). Then, all students participate to the European Business Intelligence and Big Data Summer School (eBISS). In the third semester, students chose one of the three specializations Large-Scale Data Analytics (TUB), Business Process Analytics (TU/e), and Decision Support and

Data Analytics (CS). The fourth semester is dedicated to the master's thesis and can be carried out as an internship in industry or in a research laboratory in any full or associated partner. Eventually, all students attend the Final Event devoted to master's theses defenses and the graduation ceremony. The tuition language is English.

The program targets students with a Bachelor of Science (or a level equivalent to 180 ETCS) with major in Computer Science, as well as an English proficiency corresponding to level B2 of CEFR. The program will deliver a joint degree to graduates following the mobility ULB, UPC, and CentraleSupélec, and three degrees from ULB, UPC, and the university of the specialization (CentraleSupélec, TUB or TU/e) to graduates following the other mobilities.

For further information about mentoring please consult Section 1.12.1.

8.1 Specialization

The following table summarizes the specialization program:

Quarter	Code	Unit	EC
1	2AMI10	Foundations of process mining	5
1	2AMS10	Longitudinal data analysis	5
1	2IMI05	Capita Selecta AIS	5
2	2AMI20	Advanced Process Mining	5
2	2IMV20	Visualization	5
2	2IMI00	Seminar Analytics for Information System	5
	2IMC00	**Master project** [1]	30

[1] *The student is allowed to start with the graduation project only after the Master's study program has been approved by the examinations committee. See Section 1.13 for further details on admission, planning and assessment of the Master project.*

Part III

Organization and regulations

9 Research groups

In this chapter, you can read about the different research groups associated with the master programs. Each group provides a short description of their research area, and mentions some courses that are relevant for students who wish to participate their research. The courses are not meant to be obligatory for candidate graduates, but they give an impression of the predispositions of the staff. The contact person mentioned may give you additional information on the possibilities of a graduation project in the corresponding group.

Starting from 2015-2016 all master courses offered by the Computer Science department start with 2IM followed by a letter representing a research group, as follows:

A or G: Algorithms, Geometry and Applications (Section 9.1.1),
C: Courses not specific for a research group such as internship or master project,
D: Databases (Section 9.1.3),
F: Formal System Analysis (Section 9.1.5),
I: Process Analytics (Section 9.1.2),
M: Data Mining (Section 9.1.4),
N: System Architecture and Networking (Section 9.1.6),
P: Software Engineering and Technology (Section 9.1.8),
S: Security (Section 9.1.7),
U: Uncertainty in AI (Section 9.1.9),
V: Visualization (Section 9.1.10).

Check which groups offer the courses you have enjoyed most and use this information when choosing your master project.

9.1 Research groups in the CS department

This section describes the research groups that provide graduation projects for all master programs, i.e., BIS, CSE, DSIE, ES, and IST.

9.1.1 Algorithms, Geometry and Applications (A)

Contact person: dr. Wouter Meulemans

The ALGA cluster (Algorithms, Geometry, and Applications) studies the design and analysis of algorithms and data structures, one of the core areas within computer science. Research in ALGA ranges from curiosity-driven to motivated by concrete applications, and from purely theoretical to experimental. Topics of interest include:

- *Computational geometry* deals with the design and analysis of algorithms and data structures for spatial data. We study fundamental algorithmic as well as combinatorial problems in this area, with the aim of developing an algorithmic foundation to tackle geometric problems arising in other domains.
- *Moving object analysis.* Over the past years the availability of devices that can be used to track moving objects led to an explosive growth in movement data. We study algorithms to analyze such data, both for moving point objects and for moving and deforming regions.
- *Parameterized complexity* offers a rigorous toolkit to develop exact algorithms for NP-hard problems that are provably efficient on inputs whose structural complexity is limited. We study techniques for kernelization, which aim to reduce the size of an input without changing the answer to the problem.
- *Geovisualization.* Algorithms play an important role in automated cartography and geovisualization. Our work in this area includes the design and computation of thematic maps and of spatially informed visualizations.
- *Massive data algorithmics.* We study algorithms for data sets that are too large to be stored on a single machine. In particular, we study streaming algorithms (which operates on data streams without explicitly storing the stream) and distributed algorithms (which operate on data that is distributed over many machines).
- *Mobile agents.* We explore applications of computational geometry to engineering problems motivated by mobile agents. These include path planning and routing of single- and multi-agent systems, assembly and reconfiguration of modular systems, and coordinated distributed computation for programmable matter.
- *Networks* for communication, transportation, finance and energy form the backbone of modern society. We study algorithmic questions concerning the design and usage of network structures, both for abstract networks and for networks that are embedded in geometric spaces.
- *Digital humanities.* The increased digitization of cultural heritage artifacts as well as the prevalence of social media, create an ever-growing set of highly complex data which humanities researchers need to analyze. Our work focuses on visual analytics solutions for exploring such data and on topological analysis of high dimensional semantic spaces.

