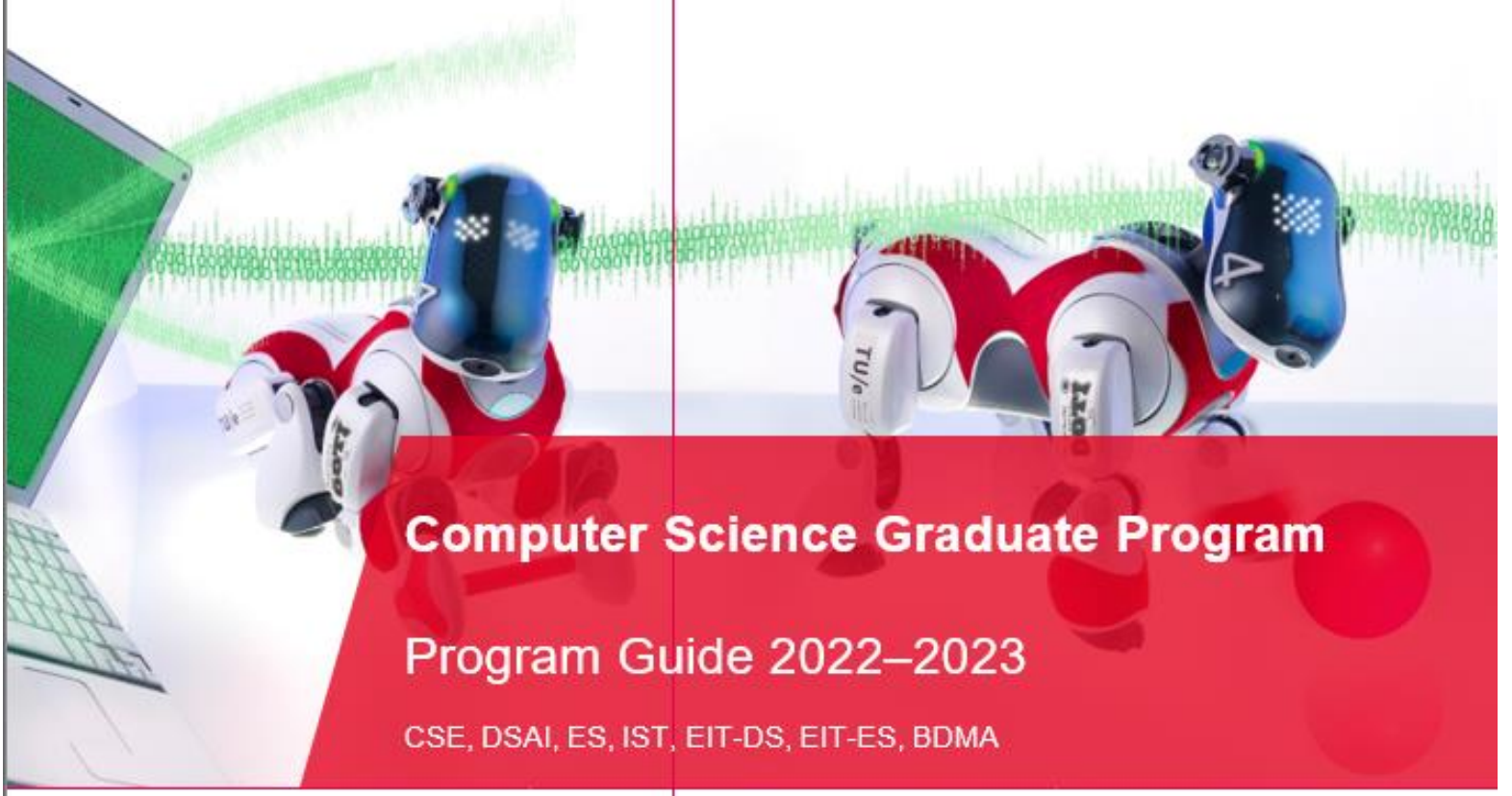
Department of Mathematics and Computer Science

TU/e Technische Universiteit Eindhoven University of Technology



Computer Science Graduate Program

Program Guide 2022–2023

CSE, DSAI, ES, IST, EIT-DS, EIT-ES, BDMA

Where innovation starts

Computer Science Graduate Program

Program Guide 2022–2023

For master programs CSE, DS&AI, ES, IST, EIT, BDMA, and for pre-Master programs

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

This document is made for student reference. For official regulations, the Program and Examination Regulations (see Appendix A) are always leading.

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Version: 1.0

Timeline of the Master Program

At the start of your Master:

1. Attend the Master kickoff (August 30-September 1. August 29 is Welcome Day for international students)
2. Register for courses before the Quarter 1 ("Q1") course registration deadline on August 28.
    a. Tips: A full-time study load is 3 courses per quarter (15 ECTS). Choose your Q1 courses based on the information in the chapter corresponding to your master program, and the advice you got from the academic advisor via email. Furthermore, it is advised to start with foundational/mandatory courses, and homologation courses (if required).

During your Master:

3. Make a plan for your studies:
    a. Meet with your Mentor. In Q1, you will be matched with a Mentor (a professor in the department). Your mentor will contact you to schedule a first meeting. It is recommended to discuss your academic interests with your mentor so they can advise your course planning.
    b. Questions about curriculum, planning/timing, regulations, or university services? Contact the academic advisor (Section 10.3)
    c. Do you want to go abroad for courses or internship? Ideally, you should start organizing this at least 6 months before you would like to go. (Section 1.6.4)
    d. **Turn in the Individual Study Program Form**. This lists all the courses you plan to take as part of your degree. It is recommended to do this in Q3 of your first year, or when you have completed at ~ 30 ECTS. (Section 1.6.1). It is recommended to discuss your elective choices with your mentor or a representative from the research group in which you want to graduate (section 9.1).
4. Watch out for regular announcements about your program: you will be registered for the Canvas course 2CSE000, 2ES000, or 2AMC99 (for CS students, ES students, and DSAI students, respectively). Announcements about the program will be posted there.
5. Do your graduation phase(worth 40 ECTS). It is made of 2 parts (NOTE: EIT and BDMA students have 1 part; they have no preparation phase. This is also true for students who started the master 2 or more years ago.)
    a. Start the preparation phase (10 ECTS), usually in [Q1 and] Q2 of your second year. You need to have a graduation supervisor in order to start the preparation phase (Section 1.8.1). You need permission to start your preparation phase. To obtain this permission you must turn in the P**reparation phase form**.
    b. After you defend the Preparation Phase, start graduation project (30 ECTS). You need to have completed at least 80 ECTS and have passed preparation phase to be allowed to start. Then you turn in the **Graduation Plan form**.

As you approach the end of your Graduation Project:

6. Plan the date of your thesis defense ≥4 weeks in advance. If you are planning to defend in July or August, it is recommended to start scheduling this 6-8 weeks in advance (if possible) to avoid potential scheduling conflicts with professors during the summer holidays.
7. Ensure your assessment committee has been composed. See the graduation checklist page of your master program on the Education Guide website for details about this.
8. Register for an Examination Committee meetings at least four weeks in advance via OSIRIS (see Section 1.9). The one you register for should take place at least two weeks after your thesis defense. (Note: Students are <u>not</u> present for this meeting. This is the meeting where the university checks that you meet graduation requirements. Registering for it puts you on the list of students to be checked.)
9. Attend the graduation ceremony! (You can check the dates on the education guide). 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, EngD) courses in Computer Science, Data Science and Applied Mathematics.

The CS domain 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.
- 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 DS domain offers one master program:

- Data Science and Artificial Intelligence (DSAI). This master program is grounded in two scientific disciplines: data science and artificial intelligence.
- Furthermore, this program has an EIT Digital Data Science track and hosts a Big Data Management and Analytics Erasmus Joint Master Degree.

The two postgraduate programs are:

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

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 approximately 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 or Foundational courses to create a sufficient layer of theory and general or program- related knowledge.
2. Specialization and/or elective courses. Depending on a student's interests, there may be a longer or shorter list of electives. These can also be used to prepare for the graduation project. In addition there is room for free electives.
3. (optional) International experience and or internship. 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 (Section 1.6.4). Note that international experience is not required.

4. Master project and thesis to be spent on a specialist topic of theoretical or practical nature. It should always address an open research question. 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 Academic calendar and examination schedules

Each academic year is divided into two semesters (September to January and February to July). Each semester consists of two quarters (quartiles). There are four quarters each academic year, consisting of eight weeks of lectures followed by an examination period of two weeks. Details can be found in the Academic Year agenda in the education guide.

Quarter	Period
1	September 5, 2022 – November 13, 2022
2	November 14, 2022 – February 5, 2023
3	February 6, 2023 – April 23, 2023
4	April 24, 2023 – July 9, 2023
interim	August 14, 2023 – August 19, 2023

You are expected to be available and present during all weeks with classes and 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!

1.3 On-campus availability requirement

Students registered at TU/e are expected to be available for educational activities on campus. In the past, education had to be moved online due to COVID-19. At the time this Program Guide was written (before the start of academic year 2022-2023), it was the intention of the university for education to be entirely on-campus. Therefore, students should be aware that staying in a different city/country because of the pandemic is not considered a valid reason to be unavailable for educational activities. Students will be notified via their TU/e email address if this regulation changes due to COVID.

1.4 Course and exam registration

Students must register themselves for courses. This is done on OSIRIS. Participation in a course is only possible if you have registered for the course via OSIRIS. Students who wish to de-register from a course should do so on Osiris before the start of the quarter. Questions about course registration and de-registration can be directed to ESA Helpdesk at ESAhelpdesk@tue.nl.