ALGA offers master thesis projects both internally and externally: at a company or abroad. See https://alga.win.tue.nl/ for more information on ALGA, including examples of completed projects.

Relevant courses are:

- Advanced algorithms (2IMA10)

- Geometric algorithms (2IMA15)
- Algorithms for geographic data (2IMG15)
- Exact Algorithms for NP-hard Problems (2IMA25)
- Topological Data Analysis (2IMG10)
- Seminar applied geometric algorithms (2IMG00)
- Seminar algorithms (2IMA00)
- Capita selecta applied geometric algorithms (2IMG05)
- Capita selecta algorithms (2IMA05)

Other relevant courses:

- Graphs and algorithms (2MMD30)
- Visualization (2IMV20)
- Visual computing project (2IMV10)
- Interactive virtual environments (2IMV25)
- Foundations of Data Mining (2IMM20)

9.1.2 Process Analytics (I)

Contact person: dr. Dirk Fahland

Nowadays, data drives the world. Data which is generated by a plethora of computer systems typically designed to support some operational process. These operational processes vary from production processes to administrative processes. The process analytics group at our department is a world-leading research group that focusses on the modelling and analysis of these processes. Central to our research is the presence of a "case", i.e. an object which can be tracked over time and to which all the data relates. Think of, for example, patients in a hospital going through a treatment process, a suitcase moving through an airport's luggage handling system or an insurance claim virtually moving through an insurance company. The tools and techniques to analyse such data are commonly known under the name process mining.

The research in the our group continues to expand outward from a classical situation of data with clear case notions in the context of explicitly structured processes to a broad, multi-faceted field, where processes are less structured or consist of many interacting artifacts and where case notions in data become more fluid or in which processes are complex, multi-dimensional networks.

The two main research lines of the group are:

- Process Modeling and Analysis. Models are commonly used to answer questions related to correctness and performance. One of the main goals here is to incorporate contemporary topics such as privacy or GDPR compliance into the models without loosing the mathematical foundations of Petri nets.
- Process Mining. Process mining techniques are used to extract process-related information from event logs, e.g., to automatically discover models, check conformance, and augment existing models with additional insights extracted from some event log.

The goals are to significantly improve the state-of-the-art in process discovery, to advance the state-of-the-art in conformance checking, and to predict problems, i.e., provide warnings based on historic information (e.g., a case will be late or an error is likely to occur).

The application areas for our work are broad and include the healthcare domain, customer journeys, logistics and manufacturing.

Relevant courses are:

- Foundations of process mining (2AMI10)
- Advanced process mining (2AMI20)
- Seminar analytics for information systems (2IMI00)
- Capita selecta analytics for information systems (2IMI05)

9.1.3 Databases (D)

Contact person: prof. George Fletcher

Data-intensive systems are crucial in modern computing, analytics, and data science. The Database (DB) group studies core engineering and foundational challenges in scalable and effective management of big data. Current research in the DB group focuses primarily on problems in streaming data, data approximation, and the management of massive graphs such as social networks, financial networks, and biological networks. Expertise within the group includes query language design and foundations, query optimization and evaluation, data analytics, data integration, and personalization. In addition to dissemination of research results in the leading scientific venues in the data management field, the DB group impacts the broader community through open-source software development, training and mentoring of early-career scientists, industrial R & D collaborations, and serving on international efforts such as the LDBC Graph Query Language Standardization Task Force.

DB group investigations into both the theory and engineering of data management systems are inspired by real-world application scenarios in close cooperation with public-sector and industrial research partners. Academic partners of the group range across leading research groups in Europe, Asia, and North America. Recent collaborators include Oracle Labs, Neo4j, University of Toronto, National University of Singapore, University of Lyon 1, and TU Dresden.

Relevant courses are:

- Seminar databases (2IMD00)
- Capita selecta databases (2IMD05)
- Engineering Data-Intensive Systems (2IMD10)
- Big Data Management (2IMD15)

9.1.4 Data Mining (M)

Contact person: prof. Mykola Pechenizkiy

Data mining and information retrieval automate the extraction of information and knowledge from large amounts of data; often so much data is collected that manual analysis is

no longer possible. Data mining and information retrieval assist data analysts in locating relevant information and patterns in the data.

Relevant courses are:

- Web information retrieval and data mining (2IMM15)
- Foundations of Data Mining (2IMM20)
- Deep learning (2IMM10)
- Seminar Data Mining (2IMM00)
- Capita selecta data mining (2IMM05)

9.1.5 Formal System Analysis (F)

Contact person: prof. Jan Friso Groote

The focus of the specialization FSA is on modeling and verifying behavior of systems and programs. Behavior must be understood as all possible actions that a system can consecutively perform during its lifetime.

Computer-based systems are so complex, that it is impossible to program them without understanding how the different software components communicate, and what the responsibilities of these parts are. By modeling the behavior, these responsibilities are made explicit. Due to the complexity of the matter at hand, it is also non-trivial to get these behavioral models correct. For this purpose we use analysis techniques. Primarily, these are used to find flaws in the model, and ultimately these are employed to show that the modeled behavior satisfies all the requirements. For instance, a data communication protocol must not lose messages, and a firewall should under no circumstance let an intruder pass. With current modeling techniques it is no problem to model the communication patterns of even the most complex systems. Using modal formulas most requirements can be formulated in a formal, precise way. Using one of the many existing process equivalences, it is very well possible to state the behavioral equivalence between implementations and specifications. So, in general, it is not really problematic (but sometimes hard) to formulate the properties that a system ought to have.

The current technological bottleneck is our capability to prove that a requirement holds for a given model (the model checking problem) or that two processes are actually equivalent (the equivalence checking problem). The major research activity of this group is to increase the strength of the analysis tools. The core problem of the analysis of behavior is the state space explosion problem. There are so many states in which a system can end up, that it is generally impossible to explore these all individually. For this purpose, we must use so-called symbolic techniques to enable the verification. These techniques come from the realm of automatic reasoning, term rewriting and computer assisted theorem checking. Also, state space reduction techniques (abstract interpretation, confluence checking) are relevant to reduce the problem size. Visualization turns out to be a relevant tool, to detect unforeseen problems and to increase insight in the behavior. Knowledge of algorithms, including I/O-efficient algorithms is relevant, to construct analysis tools capable of dealing with huge state spaces.

In order to investigate how effective our analysis techniques are, we are constantly assessing their practical use. For instance, the FSA group is involved in the standardization

of several protocol standards (e.g. firewire). Our role is to assist the standardization process by showing where the protocol does not conform to its intention. With several of the embedded system industries around Eindhoven, we have a similar relationship: we design, model and analyze (parts of) the behavior of the equipment they are building.

Relevant courses are:

- Automated reasoning (2IMF25)
- System validation (2IMF30)
- Algorithms for model checking (2IMF35)
- Seminar formal system analysis (2IMF00)
- Capita selecta formal system analysis (2IMF05)
- Program verification techniques (2IMP10)
- Process algebra (2IMF10)
- Proving with computer assistance (2IMF15)
- Architecture of distributed systems (2IMN10)
- Advanced algorithms (2IMA10)
- Generic language technology (2IMP20)
- Visualization (2IMV20)

9.1.6 System Architecture and Networking (N)

Contact person: prof. Nirvana Meratnia

Imagine just any electronic system that is not somehow networked with other systems. Found one? Must be a pretty boring system then, since one of the fascinating developments of the last years is that devices of all form factors and functionality become connected. In our group we study parallel and distributed systems with an emphasis on pervasive systems or, as we call it, Resource Constrained Networked Embedded Systems.

Master thesis assignments are related to the research topics of SAN, which focus on distributed aspects of RCNES (middleware and networked services), on the platform (predictable and reliable resource management) and on efficient embedded computations (typical for signal processing). Research questions are, for example, how to build and manage applications composed from distributed services, and how to perform distributed resource management.

We pay a lot of attention to quality aspects, which include performance, predictability, dependability, programmability and security. A dominant issue in our work is therefore the architecture of these RCNES, in particular the software architecture, as this is where the quality aspects are addressed. We relate our work to application domains which we see as vehicles for our research. Example application domains include distributed media systems, wireless sensor networks, automotive electronics, smart lighting and cyber physical systems. Much of this work is done in cooperation with industry through national and international projects.