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 or 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 in mind that students who want to take (a) Bachelor College course(s) as part of the master program, that have not been prescribed/recommended upon admission, should submit a motivated request to the examination committee.

Exams:

Important, especially for Bachelor College graduates: Registration for a course does not always mean automatic registration for the exam. You should always double-check that you are registered for your exams before the exam registration deadline. For courses that are evaluated through assignments you do not need to register for the exam as there is no exam.

Students at TU/e have two opportunities to take an exam for a course. The first is during the examination period of the quarter in which the course was offered. At the end of the following quarter, students who did not pass the first attempt of the exam, or who would like to try to improve the grade they got, can register for another attempt at the exam. This is called a re-sit exam. **Master students must register themselves for re-sit exams**. Details can be found in the regulations (Appendix A)

1.5 Individual support: Advising and Mentoring

The university offers many different kinds of support for students. There are two main staff members who you can approach for individual support within the department: the Academic Advisor and your Mentor. On a university level, there are other coaches and advisors, which are described in more detail below.

Note that the Academic Advisors and Mentors will not make academic decisions for you; it is your responsibility as a student to design your own program. However, they are glad to guide you along the way and answer your questions.

1.5.1 Academic Advising

The Academic Advisor is a non-academic staff member who knows the details of your program's curriculum and how the regulations apply to various situations. They can also tell you about the diverse array of resources offered to students at our university. You can approach your Academic Advisor with questions about study planning, but also with other topics. For example, if you have a personal issue that is affecting your studies, or simply can't figure out where to start with a question, you can contact the Academic Advisor (see section 10.3). They will either help you themselves or refer you to another staff member when necessary.

1.5.2 Mentoring

Your Academic Staff Mentor[1] is an academic staff member who is an expert in the field you study. Within the first few weeks of your Master program, a Mentor will be assigned to you. (note, this is

[1] Previously called "Teacher Coach"

not the same as the Student Buddy/Student Mentor who you may have met at the Master Kick-off!) Your Mentor can advise you on things like choosing your first electives based on your interests, career development, and your specialization within the master program.

1.5.3 University-wide student support

Central Education and Student Affairs (ESA) also offers a variety of services for students who need more support. There are different types of guidance or counsellors who help on different topics, as well as digital resources and group trainings. Some of the support people and programs are:

- Student psychologists (these are psychologists for students, not students training to be psychologists)
- Study management advisors
- Student counsellors (Studentendecanen)
- Confidential counsellors
- Career Academy
- And others…

There is also a wellbeing platform, as well as group training sessions. These group trainings are on topics like procrastination, fear of failure, setting goals for your studies, etc. You can find plenty of details about these services, and other support, on the Student Guidance page of the Education Guide.

1.5.4 Extra support during your studies, or studying with an impairment

The university offers resources to students who need extra support with their studies. For example, students who are studying with Autism, AD(H)D, or other mental or physical impairments, but also students who are pregnant, caring for children or family members, or who have TopSport status. The resources and support options are detailed on the education guide page called "Extra support during your studies". You can even already indicate that you need extra support when you register for the master program on StudieLink. Note that if a student needs special exam facilities these need be arranged many weeks in advance, so it is good to start as soon as possible. Questions can be directed to your academic advisor (section 10.3) or the student counsellors (section 1.5.3)

1.6 Designing your study program: choosing courses, etc.

Students are responsible for designing their own study program. "Designing a study program" includes selecting courses according to the curriculum of your Master program (see Part II), mindfully choosing electives, and choosing a specialization topic for the graduation project. (Note that a study program is sometimes also referred to as a "program of examinations".) In the rest of section 1.6 you can find guidelines to help you with the process.

1.6.1 Approval of your courses: the study program form

You have some freedom when it comes to which courses and electives to choose. The courses you choose must be approved; each student is responsible for designing their own study program, **filling out the Study Program Form, and submitting it for approval**. You do this by sending the form to the student administration at CSA.MCS@tue.nl. The Study Program form is available on your program's pages of the Education Guide. The CSA will notify you when your Study Program Form has been approved.

It is highly recommended to turn in the form during your first year of studies. This way, you can be sure you are taking appropriate courses, and the department knows which research group you are interested in graduating in, thus ensuring sufficient supervising capacity for the graduation projects. You can make in your Study Program form later if necessary.

Use the curriculum described in the chapter about your program to guide your choices. Students who did the TU/e bachelor should note that **the PlanApp is not currently used for the Master programs**. If there are questions, you can ask your academic advisor (section 10.3) or your academic staff Mentor (section 1.5.2).

1.6.2 Admission with deficiencies: homologation courses

It is possible for students with varied academic backgrounds to be admitted with small academic deficiencies. In this case, the admission committee will point this out and assign (a) bachelor-level course(s) at TU/e to the student to make up the deficiencies. These are called homologation courses. The admission committee will inform the student which homologation courses they must take, if any, in the student's admission letter.

Assigned homologation courses are a required part of the student's academic program, with the exception of students in the Embedded Systems program. For Embedded Systems students, the homologation courses are just recommended and not required. Embedded Systems students can refer to the related section (section 5.1.6) to learn more about the homologation recommendation tool.

If you were assigned a homologation course, but you think one of your bachelor courses already sufficiently covered the topic, you are allowed to request to be exempted from the homologation course. If you would like to make this request, you can contact the academic advisor to discuss the process.

1.6.3 Courses at another university

In addition to taking courses at TU/e, students can follow courses offered by other universities.

In general, any Master-level course offered any Dutch university could count towards a student's Master degree, as long as it approved by the Examination Committee. You can get this approval by including the course in your Study program form and including a link to the course description in the host university's course catalogue (section 1.6.1). Note that the course should not have content overlap with other courses you are taking for your degree. It is highly recommended that you seek this approval before taking the course, to avoid taking a course that is not approved.

There are also more streamlined ways to register for courses at other Dutch universities: if you register for a course via EUWW, the background administration is taken care of for you. There is also the EuroTeq program, where you can register for a course at a partner university in another European country. Most EuroTeq courses are online courses. For more information at EUWW and EuroTeq, look online.

When choosing a EUWW or EuroTeq course, it's important that the content does not overlap with the content of other courses in your program, and that the course and exam scheduling do not conflict with other courses you take. It is recommended to get approval for the course before you take it, so that you can be sure it will count toward your degree. You can get approval by including it in your study program form.

1.6.4 International experience

Students who do not have a degree or certificate(s) from a university in another country are encouraged (but not required) by the Graduate School to gain international 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

If you are interested in studying abroad, please be sure to check the most up-to-date information about international travel (regarding the Corona pandemic) on the university's website. Procedures related to obtaining an international experience are further detailed on the education guide. (tip: google "international experience tue education guide" for the best link!). This includes information about grants and scholarships.

Organizing your stay abroad requires careful planning. It is therefore essential that you contact the following offices as early as possible. They will help you make sure you don't miss any steps preparing your international experience:

- Your academic advisor (section 10.3)
- The department's exchange officer: Exchange.MCS@tue.nl

Going abroad is not a valid reason for missing mandatory courses or homologation courses. If you need help, the academic advisor can help you with this academic planning, and either the academic advisor or the department's exchange coordinator can help you find out if the courses you want to take abroad fit into your master program.

1.6.5 Internship or company experience

An internship (15 ECTS) may be chosen as part of your Master program. It is optional and not a required part of the program. An internship can be carried out in academia or in industry, in the Netherlands or abroad. The objective is to gain experience in your future work field. Please note that this experience can also be gained during your graduation project.

An internship is supervised by an academic staff member at TU/e, called an internship supervisor. This ensures that the internship meets academic criteria. A student has the opportunity to find their own internship and their own internship supervisor; they are not provided to you by the department. We strongly advise that you contact a supervisor at TU/e before you contact a company.

In addition to finding an internship supervisor, the student must also have the internship approved by via the Internship Plan form. This can be found on the Education Guide page of your master program. The student should attach a brief description of the internship and a motivation to the Internship Plan form.

Questions about the process of doing an internship can be directed to the Academic Advisor or your Mentor.

Students should note that it is not allowed to do both an internship and the graduation phase (section 1.8) in a company. If one is in a company, the other would need to be at TU/e or another

educational research institution. A student's internship and graduation phase should not have the same supervisor.

Internship Rules and Regulations:

- The study load is 15 ECTS, corresponding to ca 420 hours of study
- The Internship should fit in the study program and it should contribute to the learning outcomes of the Master's degree program
- Approval for the internship is requested via the Internship Plan form. This must be submitted before the internship starts.
- The Internship can be done externally (at a company or other university) or internally (at TU/e)
    - Internship and graduation *cannot* both be done in industry. This means that if you do an internship with an external company, your graduation project needs to be done at TU/e.
    - The internship supervisor and graduation supervisor must be different; a student's internship supervisor cannot be the same person as their graduation phase supervisor.
- A student's internship and graduation phase must be on distinct topics.

1.7 Professional portfolio

Professional Portfolio is made up of weekly sessions organized by the department. Students can choose which weeks they want to go to. These weekly sessions give students the opportunity to:

- Attend presentations from relevant research groups about the topics the groups are working on. **This is particularly useful to help students decide which group they would like to specialize with for their graduation phase.**
- Follow professional identity trainings
- Attend presentations from companies
- Participate in professional skills workshops

In academic year 2022-2023, a Professional Portfolio pilot is running. Therefore, participation is not mandatory, but students are *highly* encouraged to take part. More information is shared with students in the first weeks of their master program. They can then sign up to get more information and participate.