Relevant courses are:

- Real-time systems (2IMN20)
- Architecture of distributed systems (2IMN10)

- Internet of things (2IMN15)
- Seminar system architecture and networking (2IMN00)
- Capita selecta system architecture and networking (2IMN05) (not always given)

Other relevant courses are:

- Quantitative Evaluation of Embedded Systems (2IMN25)
- VLSI programming (2IMN35)
- Seminar information security technology (2IMS00)
- Principles of data protection (2IMS25)
- Advanced algorithms (2IMA10)
- Generic language technology (2IMP20)
- System validation (2IMF30)

9.1.7 Security (S)

Contact person: prof. Sandro Etalle

Advanced and nation-state malware, evolving attack engineering techniques evading sophisticated monitoring mechanisms, to the new frontiers of IoT security, access control, and physical security, cybersecurity challenges are countless.

In reaction to this, SEC's approach to system security is multi-faceted and covers offensive and defensive aspects of system security, trust management and compliance control systems, system monitoring and cyber-physical security, always targeting concrete security problems and addressing the underlying, fundamental issues at their core. SEC's strength lies precisely in its ability to empirically and theoretically understand the full security process: from attack generation and system management, to policy specification and user aspects.

Research in the Security (SEC) group spans three areas vital to the security of decentralized and embedded systems:

- Security policy specification & enforcement
- Security of embedded systems
- Threat intelligence and defense

SEC sits at the cutting edge intersection of these areas, addressing particularly challenging operative and theoretical problems: for example, by monitoring underground activities and studying the techno-economic principles driving attack production, SEC maintains a unique perspective on the offensive side of computer security. This understanding channels into novel approaches such as new monitoring techniques to detect attacks targeting IT and IoT systems alike and respond to these with adaptive security and authentication mechanisms. SEC has made significant contributions to secure key storage in embedded systems by devising algorithms for randomness extraction from Physical Unclonable Functions (PUFs). Furthermore, SEC pioneered Quantum Readout of PUFs, an object authentication technology that is immune to spoofing.

Relevant courses are:

- Seminar information security technology (2IMS00)

- Verification of security protocols (2IMS15)
- Principles of data protection (2IMS25)
- Cyberattacks Crime and Defenses (2IMS20)
- Cryptology (2MMC10)
- Cryptographic Protocols (2DMI00)
- Applied Cryptography (2DMI10)
- Physical aspects of digital security (2IMS10)
- Software evolution (2IMP25)

9.1.8 Software Engineering and Technology (P)

Contact person: prof. Mark van den Brand

Software has become one of the key enablers of modern society. In almost all activities that we do as human beings software plays a role, whether this is social media, buying goods, monitoring our sports activities, or in the production of goods.

The high-tech industry, in particular, is facing two trends. First of all, the amount of software is growing rapidly. Secondly, the quality of software is decreasing. These trends result in new research challenges. How to develop more high quality software in less time? How to guarantee the quality of the software? How to deal with the huge amount of existing software? The answers to these questions are not straightforward. A common theme in the answer to these questions is model driven software engineering. Models provide a higher level of abstraction and thus allow the specification of more functionality in less code. The models can also be used as starting point for simulation and verification. Finally, existing software can be analysed and the underlying models can be extracted. The research focus of the research group SET is on model based software development including model management, development of GPU software, and on software evolution.

The field of model based software development is broad. We concentrate on the development of tooling to support the development of models in domain specific formalisms using meta-modeling techniques. Research on tooling for model based software development includes the modularity of meta-models, the description of semantics of domain specific languages, the verification of model transformation formalisms, and the co-evolution of models and meta-models. Software in high-tech equipment does not work in isolation but is combined with models of other engineering disciplines, this leads to the model management challenges, how to identify and store relevant relations between heterogeneous models.The ultimate goal is to provide a tool set which provides high fidelity software generation.

In the last two decades, GPUs have been applied very successfully in many areas, such as machine learning, astrophysics, climate research, molecular modelling, and formal verification. However, to achieve high performance, a programmer must be very knowledgeable about the GPU's architecture. In the SET group, we conduct research on techniques to support programmers, making the development of GPU software more efficient and less prone to errors, and in turn we investigate how GPUs can be employed to accelerate those techniques.

Given the fact that software engineering is an activity carried by humans, on top of technological challenges software engineering research also considers social and socio-technical

ones. Multiple studies have shown that human (e.g., demographics, personality) and collaborative (e.g., communication) aspects of software development affect the quality of the software product delivered as well as the sustainability of the development teams. Lion's share of the software evolution research is empirical in nature, i.e., it requires combination of software development skills with data analysis skills.