1.8 Graduation Phase: Preparation phase + Graduation project

At the end of your studies, you will do the graduation phase. This is the final part of your master degree. It is made up of two parts: first you do the preparation phase (worth 10 ECTS) and then the graduation project (worth 30 ECTS). (Note: Some people informally call the graduation phase the master thesis or master project.)[2]

You are allowed to do the graduation phase at TU/e, in another university or research institution, or at a company. It can be in the Netherlands or abroad. In all cases, you still need a supervisor from TU/e. If you did the 15 ECTS internship as part of your master program, and it was at a company,

[2] EIT and BDMA student do not have a preparation phase. This is also true for students who follow the curriculum from Academic year 2020 or earlier.

you must do the graduation project at TU/e or another university or research institution. The internship supervisor cannot be the same person as the graduation supervisor.

There are certain requirements that you need to meet before starting the preparation phase or the graduation project. They are listed below. Please read them carefully.

1.8.1 Planning and starting the graduation phase

During your graduation phase, you do a research project. In order to prepare for this, there is a "preparation phase" worth 10 ECTS. This consists of a literature review and thoroughly defining the research question that you will work to answer during the rest of your project. This is described in further detail below.

All students should also look at the Graduation Checklist on the Education Guide website to make sure they follow the correct administrative steps!

Before starting the preparation phase:

- Find a supervisor. This must be an assistant, associate, or full professor from an appropriate research group at TU/e (see chapter 9). (During your studies, you will already choose electives based on the general research topic you want to focus on during your graduation phase. Your supervisor will most likely be from this research group)
- If you were assigned any homologation courses when you were admitted (section 1.6.2), they must be passed.
- **Turn in the Preparation Phase form**, which is available on the Education Guide website. This form is used by the department to make sure that you meet the requirements to start the preparation phase, and check other details.

Timing: Typically, you do the preparation phase in the quartile before your start your 30 ECTS graduation project. It is allowed to start slightly earlier by spreading the 10 EC over two quartiles. Note that neither the preparation phase nor the graduation project need to start at the beginning of a quarter, or end at the end of a quarter; the exact timing is flexible. This is to be discussed with and agreed on with your graduation supervisor. **In any case, the preparation phase should end when you plan to start the graduation project (30 ECTS).**

During the preparation phase:

The preparation phase is an individual project of 10 credits supervised by your graduation supervisor and its objective is to define a concrete graduation project. Together with your supervisor, you decide on your topic and a global planning for the preparation phase and your graduation project. During the Preparation phase, you create:

- a precisely defined problem statement,
- an analysis of the state-of-the-art including a thorough literature survey,
- define the expected end result,
- an outline of the planned research and development approach (possibly already supported by some initial theoretical analyses, a small example or case study, and/or some initial experiments),
- a project planning with clearly defined milestones (decision points) and deliverables (results).

At the end of the preparation phase:

You present the project proposal report to the intended assessment committee that will also evaluate the graduation project.

The purpose of this preparation phase is to ensure that you can begin your graduation project with a well-defined research problem that is feasible to solve in the given context, particularly regarding the availability of required data, context information, and stakeholder objectives.

There are three possible conclusions: you pass the preparation phase and continue with the same project for the graduation project; you pass the preparation phase, but must find a different graduation project; you fail the preparation phase, and need to do a new preparation phase on a different topic with a different supervisor.

1.8.2 During the Graduation project

After you successfully completed your preparation phase you can begin your graduation project (30 ECTS). You also need to **submit the Graduation Plan form for approval** on time. This is available on the Education Guide website.

During the preparation phase you already developed the graduation topic and a project planning together with your supervisor. You now also arrange the supervision method, including how often you and your supervisor will meet to discuss progress.

In general, the graduation project should be completed within 6 months from the start. However, students who work on the project full-time are allowed up to 9 months to finish the graduation project. (This time period refers only the graduation project portion of the graduation phase; it does not include the time you spend on the preparation phase.) The minimum duration of the project is 4 months. You are not allowed to defend your thesis until 4 months after the defense date of your preparation phase.

1.8.3 Final presentation and thesis defense

The final component of your master program is the final presentation and thesis defense. You must finish all courses and other study components before you defend the thesis. You can discuss arrangements for scheduling the defense with your supervisor as you approach the end of the project.

You complete your graduation project by writing a report about your project, a giving a public final presentation. The defense following the presentation, however, is not public; only the student and the assessment committee are present.

You will also need to register for an examination committee meeting after your defense. This is not a meeting that the student attends. Rather, it is the meeting in which the examination committee checks if you have met all requirements to graduate. You can find details about this and finishing your thesis in the Graduation Checklist on the Education Guide website.

1.8.4 Confidentiality

If a student does their master thesis in collaboration with a company, sometimes the company asks the student to sign an NDA or an extensive confidentiality agreement. Students should keep in mind that they have to write a master thesis, which cannot be confidential forever. Details about

confidentiality agreements can be found on the Education guide. If you have further questions, reach out to the academic advisor.

1.8.5 Plagiarism and the thesis

The university takes scientific integrity seriously. During your studies, you will sign the Code of Scientific Conduct. Part of what you agree to in that document is to not commit plagiarism (e.g., taking credit for material that is not your own) or scientific fraud (e.g., fabricating data). You can read more about this, and the consequences for committing fraud in section 1.13.1.

1.9 After the project

See the Graduation checklist page of your program on the Education Guide website for an overview of the steps to be taken toward the end of your project and after your project.

1.10 Honors Program

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 credits 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 Verbeek (k.a.b.verbeek@tue.nl) and for DS&AI, dr. Vlado Menkovski (v.menkovski@tue.nl). See also the "honors program" page of the Education guide website.

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 of 6 ECTS 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 content 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 doing 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.

1.10.2 Honors Academy

Honors Academy is a university-wide 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 honors programs' coordinators: dr. Kevin Verbeek (k.a.b.verbeek@tue.nl), and for DS&AI, dr. Vlado Menkovski (v.menkovski@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 Double degree program CSE and SEC

The qualification to teach computer science to senior secondary school pupils in the Netherlands is coupled to the 3TU master program Science Education and Communication (SEC). This program en- compasses 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: math, physics, chemistry or computer science. Please note that the SEC program is completely lectured in Dutch!

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

1.12 Quality assurance & Course surveys

After each quarter, students are asked to fill out a course survey for each course they participated in. It is of vital importance that students participate since only questionnaires with a sufficient number of respondents are taken into consideration.

The students' responses are anonymous and are taken seriously by program management; they are discussed first by the Quality Assurance Officer with the Program Management and later by the Program Committee. Lecturers are asked to read and respond to their course's evaluation as well. Positive course evaluations can help the program understand what teaching practices are beneficial. If a course has particularly negative evaluations, the lecturer should create an improvement plan with their supervisor.

Students can also give constructive feedback in roundtable discussions about specific courses, via the education officer of the Study Association GEWIS, or directly to the lecturer of the course.

The opinion of students on the quality of the graduation phase 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 Program management and the Examination committee.

1.13 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. (Appendix A)
- Regulations of the Examination Committee. Topics covered include exams, fraud, graduation and internship.
- Directive Double Diplomas. These are the regulations for students doing a double degree.

The aforementioned documents can be found on the Education Guide pages of the master programs.

1.13.1 Academic honesty

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. Please read the code of conduct very carefully: you will be required to sign a declaration stating that you have read it. 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 the student's 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 the other student's 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.

The Learning Outcomes for each master program or master track are described in the Program and Examination Regulations.

2
Pre-Master Programs

Pre-master programs are meant to prepare students with a technical bachelor degree (HBO) for a University-level Master program. It is not intended for students with a deviating University-level bachelor. Those students can take preparatory courses during their bachelor and take homologation courses (section 1.6.2), or can choose to follow the relevant preparatory bachelor program.

2.1 General Rules

The pre-master programs have only one starting moment (September). Successful completion of the pre-master program grants admission to the corresponding master program.[3] The pre-master must be completed within one academic year. Students who think they will not be able to do this should contact the academic advisor as soon as possible. Depending on the circumstances, the student may be advised to unenroll from the pre-master.

Usually, pre-Master students only take courses that are part of their pre-Master. However, students that have successfully completed a large part of their pre-master program during the first half-year of their studies, and who would be at a demonstrable disadvantage if they were 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. The application should be discussed with and submitted to the pre-master academic advisor (section 10.3).

These are the requirements and steps:

- Students should have to pass all courses during the first semester to be eligible for this exception. This idea should be discussed with the academic advisor in advance.
- Students following a 30 EC pre-master program that can be followed within one semester are not eligible.
- Maximum of 15 EC of master study's components can be approved.
- The eligible courses have to be determined in advance.
- 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.

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:

[3] Note that completing the Pre-master does not grant admission to international programs like EIT Embedded Systems, EIT Data Science, Erasmus Joint Master Degree: Big Data Management and Analytics

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

2.3 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	Course Code	Course name	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 also recommended to follow 2WF70 Algebra for security.

2.4 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	Course Code	Course name	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	Course Code	Course name	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

2.5 Data Science and Artificial Intelligence

The pre-master program for a student with prior knowledge in Linear Algebra totals to 30 EC and consists of the following units:

Quarter	Course Code	Course name	ECTS
1	2IHA10	Algorithms and Data structures	5
1	2IT60	Logic and set theory	5
1	2DI90	Probability and statistics	5
2	2IIG0	Data mining and machine learning	5
2 or 3 (respectively)	2ID50 *or* JBI050	Data modelling and databases *or* Data management for data analytics	5
2	JBI100	Visualization	5

The pre-master program for a student with prior knowledge in Probability and Statistics totals 30 EC and consists of the following units:

Quarter	Course Code	Course name	ECTS
1	2WF20	Linear Algebra 1	5
1	2IT60	Logic and set theory	5
2	2IIG0	Data mining and machine learning	5
2 or 3 (respectively)	2ID50 *or* JBI050	Data modelling and databases *or* Data management for data analytics	5
2	JBI100	Visualization	5
3	2IL50	Data Structures	5

Part II: Master Programs

3 Computer Science in Engineering

The CSE Master program is a research-oriented master on Computer Science and Engineering, to which all clusters in the Computer Science and Data Science domains of the Department of Mathematics and Computer Science contribute by means of courses and graduation assignments. The CSE curriculum consists of a broad range of advanced courses offered by the researchers within these clusters. The courses span a broad range of the following topics: algorithms, databases, formal methods, internet of things, data mining and machine learning, artificial intelligence, process analytics, security, (embedded) software engineering, system and software architecture, and visualization.

3.1 Curriculum

The CSE Master curriculum is structured according to three focus areas: Algorithms & Theory, Architecture & Systems, and Software & Analytics. Each of these focus areas is captured by a set of foundational courses and deepening courses. These focus areas are described later in this chapter.

You obtain breadth in research by selecting a foundational course from each focus area, and specialize in one of the focus areas by selecting additional foundational or deepening courses. In the second half of your studies, you participate in one of the research seminars, bringing you to the forefront of research in your chosen direction.

Specifically, the 120 EC of the CSE Master are allocated as follows. Further explanation is below the table.

CSE curriculum component	ECTS
Foundational courses	15
Specialization (in one focus area)	15
CSE Specialization electives	30
Free electives	15
Seminar	5
Graduation Phase (preparation phase + graduation project)	10+30
TOTAL	***120***

To compose your study program, choose one foundational course from the focus area Algorithms & Theory, one foundational course from the focus area Architecture & Systems, and one foundational course from the focus area Software & Analytics (15 EC in total). That fulfills the “Foundational courses” part of the curriculum. In addition, choose three more courses (foundational or deepening) from *one* focus area (15 EC in total). That is the “Specialization (in one focus area)” portion of the program. The list of “CSE Specialization electives” is later in this chapter.

3.1.1 Focus areas

This section describes the foundational and deepening courses of each Focus area. You can use this information to choose your Foundational courses (15 ECTS) and Specialization (in one focus area) courses (15 ECTS).

Algorithms & Theory: A deep mathematical understanding of computation and semantics is indispensable for reasoning about the quality and efficiency of algorithms, data structures and (concurrent) systems. This focus area thus encompasses, for example, improving and understanding trade-offs between algorithm efficiency and quality, exploring and pushing the limits of computation, modelling and (manually, mechanically or fully automatically) verifying computational and/or concurrent systems. The courses for Algorithms & Theory focus area are as follows:

Quarter	Course code	Course name	ECTS
Foundational			
1	2IMA10	Advanced Algorithms	5
1	2IMF25	Automated Reasoning	5
4	2IMF10	Process Algebra	5
Deepening courses			
1	2IMA20	Algorithms for Geographic Data	5
2	2IMA15	Geometric Algorithms	5
2	2IMA35	Massively Parallel Algorithms	5
3	2IMA25	Exact Algorithms for NP-hard Problems	5
3	2IMF15	Proving with Computer Assistance	5
4	2IMA30	Topological Data Analysis	5

Architecture & Systems: Modern digital systems involve complex interactions between various hardware and software components operating under functional and non-functional requirements. This focus area addresses the understanding and management of the architecture, interactions, behavior, and trade-offs in such systems. In particular, it focuses on the theory and practice for the modeling, design, implementation, analysis and verification of complex networked, embedded, large-scale and data-intensive systems. The courses for Architecture & Systems focus area are as follows:

Quarter	Course code	Course name	ECTS
Foundational			
1	2IMN10	Architecture of Distributed Systems	5
1	2IMF30	System Validation	5
2	2IMD10	Engineering of Data Systems	5
Deepening courses			
2	2IMF35	Algorithms for Model Checking	5
2	2IMN15	Internet of Things	5
2	2IMN20	Real-time Systems	5
3	2IMN25	Quantitative evaluation of Embedded Systems	5
4	2IMN35	VLSI Programming	5

Software & Analytics: Software is a key enabler in Computer Science. The development of software should be efficient and result in high-quality software. This focus area addresses the development of high-quality software in an efficient way. It does so by providing knowledge on developing correct software by construction and by combining principles and methodology of software development with analysis of information sources, specifically by mining software repositories to understand the effects of software evolution. The courses for Software & Analytics focus area are as follows:

Quarter	Course code	Course name	ECTS
Foundational			
1	2AMM20	Research Topics in Data Mining	5
2	2IMP10	Program Verification Techniques	5
3	2IMP25	Software Evolution	5
Deepening courses			
1	2AMI10	Foundations of Process Mining	5
1	2IMN30	Machine Learning for Industry	5
2	2IMP40	Empirical Methods in Software Engineering	5
3	2AMD15	Big Data Management	5
4	2IMP30	System Design Engineering	5
4	2IMP20	Domain Specific Language Design	5

3.1.2 CSE Specialization electives

30 ECTS of your program are made of "CSE Specialization electives". These can either be more courses from the Focus area courses, or courses from the list below. Furthermore, it is also possible to choose international experience courses or an internship for this section, subject to relevance and approval by the Examination committee (section 1.6). This should be done in advance. If you would like to request to use international experience courses as CSE specialization electives, please discuss this with your academic advisor. More information about the internship can be found in Part 1 of this document.

Quarter	Course code	Course name	ECTS
1	2IMS10	Physical aspects of digital security	5
1	2IMS25	Principles of data protection	5
1	2IMV25	Interactive virtual environments	5
2	2DMI20	Software security	5
2	2IMS20	Cyberattacks, Crime and Defenses	5
3	2AMM15	Machine Leaning Engineering	5
3	2IMS15	Verification of security protocols	5
3	2IMS30	Advanced Network Security	5
3	2IMV10	Visual computing project	5
4	2AMM10	Deep Learning	5
4	2IMP15	Software project management	5
4	2IMV15	Simulation in computer graphics	5
(Year)	2IMC10	Internship [1]	15

[1] *Subject to approval and relevance. The student can only start an internship (2IMC10) with permission of the Examination Committee*

Capita Selecta courses 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. The capita selecta can be followed only by permission of the responsible lecturer. Students do not have a "right" to do these courses, but they may be granted the possibility. When included, capita selecta courses are part of the CSE specialization electives. Further questions about the capita selecta can be directed to the academic advisor.

3.1.3 Free electives

To compose the 15 ECTS free electives part of your study program you can choose courses to broaden your horizon from:

- Other TU/e programs
- Other universities
- CSE or focus area foundation or deepening courses

In principle, all master courses offered at the TU/e can be chosen as free electives. Taking other mathematics and computer science related courses is recommended, as well as computer science related courses from other universities (provided their topics do not overlap with the TU/e courses you already take). You can also take EWUU, EuroTeq, or international exchange courses (see sections 1.6.3, 1.6.4 and 1.6.5). **Remember that the courses you choose must be approved** (section 1.6).

Note that if you have homologation courses (section 1.6.2), these are part of your free electives. It is also possible to include up to 15 ECTS of bachelor-level courses as part of your free electives. Note that any homologation courses contribute to this 15 ECTS maximum. If you want to take bachelor-level courses as part of your master degree, but they were not assigned to you as homologation courses, this should be discussed with your mentor and your academic advisor, and needs to be approved by the examination committee. It is recommended to request this approval well in advance of taking the bachelor course(s).

3.1.4 Seminar

CSE students are required to take a seminar. This is meant to help prepare you for the graduation project. Therefore, it is recommended to do the seminar in the field that you would like to do your graduation project in. Some research groups require you to have done their seminar in order to graduate with them, while others don't. (A summary of the research groups in the department can be found in Chapter 9).

You should be in at least the 4th quarter of your master program before you take a seminar. Below you will find a list of seminars for CSE students.

Quarter	Course code	Course name	ECTS
2	2IMD00	Seminar Datamanagement	5
2	2IMF00	Seminar Formal System Analysis	5
2	2IMI00	Seminar Process Analytics	5
2	2IMM00	Seminar Data Mining	5
2	2IMN00	Seminar Interconnected Resource-aware Intelligent Systems (IRIS)	5
2	2IMP00	Seminar Software Engineering and Technology	5
2	2IMU00	Seminar Uncertainty and AI	5

[table continued on next page]

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Quarter	Course code	Course Name	ECTS
2	2IMV00	Seminar Visualization	5
4	2IMA00	Seminar Algorithms	5
4	2IMS00	Seminar Information Security Techonology	5

3.1.5 Graduation Phase

The graduation phase is worth 40 ECTS. It is made of the preparation phase (10 ECTS) and the graduation project (30 ECTS). You do not need to register for the Preparation phase or Graduation Project using Osiris. (Note: Some people call the graduation phase or graduation project the "master project" or "master thesis". This is mentioned here to avoid confusion.)

Students usually start the preparation phase in the 5th or 6th quarter of their studies , followed by the master project in the 7th and 8th quarters. The Preparation graduation phase 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.

Please see section 1.8 for details on the Graduation Phase.

3.2 Graduation Checklist

The Graduation Checklist page of the Education Guide website provides you with a step-by-step guide for the administrative requirements during your master program.

4 Information Security Technology

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

A Master of Science in Information Security Technology can become involved in cryptographic primitives, security protocols, data storage, communication, or information security management. Additionally, they 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 (among others) 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 policy making).