Relevant courses are:

- Generic language technology (2IMP20)
- Software evolution (2IMP25)
- Program verification techniques (2IMP10)
- Software project management (2IMP15)
- System design engineering (2IMP30)
- Applications of Data Science for Software Engineering (2IMP40)
- Seminar Software Engineering and Technology (2IMP00)
- Capita Selecta Software Engineering and Technology (2IMP05)

Other relevant courses:

- Architecture of distributed systems (2IMN10)
- Foundations of Data Mining (2IMM20)

9.1.9 Uncertainty in AI (U)

Contact person: dr. Cassio Polpo de Campos

AI and machine learning regard the study of algorithms that somehow improve through experience. The fields cover topics that are essential towards obtaining agents with some type of intelligence, including knowledge and learning representations, model learning from data, reasoning and planning under uncertainty, causality, language processing, signal and vision, and often make use of core methods and techniques from optimisation, statistics, probability, algorithmic development, and so on. The UAI group explores uncertainty in AI and machine learning from multiple angles on principles of AI, theories of representation, probabilistic AI models, algorithms for learning, reasoning and decision making. There is also an important focus on approaches that are not only accurate but efficient, interpretative, robust and trustworthy. Two lines are prominent in the group:

- Cautious and Robust AI. Many applications of AI deal with situations of severe uncertainty due to under-specified domain properties, quality and quantity of data, adversaries, open-world problems, etc. We aim at AI models for such varying conditions. They require extra cautious inferences, and must be equipped with algorithms that are robust and reliable. Imprecise probabilities represent an important tool for approaching these challenges.
- Tractable Machine Learning. Most current uses of AI orbit around models for which efficient and scalable learning and reasoning are essential characteristics. These range from weather forecast, disease control, and risk analysis to environmental impact assessments. Probabilistic circuits and graphical models are examples of areas of research of great interest. The study of complexity of models and inferences is an important task to drive the development of efficient algorithms.

Relevant courses are:

- Generative Models (2AMU20)
- Foundations of AI (planned to be offered in 2021-2022)
- Uncertainty Representation and Reasoning (planned to be offered in 2021-2022)
- Seminar Uncertainty in AI (planned to be offered in 2021-2022)
- Capita Selecta Uncertainty in AI (planned to be offered in 2021-2022)

9.1.10 Visualization (V)

Contact person: Prof. dr. Anna Vilanova

Data visualization aims to provide insight in large data sets by using interactive graphics, exploiting the unique capabilities of the human visual system to detect patterns and structures. By presenting data visually, people can see unexpected relations; by offering interaction they are enabled to explore huge data sets, driven by their interest.

The focus of this specialization is on the development of new methods and techniques for interactive visualization. The main fields of interest are information visualization and visual analytics methodology aiming at getting insight in abstract data, such as tree structures, networks, and high-dimensional data. There are multiple application areas such as medical, bioinformatics, healthcare, software. Our aims are to develop new visual representations and interaction methods, and to evaluate these on real world use cases to verify if they are effective. Some typical challenges are dealing with combinations of different data types, handling dynamic data, and understanding the needs and wants of users. Huge complex data needs solutions via a tight integration of visual and automated methods from AI. Furthermore, we explore the visualization methods as means of providing understanding of AI models. Another interest is in high performance scientific computing: exploiting the power of GPUs for visualization and computer graphics, with physically based animation and 3D shape analysis as typical applications.

Furthermore, in cooperation with the Centrum voor Wiskunde en Informatica (CWI) virtual reality systems are studied. Typical topics include the design and evaluation of 3D interactive techniques, and methods for improving image quality in virtual reality displays.

Relevant courses for the VIS specialization are:

- Visualization (2IMV20)
- Geometric algorithms (2IMA15) (given for the last time in 2020-2021)
- Visual computing project (2IMV10)
- Simulation in computer graphics (2IMV15)
- Interactive virtual environments (2IMV25)
- Seminar visualization (2IMV00)
- Capita selecta visualization (2IMV05)

Other relevant courses:

- Web information retrieval and data mining (2IMM15)

9.2 Research group in the EE department relevant for ES

Students in the ES program can do a graduation project in any of the Computer Science research groups mentioned in Section 9.1. In addition, a project is possible in the Electronic systems research group of the EE department.