After taking some courses, you will probably have a clearer picture of the academic direction you want to pursue in your studies. If not, you may want to talk to several staff members, your mentor, or the academic advisor. In the specialization for your subject, there are people that you may want to be involved with for your final graduation phase. 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 (or a representative of the group in which you think you might like to graduate) before choosing elective courses. In general, 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, although this may vary based on students' individual circumstances.

4.1 Curriculum

The Master track Information Security Technology is a two-year program of 120 ECTS in total. The program is only offered as a full-time study program, so students should average three courses per quarter. (If you want to regularly take fewer or more courses each quarter, you should talk to the academic advisor (section 10.3))

The 2022 IST curriculum has the following format:

IST curriculum component	ECTS
Mandatory courses	30
IST Stream electives	15
IAM and CSE elective courses	20
Free electives	15
Graduation Phase (preparation phase + graduation project)	10+30
TOTAL	***120***

(Note: if you started in a different academic year, you can see the Program and Examination Regulations from your start year. That is by default the curriculum you follow.)

4.1.1 Mandatory courses

The table below shows the core courses that make up the foundation of the IST program. For more information about the course, check the Osiris course catalogue.

Mandatory courses (30 ECTS):

Quarter	Course code	Course name	ECTS
1	2IMS25	Principles of data protection	5
1	2MMC10	Cryptology	5
2	2DMI20	Software Security	5
2	2IMS20	Cyberattacks crime and defenses	5
3	2IMS30	Advanced network security	5
4	2IMS00	Seminar IST	5

It is recommended to take the mandatory courses in your first quartiles, rather than waiting until the second year. For example, a student who starts in Quarter 1 would take 2IMS25, 2MMC10, and one stream elective (or homologation course) in their first quarter.

The exception is the seminar: students who start the master program in the second semester should take the seminar closer to the start of their graduation phase.

4.1.2 IST Stream Electives

At least three courses (15 ECTS) need to be taken from the list of IST Electives; you do not need to take all 5 of these courses. If you want to take more than three of these courses, they can count in the other categories of electives

IST Stream electives (15 ECTS needed):

Quarter	Course code	Course name	ECTS
1	2IMA10	Advanced algorithms	5
1	2IMS10	Physical aspects of digital security	5
2	2DMI10	Applied cryptography	5
3	2DMI00	Cryptographic protocols	5
3	2IMS15	Verification of security protocols	5
3	2IMS40	Intrusion Detection Laboratory	5

4.1.3 IAM and CSE courses

20 ECTS of the IST program is made up of electives from the list of courses from the Computer Science in Engineering master track (can be foundational, deepening, or specialization courses), or

the courses from the Industrial and Applied Mathematics Master program. The CSE courses are listed in Chapter 3. A list of IAM courses can be found in the Program and Examination Regulations (Appendix A). An internship (15 ECTS) (section 1.6.5) can also count towards this section.

4.1.4 Free Electives

To compose the 15 ECTS free electives part of your study program you can choose courses to broaden your horizon from:

- Other TU/e programs
- Other universities
- CSE or focus area foundation or deepening courses

In principle, all master courses offered at the TU/e can be chosen as free electives. Taking other mathematics and computer science related courses is recommended, as well as security-related courses from other universities (provided their topics do not overlap with the TU/e courses you already take). You can also take EWUU, EuroTeq, or international exchange courses (see sections 1.6.3, 1.6.4, and 1.6.5). **Remember that the courses you choose must be approved** (section 1.6).

Note that if you have homologation courses (section 1.6.2), these are part of your free electives. It is also possible to include up to 15 ECTS of bachelor-level courses as part of your free electives. Note that any homologation courses contribute to this 15 ECTS maximum. If you want to take bachelor-level courses as part of your master degree, but they were not assigned to you as homologation courses, this should be discussed with your mentor and your academic advisor, and needs to be approved by the examination committee. It is recommended to request this approval well in advance of taking the bachelor course(s).

4.1.5 Graduation phase

The graduation phase is worth 40 ECTS. It is made of the preparation phase (10 ECTS) and the graduation project (30 ECTS). IST students can do their graduation phase with a computer science research cluster or with the Coding and Crypto group from the discrete mathematics cluster. You do not need to register for the Preparation phase or Graduation Project using Osiris. (Note: Some people call the graduation phase or graduation project the “master project” or “master thesis”. This is mentioned here to avoid confusion.)

Students usually start the preparation phase in the 5th or 6th quarter of their studies , followed by the master project in the 7th and 8th quarters. The Preparation graduation phase 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.

Please see section 1.8 for details on the Graduation Phase.

4.2 Graduation Checklist

The Graduation Checklist page of the Education Guide website provides you with a step-by-step guide for the administrative requirements during your master program.

5 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 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 reliable and resource-efficient (e.g., energy, computational and network resources) 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.

5.1 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.

ES curriculum component	ECTS
Mandatory courses	25
Stream mandatory courses	15
Stream electives	15
Free electives	25
Graduation Phase (preparation phase + graduation project)	10+30
TOTAL	***120***

The curriculum has a core of 25 EC consisting of five courses that are mandatory for all Embedded Systems students. The curriculum is further structured into four streams. Students choose one stream and follow its courses. The streams are:

- Systems on Chip

- Embedded Software
- Embedded Networking
- Cyber-Physical Systems

In the following sections, more details for each of the streams are given.

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. Each stream is made of a mandatory part of 15 ECTS and a stream elective part of 15 ECTS. Each stream has its own list of stream electives.

The graduation project of the Embedded Systems program consists of a 10 ECTS preparation phase and a 30 ECTS graduation project. The remaining 25 ECTS of the program may be composed of free electives.

Students are encouraged to consider including international experience (courses or research in another country) as part of their program. However, this is not required. This experience is particularly valuable to students that do not yet have international experience and are not intending on doing their master project abroad.

5.1.1 Mandatory courses

The following are the mandatory courses of the Embedded Systems program

Quarter	Course code	Course name	ECTS
1	2IMF30	System Validation	5
2	5SIA0	Embedded Computer Architecture	5
2	2IMN20	Real-time Systems	5
3	2IMN25	Quantitative Evaluation of Embedded Systems	5
4	5LIB0	Embedded Systems Laboratory	5

5.1.2 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.

Students who choose this stream must take all its Mandatory courses, and at least 15 ECTS of its Stream elective courses. Additional stream electives can be taken, which will count as free electives.

Quarter	Course code	Course name	ECTS
Stream Mandatory courses			
1	2IMF25	Automated Reasoning	5
2	5LIH0	Digital Integrated Circuit Design [1]	5
4	5LID0	Systems on Silicon	5
Stream Elective courses [2]			
1	5CCA0	Semiconductor physics and materials	5

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Quarter	Course code	Course name	ECTS
1	5LIN0	Video Processing	5
2	2IMNT1	Embedded computer architectures [3]	5
2	5LIG0	Applied Combinatorial Algorithms	5
2	5LIF0	Advanced Digital Circuit Design	5
3	5LIL0	Intelligent Architectures	5
3	5LIE0	Multiprocessors	5
3	5LIM0	Parallelization, Compliers and Platforms	5
3	5SIB0	Electronic Design Automation	5
3	5LIJ0	Embedded Control Systems	5
4	2IMN35	VLSI Programming	5
4	5LIA0	Embedded Visual Control	5
6	2IMF00	Seminar Formal Systems Analysis [4]	5

1 It is forbidden to include both of the following courses as part of your Master program of examinations: 5LIH0 Digital integrated circuit design and 5LIP0 Digital integrated circuits: fundamentals.
2 At least 15 credits of this list of stream electives have to be chosen.
3 The course 2IMNT1 is offered by TU Twente in Enschede. Secondary enrollment at the TU Twente us required to take the course.
4 A seminar may be followed starting from the fourth quarter of the program.

5.1.3 Embedded Software stream

The behavior 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.

Students who choose this stream must take all its Mandatory courses, and at least 15 ECTS of its Stream elective courses. Additional stream electives can be taken, which will count as free electives.

Quarter	Course code	Course name	ECTS
Stream Mandatory courses			
1	2IMF25	Automated Reasoning	5
3	5LIM0	Parallelization, Compliers and Platforms	5
4	2IMP30	System Design Engineering	5
Stream Elective courses [1]			
1	2IMN10	Architecture of Distributed Systems	5
1	5LIN0	Video Processing	5
2	2DMI20	Software security	5
2	2IMP10	Program Verification Techniques	5
2	5LIG0	Applied Combinatorial Algorithms	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

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Quarter	Course code	Course name	ECTS
4	2IMN35	VLSI Programming	
4	2IMP20	Domain Specific Language Design	5
4	5LIK0	Embedded Signal Processing Systems	5
6	2IMF00	Seminar Formal Systems Analysis [2]	5
6	2IMN00	Seminar Interconnected Resource-aware Intelligent Systems (IRIS) [2]	5
6	2IMP00	Seminar Software Engineering and Technology [2]	5

1 *At least 15 credits of this list of stream electives have to be chosen.*

2 *A seminar may be followed starting from the fourth quarter of the program.*

5.1.4 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.

Quarter	Course code	Course name	ECTS
Stream Mandatory courses			
1	2IMN10	Architecture of Distributed Systems	5
1	5LIC0	Networked Embedded Systems	5
2	2IMN15	Internet of Things	5
Stream Elective courses [1]			
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	2IMS30	Advanced Network Security	5
3	2IMS15	Verification of Security Protocols	5
3	5SIB0	Electronic Design Automation	5
4	5LIK0	Embedded Signal Processing Systems	5
4	5LIA0	Embedded Visual Control	5
4	5LID0	Systems on Silicon	5
4	2IMP30	System Design Engineering	5
6	2IMF00	Seminar Formal System Analysis [2]	5
6	2IMN00	Seminar Interconnected Resource-aware Intelligent Systems (IRIS) [2]	5

1 At least 15 credits of this list of stream electives have to be chosen.
2 A seminar may be followed starting from the fourth quarter of the program.

5.1.5 Cyber-Physical Systems stream

Cyber-Physical Systems are characterized 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 focuses on the control and signal processing aspects of cyber- physical systems.

Quarter	Course code	Course name	ECTS
Stream Mandatory courses			
2	2IMN15	Internet of Things	5
3	5LIJ0	Embedded Control Systems	5
4	5LIK0	Embedded Signal Processing Systems	5
Stream Elective courses [1]			
1	5CSA0	Modelling Dynamics	5
1	2IMN10	Architecture of Distributed Systems	5
1	5LIC0	Networked Embedded Systems	5
2	5LIG0	Applied Combinatorial Algorithms	5
2	5LIF0	Advanced Digital Circuit Design	5
2	5LIV0	Video Health Monitoring	5
3	2IMP25	Software Evolution	5
3	5LIM0	Parallelization, Compliers and Platforms	5
3	5LIE0	Multiprocessors	5
3	5LIL0	Intelligent Architectures	5
3	5SIB0	Electronic Design Automation	5
4	2IMN35	VLSI Programming	5
4	5LIA0	Embedded Visual Control	5
4	2IMP30	System Design Engineering	5

1 At least 15 credits of this list of stream electives have to be chosen.

5.1.6 Free electives

To compose the 25 EC free electives part of your study program you can choose courses to broaden your horizon from:

- Other TU/e programs
- Other universities
- More courses from the Embedded Systems curriculum
- An internship (section 1.6.5)

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. Note that you must take a placement test with the language center before you can register for SFC640. You can also take EWUU, EuroTeq, or international exchange courses (see sections 1.6.3, 1.6.4, and 1.6.5). **Remember that the courses you choose must be approved** (section 1.6).

Note that if you have homologation courses (section 1.6.2), these are part of your free electives. If an Embedded systems student was suggested to take a homologation course in their admission letter,

it is not required that the student follows the course. It is only highly recommended. Students are also recommended to test their own background knowledge with the homologation recommendation tool. If you do not know how to access the homologation recommendation tool, contact the academic advisor.

While you are encouraged to focus on Master courses, it is also possible to include up to 15 ECTS of bachelor-level courses as part of your free electives. Note that any homologation courses contribute to this 15 ECTS maximum. If you want to take bachelor-level courses as part of your master degree, but they were not assigned to you as homologation courses, this should be discussed with your mentor and your academic advisor, and needs to be approved by the examination committee. It is recommended to request this approval well in advance of taking the bachelor course(s).

5.1.7 Graduation Phase

The graduation phase is worth 40 ECTS. It is made of the preparation phase (10 ECTS) and the graduation project (30 ECTS). ES students can do their graduation phase with computer science or with Electrical Engineering (see section 9.2). You do not need to register for the Preparation phase or Graduation Project using Osiris. (Note: Some people call the graduation phase or graduation project the “master project” or “master thesis”. This is mentioned here to avoid confusion.)

Students usually start the preparation phase in the 5th or 6th quarter of their studies , followed by the master project in the 7th and 8th quarters. The Preparation graduation phase 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.

Please see section 1.8 for details on the Graduation Phase.

5.2 Graduation Checklist

The Graduation Checklist page of the Education Guide website provides you with a step-by-step guide for the administrative requirements during your master program.

6
Data Science & Artificial Intelligence

As the name of the program implies, the MSc Data Science & Artificial Intelligence (DS&AI) program is grounded in two scientific disciplines: data science and artificial intelligence. The main aim of the program is to educate Masters of Science in engineering who are able to combine advanced data analytics techniques and AI methods in order to understand, apply and create systems that behave intelligently and extend human intelligence in a responsible, transparent, and explainable way.

We strongly believe that society needs experts who can support and enhance our human capabilities to solve complex problems, gain deeper understanding, and achieve results that were not attainable before in a trustworthy and explainable way, by analyzing (large amounts of complex) data and representing, analyzing, and reasoning over (domain) knowledge using the structured skills, techniques, and the deep knowledge and understanding of Data Science methods with the state-of-the-art methods of AI.

The DS&AI program has the ambition that DS&AI graduates are Data Scientists and AI Engineers with the ethos of a "civil engineer," having deep technical abilities in the above expertise areas to develop smart solutions (instead of brute forcing) that

- are robust, trustworthy, fair, and secure,
- work together with people (not instead of),
- include the human factor in the process and in the result, and
- turn data into value under technical, social, and ethical aspects.

Hence the core content of the intended DS&AI program is the combination of its two underlying scientific disciplines, data science and artificial intelligence together with ethics and challenge-based learning. Data Science studies all principles and techniques of collecting, storing, managing, preparing, processing, analyzing, and visualizing data. Artificial Intelligence studies all principles and techniques for supporting and augmenting intelligent behavior. These two disciplines create knowledge from data and intelligence from knowledge.

There are many different areas within Data Science & Artificial Intelligence that support this process. The Master's program DS&AI is organized around six areas, each containing three to four coherent courses within the program. These areas are:

- Data Engineering and management
- Algorithmic Data Analysis
- Explainable Data Analytics
- Statistics
- Data Mining and Machine Learning
- AI and Machine Learning

Through ethics and challenge-based learning, students integrate their skills from the different expertise areas in various real-life contexts, providing reflection on their methodology and way of working as an AI Engineer.

6.1 Curriculum

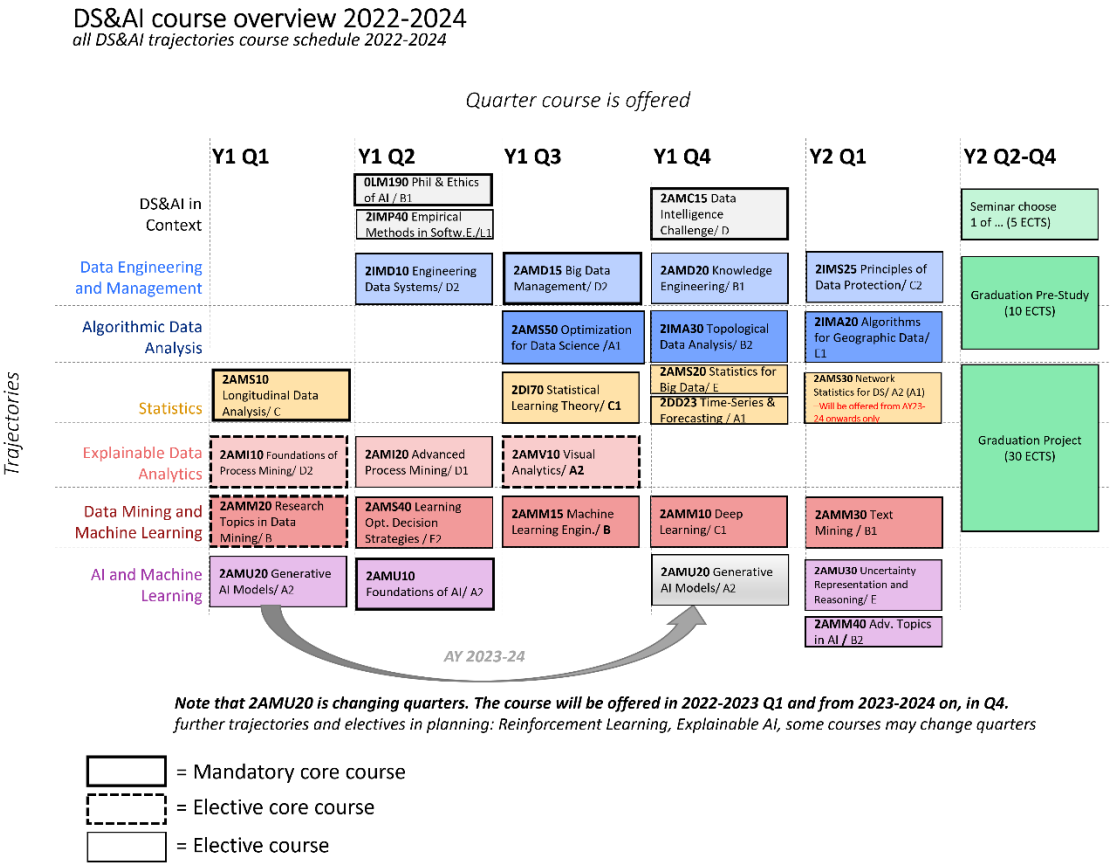
The Master program Data Science & Artificial Intelligence is a two-year program of 120 ECTS in total. It is possible to enter the program at the start of either semester; however, starting in February is not advised and will most likely lead to a study delay. If you'd wish to start in February, always consult with the academic advisor first. The program is only offered as a full-time study program. However, it is possible to study at a different pace, taking less courses per quartile. Again, this should be discussed with the academic advisor (section 10.3).