Contact adress: Secretariaat ES

The mission of the section electronic systems is to provide a scientific basis for design trajectories of digital electronic circuits and systems "from (generalized) algorithm to realization". To identify the key problems, and verify the validity, robustness and completeness of our results, we develop, implement and maintain consistent and complete flows, and use them for realizing innovative multimedia hardware with emphasis on video processing and embedded architectures.

The research focuses on how to convert the "art" of designing electronic systems into methodology, an absolute necessity, because

- the complexity of modern integrated circuits continues to increase,
- new physical phenomena at submicron feature dimensions are having more and more impact, not only on performance, but even on the functionality,
- and the heavy demand pull from signal processing applications, in particular multimedia and telecommunications, requires rigorous and robust answers.

The approach taken is an algorithmic one, based on combinatorics and process algebra. The main application area is video processing. More information can be found on `https://www.tue.nl/en/research/research-groups/electronic-systems/`.

Relevant courses are:

- Applied combinatorial algorithms (5LIG0)
- Embedded computer architecture (5SIA0)
- Electronic design automation (5SIB0)
- Embedded signal processing systems (5LIK0)
- Video processing (5LIN0)

10 Academic administration

10.1 Academic administration of the department

The structure of the academic organization is based on the Academic Administration Structure Modernization Act (MUB), as implemented in the academic year 1997–1998. A student may contribute to the improvement of the academic organization as a member or advisor on the Department Board, the Study-program Committee or the Department Council. Participation in these organizations offers special privileges, such as facilities for oral instead of written exams or extra opportunities for taking examinations outside regular scheduling.

Important organizations:

- The Department Board (Faculteitsbestuur);
- The Program Director (Opleidingsdirecteur);
- The Program Committee (Opleidingscommissie);
- The Examination Committee (Examencommissie);
- The Department Council (Faculteitsraad);
- The CS Division and Professors (Capaciteitsgroep en Hoogleraren);
- The CS Division Board (Capaciteitsgroepsbestuur);
- The Department Office (Faculteitsbureau);
- The Student Council (Studentenraad).

10.1.1 Department Board of Mathematics and Computer Science

The Department Board appoints a program director for the graduate program, vice program director and a program manager for each master program. The program director and program manager are mandated to develop, organize and implement the master program. Although some authority is delegated to the program director, the Department Board retains final responsibility for each master program. This means that the program director must report to the Department Board. The Department Board establishes the program and

examination regulations (PER, in Dutch OER) and the program budget, and oversees the implementation of the master program. The Department Board is comprised of four members: the dean and chairperson, two vice-deans and the managing director. A student advisor also participates in the board meetings, as advisor. Other attendees at the board meetings are the policy advisors and the department secretary.

The current members of the Department Board are:

Dean:	prof. dr. J.J. Lukkien
Vice-dean:	prof. dr. E.R. van den Heuvel
Managing director:	dr. R.C. van der Drift
Secretary:	dr. O. Houben - van Herwijnen

10.1.2 Program Director

Every year the program director outlines in the PER the academic program and policies, including the program structure and curriculum. the program director develops the program curriculum in close consultation with the teaching staff and the curriculum committee. The Program Committee advises the program director on his curriculum and quality plans. The program director is also in charge of the development and implementation of a quality management system. The program director advises the Division Board on the academic program. Whenever necessary, he also advises the Division Board on quality improvement and performance of the academic staff. The program director relies on the Department Office for administrative and managerial support. The Department Office also advises the program director on academic issues.

In the Computer Science graduate program, some of the responsibilities of the program director are delegated to program managers. Each master program has a program manager. The study-program director, the vice-director, and the program managers together form the Educational Board:

Program director:	prof.dr. M.G.J. van den Brand
Program manager CSE:	dr. W. Meulemans
Program manager DSIE:	dr. D. Fahland
Program manager ES:	dr. S.P. Luttik
Program manager EIT-ES:	dr. T. Ozcelebi
Program manager IST:	dr. B. Škorić
Program manager EIT-DS and EMJMD BDMA:	dr. R. Medeiros de Carvalho

10.1.3 Program Committee

The program committee (OC) is appointed by the Department Board, and it has the following tasks:

- to advise the program director and the Department Board on issues relating to the PER
- to annually evaluate the implementation of the PER
- to advise on all issues relevant to the academic program

There are two relevant program committees: for the CSE program including the special tracks IST and DSE and for the ES program including the special track EIT-ES.

10.1.4 Examination Committee

The Departmental Board appoints an Examination Committee for each program. This committee is responsible for organizing and coordinating the examinations, and for appointing examiners in accordance with the provisions of Art. 7.12 of the Higher Education and Scientific Research Act 1997. Its members are all drawn from the Computer Science and Engineering teaching staff. The Examination Committee must approve the Examination Regulations to ensure the probity and integrity of all examinations, and will take all necessary measures in this regard. Its secretary is dr. P. Veltkamp.

10.1.5 Department Council

The Departmental Council has a statutory advisory function and certain decisions made by the Departmental Board require the formal approval of the Departmental Council. This will be the case if those decisions entail any amendment to department statutes, or the Education and Examination Regulations. The Departmental Council has ten members, of whom five are staff members who are elected by the staff, and five are students elected by students within the department.

You can find more information on the activities of the Department Council on their web site: https://intranet.tue.nl/en/university/departments/mathematics-and-comput the-department/department-council/.

10.1.6 CS Division and professors

The general tasks of the CS Division are:

- to contribute to the preparation and implementation of the educational and exam programs
- to contribute to the research programs
- to contribute to the interdepartmental and inter-university education and research programs

In addition, the CS Division Board aims to come to agreement with the study-program director on issues of quantity and quality of academic staff.

The tasks of the professors are:

- to develop their assigned research areas
- to advise the study-program director and program manager on the contents of the educational program.

Full professors: a complete list is available on the web site

10.1.7 Academic advisor

The academic advisors for all master and pre-master programs are dr. Natasha Stash, Katie MacLeod MA and Lisa Langley MEd (only pre-master).

Office: MF 5.104b/MF 5.104b/MF 5.098

E-mail: Academic.Advisor.MCS@tue.nl

Phone: 040-247 2322/8631/3790

Drop-in hour:
- brief questions (<10 minutes): by email or online "drop-in" hour. See Information Canvas page (2CSE000 or 2ES000) for details..
- longer questions: by appointment only. Schedule an appointment.

10.1.8 Student administration and Education secretariat

Student administration: (MF 5.102)
csa.mcs@tue.nl

Education secretariat: (MF 5.105)
secretariaat.opleiding.win@tue.nl
(040-)2475630 or (040-)2474272

10.1.9 Student Council

The Student Council's (StudentenRaad, SR) main goal is to help solve problems in the educational process, such as problems with examinations, time tables or professors. The SR also mediates in cases where individual students encounter problems, and it serves as a first information point for students who do not know who to go to if they have a question. In many cases, the SR can refer students to the right place. Students with complaints or questions can reach the SR in the following ways:

- During one of the biweekly meetings.
- By e-mail: sr@win.tue.nl or complaints@gewis.nl
- By contacting the education commissary of GEWIS: oc@gewis.nl

Finally, the SR attempts to stimulate and facilitate contact among student members of the study program committees (OCI, ECM, OC-CSE, OC-ES, OC-SEC), the Faculty Council (FR), University Council (UR) and the Student advisory Body (SAO) and to discuss the items on the agendas of each of these bodies. This is why members of these bodies are always encouraged to be present at SR meetings.

10.2 Facilities

10.2.1 Buildings

The department of Mathematics and Computer Science is located in the upper five floors of MetaForum. Regulations on access to university buildings are described in the departmental chapter of the student statutes and on the use of computer rooms are outlined on the website. For oral English explanation of these regulations, contact the Computer Services Office in room MF 3.083, telephone number (040)(247) 2802 or e-mail wshelp@win.tue.nl.

10.2.2 Lecture rooms, halls and other instruction facilities

The department uses lecture rooms within the whole university. Lecture rooms and halls are managed at institutional level. Reservations of the meeting and instruction rooms in

MetaForum can be arranged through the department student administration, telephone number (040)(247) 2379/8343 or on e-mail csa.mcs@tue.nl. Alternatively, you can book a smaller room using the Book My Space app, see the intranet website of Book My Space.

10.2.3 Library services

The TU/e Library holds a large and up-to-date collection of scientific information. The TU/e Library website https://www.tue.nl/library provides round-the-clock access from any workplace to a wealth of digital information resources using advanced search tools. The TU/e Library collection is focused mainly on the technical sciences. Collection policy is linked directly to fields of research at TU/e departments.

The fully redeveloped and centralized TU/e Library is now located in MetaForum, the building in the centre of the campus. It provides the TU/e community with an inspiring and information-oriented environment for individual and collective study and work. There are over 950 study seats divided into quiet areas near the book collection and workspaces where groups of students can discuss their assignments. Each seat is equipped with wireless Internet access. Students may borrow publications from the Library free of charge using a fully automated loan system.