6.1.1 Program Composition

The Master program on Data Science & Artificial Intelligence is structured into trajectories. Each trajectory contains a set of 2-4 coherent courses that go from foundational knowledge to advanced expertise. The image below shows the different types of courses and their scheduling. (Note that 2AMM30 and 2AMM40 have a capacity/enrolment limit, at least in academic year 2022-2023.) You compose your program of examinations by:

- Following all core courses in the trajectories of the program (30 credits)
    - 25 credits of mandatory core courses *(bold lined course in the table below)*
    - 5 credits of elective core courses *(bold, dashed lined courses)*
- Choosing specialization electives (30 credits) from the trajectories in the form of
    - 2 trajectories you declare as your major trajectories (10 credits per major trajectory)
    - 1 or 2 more trajectories you declare as your minor trajectories (10 credits)
        1. 1 trajectory with 10 credits, or 2 trajectories 5 credits each
- Choosing free electives (15 credits)
- Completing your program with the graduation phase (45 credits) *(green courses)*
    1. 5 credits seminar
    2. 10 credits preparation phase
    3. 30 credits graduation project

[see image on next page]



6.1.2 Trajectories

The DS&AI program is divided into seven trajectories, listed here. These are described in further detail below.

1. Data Science & Artificial Intelligence in Context (general trajectory)
2. Data Management
3. Algorithms
4. Explainable Data Analytics
5. Statistics
6. Data Mining and Machine Learning
7. AI and Machine Learning

Trajectories number 2 through 7 can be elected as major or minor trajectory.

Data Science & Artificial Intelligence in Context: When working as an engineer in Data Science & Artificial Intelligence, you will identify and solve societal and technical problems. The problems you face will present themselves, not in a clearly defined technical manner as taught in the technical trajectories, but rather, you will encounter them in the context of an existing organization or system where specific stakeholders such as citizens, workers, customers, patients, farm animals, or wildlife face a problem. Your obligation as an engineer is to understand this context, it's requirements and objectives and the different aspects and objectives that define what desirable and undesirable solutions are. More often than not, you will see that the problem and its objectives are different than initially presented to you by stakeholders in the light of available data; that data is incomplete or

insufficient. You will also see that objectives from different stakeholders and context constraints contradict each other, both in being achievable through technical solutions, but also in their impact on the stakeholder and the context: a solution that works seemingly well according to various technical quality criteria may have potentially disastrous consequences for users, or people affected by this solution.

As an Engineer in Data Science & Artificial Intelligence, you must be aware of all the requirements and objectives of the problem you are aiming to solve, taking the full context into account.

Data Management: We live increasingly in a data-driven world. Data and data analytics play a central role not only in technical systems but also broadly in organizations and society, across government, academia, and industry, and both in private and public spaces. We are awash in massive complex data collections containing tremendous untapped value.

Data Management Systems (DMS) provide the fundamental underlying infrastructure to identify and realize this value. DMS provide for the end-to-end care, maintenance, and use of data towards revealing actionable insights into big data. Data-intensive systems consequently must address a broad range of basic scientific challenges, such as efficient scalable human-data interaction, explainable and secure data storage and access, knowledge modeling and extraction, and scalable data analytics for data science and artificial intelligence applications. DMS are responsible for efficiently and effectively addressing all of these intertwined challenges which are widespread in today's data-driven science and organizations.

Algorithms: Algorithms play a fundamental role in Data Science: they enable efficient automated data handling, analysis and visualization. Typical data-science problems are often time-sensitive and complex, and not even necessarily well-defined. To develop algorithmic solutions for such challenges which deliver high- quality results in a verifiable, and hence also explainable, manner, a broad set of algorithmic tools is a necessary and important part of the repertoire of each data scientist.

Explainable Data Analytics: The courses in this trajectory teach you techniques to explore and integrate various kinds of complex data by designing problem-specific visualization pipelines for data summarization, feature engineering, and hypothesis generation and evaluation (2AMV10). You will learn how to analyze data from more than one viewpoint, revealing new features and properties that are crucial for better data understanding and learning behavioral models (2AMV10, 2AMI20). You will learn how to construct highly explainable behavioral models and process models that we call glass-box models through unsupervised learning that visually describe any kind of behavior (processes) in an easily understandable manner (2AMI10, 2AMI20). On the example of process models, you will learn to adopt a mindset of evaluating models not just in terms of aggregate errors measures but along various quality dimensions including precise diagnostic information that can explain the quality of the model for each data point (2AMV10, 2AMI10, 2AMI20), and how to use the diagnostic information for improving model quality (2AMI20). The course 2AMU30 Uncertainty Representation and Reasoning from the "AI and Machine Learning" trajectory cover this topic from the angle of Machine Learning and Artificial Intelligence.

Statistics: Statistical analysis aims to understand relevant characteristics of (sub)populations or phenomena that are described by the collected data. This field of data science and artificial intelligence contains a wealth of statistical models and techniques that can summarize data into understandable statistical quantities and features that have direct impact and interpretation to real-world situations. It contains methods that may help in collecting data (e.g. survey sampling,

experimental design), modeling data (e.g. time-series, linear, non-linear, and generalized mixed models, survival and reliability), and exploring or learning from data (e.g. clustering analysis, discriminant analysis, resampling). The field characterizes itself by its capability of analyzing complex data sets and properly describing or addressing the inherent uncertainty (data collection variabilities, measurement errors, incompleteness, outliers, heterogeneities, systematic biases) in the observed data.

Choosing the appropriate statistical method for the analysis of a specific data set requires knowledge, experience, skill, and practice. For large and complex data sets there are often many different ways that a data set can be approached, and it is imperative that the strengths and weaknesses of the statistical analyses are known to the user for the tasks at hand. In large and complex data sets it is impossible to address in a statistical analysis all the different data aspects present in a data set, since statistical methods may not always be rich enough to capture all these aspects. Knowing what aspects of the data in combination with the statistical models and methods can be ignored or treated as nuisance is an important part of statistical analysis.

Data Mining and Machine Learning: Data mining and machine learning study foundations and practical approaches for knowledge discovery from vast collections of complex data. This knowledge may come in the form of patterns, descriptive, predictive and prescriptive models.

This trajectory focuses on data mining and machine learning approaches and techniques for developing end-to-end solutions for algorithmic decision making. These are so pervasive today that you probably use them dozens of times a day without knowing it, for instance in web search, speech recognition, and a variety of mobile phone applications. It is also a crucial component of data-driven industry, scientific discovery, and modern healthcare. One of the fascinating aspects of data mining and machine learning is that they automate the process by learning from examples rather than being explicitly programmed. We, as engineers, come up with approaches for meta-programming. That is, we develop intelligent computer programs that can learn to induce new useful programs from the training examples.

AI and Machine Learning: Artificial intelligence and machine learning involve the study of algorithms that 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 optimization, statistics, probability, algorithmic development, and so on. This trajectory explores AI and machine learning from multiple angles on principles of AI, theories of representation, AI models, algorithms for learning, reasoning and decision making. There is also an important focus on solutions that are not only accurate but efficient, reliable, interpretative, robust and trustworthy.

6.1.3 Free Electives

To compose the 15 EC free electives part of your study program you can choose courses to broaden your horizon from:

- Recommended DS&AI electives (see below)
- Other TU/e programs
- Other universities
- Capita selecta

In principle, all master courses offered at the TU/e can be chosen as free electives. Taking other mathematics and computer science related courses is recommended, as well as computer science related courses from other universities (provided their topics do not overlap with the TU/e courses you already take). You can also take EWUU, EuroTeq, or international exchange courses (see sections 1.6.3, 1.6.4, and 1.6.5). **Remember that the courses you choose must be approved** (section 1.6).

Note that if you have homologation courses (section 1.6.2), these are part of your free electives. It is also possible to include up to 15 ECTS of bachelor-level courses as part of your free electives. Note that any homologation courses contribute to this 15 ECTS maximum. If you want to take bachelor-level courses as part of your master degree, but they were not assigned to you as homologation courses, this should be discussed with your mentor and your academic advisor, and needs to be approved by the examination committee. It is recommended to request this approval well in advance of taking the bachelor course(s).

The following courses are recommended free electives for DS&AI:

Quarter	Course code	Course name	ECTS
Any	SFC640	Academic Writing [1]	5
Any	2IMC10	Internship	15
Any	2IM..05	Capita Selecta [2]	5
Any	2MMR40	Research Topic 1	5
Any	2MMR50	Research Topic 2	5
Any	2MMR60	Research Topic 3	5
1	2IMN30	Machine Learning for Industry	5
1	8DM50	Machine learning in medical imaging and biology	5
1	5ARA0	Software engineering for artificial intelligence	5
1	5ARB0	Data Science: data acquisition and analysis	5
1	DBM190	Designing with and for digital twins: A data-driven design perspective	5
1	7ZU4M0	Econometric analysis of housing markets: data, tools and strategies	5
1	2IMA10	Advanced Algorithms	5
1	2IMF25	Automated Reasoning	5
2	2IMA35	Massively Parallel Algorithms	5
2	5SSD0	Bayesian Machine Learning and information processing	5
2	DBM180	Designing with advanced artificial intelligence	5
2	4SC000	Optimal control and reinforcement learning	5
3	0HM340	Human-AI Interaction	5
4	5SC28	Machine Learning for Systems and control	5
4	5LSL0	Machine Learning for signal processing	5
4	1BM120	Decision making with artificial and computational intelligence	5
4	5AUA0	Advanced sensing using deep learning	5

1 It is required to take a placement test with the Language Center before being allowed to register for SFC640.
2 The capita selecta can be followed only by permission of the responsible lecturer. Further questions about the capita selecta can be directed to the academic advisor.

6.1.4 Seminar

Students should take 1 seminar from the list below.

Quarter	Course code	Course name	ECTS
2	2IMD00	Seminar Datamanagement	5
2	2IMF00	Seminar Formal System Analysis	5
2	2IMI00	Seminar Process Analytics	5
2	2IMM00	Seminar Data Mining	5
2	2IMN00	Seminar Interconnected Resource-aware Intelligent Systems (IRIS)	5
2	2AMS00	Seminar SPOR	5
2	2IMP00	Seminar Software Engineering and Technology	5
2	2IMU00	Seminar Uncertainty and AI	5
2	2IMV00	Seminar Visualization	5
4	2IMA00	Seminar Algorithms	5
4	2IMS00	Seminar Information Security Technology	5

6.1.5 Graduation phase

The graduation phase is worth 40 ECTS. It is made of the preparation phase (10 ECTS) and the graduation project (30 ECTS). You do not need to register for the Preparation phase or Graduation Project using Osiris. (Note: Some people call the graduation phase or graduation project the "master project" or "master thesis". This is mentioned here to avoid confusion.)

Students usually start the preparation phase in the 5th or 6th quarter of their studies , followed by the master project in the 7th and 8th quarters. The Preparation graduation phase 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.

Please see section 1.8 for details on the Graduation Phase.

6.2 Graduation Checklist

The Graduation Checklist page of the Education Guide website provides you with a step-by-step guide for the administrative requirements during your master program.

7 EIT Programs

TU/e participates in the EIT Digital Master School. There are the EIT digital Embedded Systems track and the EIT digital Data Science track. Students in the EIT program follow the first year of their master at one of the participating EIT universities (called the student's "entry-point university"), and the second year at another (called the "exit-point university"). After completion of the program, the student gets a degree from both universities and a certificate.

Students who want to follow the EIT master programs must apply through EIT; it is not possible to switch to EIT from one of the other Master programs of Computer Science. More information about these programs is available on the EIT digital master school's website.

7.1 EIT Embedded Systems

TU/e offers both an entry-point program and an exit-point program for EIT Embedded Systems. The various sections below describe the curriculum in detail.

7.1.1 EIT Embedded Systems Entry Point Program

The EIT-ES entry-point program has 45 ECTS of mandatory courses. Students also choose one I&E elective, and two Embedded Systems electives. The courses in these categories are listed in more detail below the Curriculum Overview table.

Curriculum Overview

	ECTS
Mandatory courses	45
I&E Elective	5
Embedded Systems Electives	10
TOTAL	***60***

Mandatory courses (45 ECTS)

Quarter	Course code	Course name	ECTS
1	2IMF30	System Validation	5
2	1ZM20	Technology Entrepreneurship	5
2	5SIA0	Embedded Computer Architecture	5
2	2IMN20	Real-time Systems	5
3	2IMN25	Quantitative Evaluation of Embedded Systems	5
3	1ZM150	Innovation Space Project	10
3	2IEIT0	Winter School	1
4	5LIB0	Embedded Systems Laboratory	5
4	2IEIT5	Summer School	4

Students also must chose 5 ECTS (1 course) from the list of I&E electives:

I&E electives (5 ECTS)

Quarter	Course code	Course name	ECTS
1	1CM22	Financial Management	5
2	1ZM120	Entrepreneurial Marketing	5
2	0HM220	Network Society	5
2	1ZM40	Strategy and Technology Management	5
3	1ZM65	System Dynamics	5
4	1ZM90	Open Innovation	5
4	0LM150	Entrepreneurship and Corporate Social Responsibility	5
4	1CM15	Project and process management	5
4	1ZM70	Entrepreneurial Finance	5

Embedded Systems electives (10 ECTS) must be chosen from the Stream Mandatory and Stream Elective courses of the master program Embedded Systems. See Chapter 5 for the list of courses.

7.1.2 EIT Embedded Systems Exit Point Program

The EIT-ES exit-point program has four mandatory courses. Students also choose at least 9 ECTS of electives and do a graduation project (Master thesis). These categories are described in detail below the Curriculum Overview table.

Curriculum Overview

	ECTS
Mandatory courses	21
Electives (Embedded Systems elective)	9
Graduation project/ Master thesis	30
TOTAL	***60***

Mandatory courses (21 ECTS)

Quarter	Course code	Course name	ECTS
1	2IMN10	Architecture of Distributed Systems	5
1	5LIC0	Networked Embedded Systems	5
1	1ZS30	Innovation and Entrepreneurship Study	6
2	2IMN15	Internet of Things	5

Electives (Embedded Systems electives) (9 ECTS) must be chosen from the Stream Mandatory and Stream Elective courses of the master program Embedded Systems. See Chapter 5 for the list of courses. Almost all courses are worth 5 ECTS, so you will likely end up taking 10 ECTS of electives. Students also have the option of taking 2IMC05/5T514 Preparation for Graduation Project ES as an elective, under the condition that the intended supervisor agrees. More information about the Preparation phase for the graduation project can be found in section 1.8.

Graduation Project/Master Thesis (30 ECTS): see section 1.8 for more details.

7.2 EIT Data Science

TU/e offers both an entry-point program and an exit-point program for EIT Data Science. The various sections below describe the curriculum in detail.

7.2.1 EIT Data Science Entry Point Program

The EIT-DS entry-point program has 50 ECTS of mandatory courses. Students also choose 10 ECTS of electives. The courses in these categories are listed in more detail below the Curriculum Overview table.

Curriculum Overview

	ECTS
Mandatory courses	50
Electives	10
TOTAL	***60***

Mandatory courses (50 ECTS)

Quarter	Course code	Course name	ECTS
1	2AMI10	Foundations of Process Mining [1]	5
1	2AMM20	Research Topics in Data Mining	5
1	2AMS10	Longitudinal Data Analysis	5
2	2IMD10	Engineering Data Systems	5
2	0LM190	Philosophy and Ethics of AI	5
2	1ZM20	Technology Entrepreneurship	5
3	2IEIT0	Winter School	1
3-4	1ZM150	Innovation Space Project	10
4	0LM150	Entrepreneurship and Corporate Social Responsibility	5
4	2IEIT5	Summer school	4

1 Students who took the TU/e course 2IIE0 Business Process Intelligence in their bachelor are not allowed to take 2AMI10 due to overlap.

Electives (choose 10 ECTS from this list)

Quarter	Course code	Course name	ECTS
1	2AMU20	Generative AI Models	5
1	2IMA20	Algorithms for Geographic Data	5
3	2AMD15	Big Data Management	5
3	2AMM15	Machine Learning Engineering	5
3	2DI70	Statistical Learning Theory	5
4	2AMD20	Knowledge Engineering	5
4	2AMM10	Deep Learning	5
4	2AMS20	Statistics for Big Data	5
4	2DD23	Time Series Analysis and Forecasting	5
4	2IMA30	Topological Data Analysis	5

7.2.2 EIT Data Science Exit Point Program

The EIT-DS exit-point program has 5 mandatory courses. Students also choose one seminar, and do a graduation project (Master thesis). The courses and seminar are described in more detail below the Curriculum Overview table.

Curriculum Overview

	ECTS
Mandatory courses	26
Seminar	5
Graduation project/ Master thesis	30
TOTAL	***61***

Mandatory courses (26 ECTS)

Quarter	Course code	Course name	ECTS
1	2AMI10	Foundations of Process Mining [1]	5
1	2IMS25	Principles of Data Protection	5
1	1ZS30	Innovation and Entrepreneurship Study	6
2	2AMI20	Advanced Process Mining	5
2	2IMP40	Empirical Methods in Software Engineering	5

Seminar (choose 5 ECTS from this list)

Quarter	Course code	Course name	ECTS
2	2IMI00	Seminar Process Analytics	5
2	2IMV00	Seminar Visualization	5
2	2IMD00	Seminar Datamanagement	5
2	2IMU00	Seminar Uncertainty in AI	5
2	2IMM00	Seminar Data Mining	5
2	2AMS00	Seminar SPOR	5
2	2IMN00	Seminar IRIS	5
2	2IMP00	Seminar SET	5
2	2IMF00	Seminar Formal System Analysis	5
4	2IMS00	Seminar IST	5
4	2IMA00	Seminar Algorithms	5

Graduation Project/Master Thesis (30 ECTS): see section 1.8 for more details.

8
Erasmus Mundus Joint Master Degree: Big Data Management and Analytics

Students following the Big Data Management and Analytics Master program can do the second year of their master program at TU/e to specialize in Business Process Analytics. It is not possible to switch to BDMA from one of the other Master programs of Computer Science at TU/e. Details about the program are available on the BDMA website.

The following table summarizes the BDMA specialization program at TU/e:

Quarter	Course Code	Course Name	ECTS
1	2AMI10	Foundations of process mining	5
1	2AMS10	Longitudinal data analysis	5
1	2AMR10	Responsible data challenge	5
2	2AMI20	Advanced process mining	5
2	2IMP40	Empirical methods in software engineering	5
2	2IMI00	Seminar process analytics	5
3+4	2IMC00	Graduation Project/Master project	30

If BDMA students have questions about their program, they can contact the academic advisor (section 10.3) or the BDMA Program Manager, dr. Renata Medeiros de Carvalho.

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.

All master courses offered by the Computer Science department start with 2IM or 2AM for Data Science followed by a letter representing a research group, as follows:

A: Algorithms, Geometry and Applications
C: Courses not specific for a research group such as internship or master project,
D: Databases
F: Formal System Analysis
I: Process Analytics
M: Data Mining
N: Interconnected Resource-aware Intelligent Systems
P: Software Engineering and Technology
S: Security
U: Uncertainty in AI
V: Visualization

The rest of this chapter goes into more detail about the research groups. You can check which groups offer the courses you have enjoyed most and use this information when choosing your master project.

9.1 CS Research Groups

This section describes the research groups that provide graduation projects for all Computer Science Master programs (CSE, ES, DS&AI, IST, DSIE, and the EIT programs)

9.1.1 Algorithms