Regular opening hours of the TU/e Library are: Monday-Friday 8.00 a.m.–11.00 p.m. and Saturday-Sunday 10.00 a.m.–10 p.m. During the examination periods the library is open till 11 p.m.! These hours can vary due to the Corona pandemic. For all further information about TU/e Library service go to our website: https://www.tue.nl/library.

10.2.4 Sale of study materials

Study material can be bought at the Lecture Notes Shop. Daily opening hours are from 8:00 to 16:30. The shop is closed during the introduction week. Inquiries can be made at: MF 1.552, telephone number (040) (247) 2446.

10.2.5 Computer Services Office

For problems with student related ICT problems, please contact the ICT Services Students Desk at MetaForum 1.557, telephone number (040)(247) 8888.

Students can print at the multifunctional printers all over the campus. Working locations for notebook use are available at the lower levels of MetaForum. Details on the regulations on the use of the computer facilities can be accessed at https://educationguide.tue.nl/organization/official-rules-and-regulations/code-of-conduct-for-computer

10.2.6 Conditions for computer use

The use of all computer and network facilities is subject to the rules listed in the document "Code of Conduct for Computer and Network Use" (Code of Conduct for Computer and Network Use), which can be downloaded from https://educationguide.tue.nl/organization/official-rules-and-regulations/code-of-conduct-for-computer-ar
Use of any facilities implies your acceptance of these rules in full.

The department's policy is that students should be able to print program-related documents free of charge. There are Multifunctional printers available on all floors of MetaForum, as well as in other buildings on campus. Each student has an own printing account

on which a balance of 15 euros is added at the beginning of each year. This balance can be checked and raised via OSIRIS.

Any problems or technical faults with hardware or software should be reported to the ICT Services Students Desk at MetaForum 1.557 , as should any infractions of the rules governing the use of the computer rooms, computers and networks.

10.3 Study association GEWIS

The study association GEWIS (union of math- and computer-science students) was founded over 25 years ago. GEWIS champions student rights, promotes student interests and offers students extracurricular activities. It organizes excursions to national companies and tries to organize an international study trip on a regular basis. It organizes the freshmen introduction week and the weekly drink on Thursdays from 16:30 until 19:00 in MF 3.155.

GEWIS publishes a magazine "Supremum", a yearbook, and organizes sporting events, (sailing-) weekends, parties and numerous other activities. On request, it is possible to organize an informal gathering at GEWIS. Every weekday from 12:30 to 13:30, GEWIS provides a book sale in MF 3.155, offering study books at reduced prices. In addition, the GEWIS-website offers old exams. The education commissary of GEWIS plays an important role as representative of students in the education processes.

GEWIS can be reached at: MF 3.155, phone number (040)(247) 2815, the website `https://www.gewis.nl`, and e-mail: bestuur@gewis.nl.

10.4 Information resources

Current information on program regulations, program changes, changes in the course schedules, practical courses, exams and other important matters is available as listed below.

Leading information on the program:

- The master program guide is digitally available.

Personal contact at the department:

- Academic advisors: dr. Natasha Stash, Katie MacLeod MA and Lisa Langley MEd
- Student Administration in room MF 5.104a (inquiries desk) or at telephone number (040)(247) 4040, for general information and inquiries about study arrangements, regulations, schedules and calendars and study results. The opening times of the inquiries desk for students are Monday-Friday 12:00-14:00 (with longer open hours during September).
- International students coordinator: ms. L. Blommaert in room MF 5.102, telephone number (040)(247) 2379 or e-mail Exchange.MCS@tue.nl
- The Study Association GEWIS is in room MF 3.155 or at telephone number (040)(247) 2815.

Personal contact at the university:

- The Education and Student Affairs helpdesk is in room MF 1.214 or at telephone number (040)(247) 4747 for general information and inquiries about financial aid, student assistantships, admissions, university passes, exam regulations etc.

Several internet sources of information are available:

- The website at https://www.tue.nl/ provides general TU/e information.
- Information about the department, academic counseling, social events and activities, etc. can be found at https://www.tue.nl/en/our-university/departments/mathematics-and-computer-science/.
- The electronic course catalog can be accessed at https://education.tue.nl/ and contains current course information. Also examinations and course schedules are available at this webpage.
- Video recordings of lectures: https://videocollege.tue.nl/

A

Teaching and Examination Regulations

A.1 CSE (including DSIE, EIT-DS, EMJMD BDMA and IST)

Available at the website:

A.2 ES (including EIT-ES)

Available at the website: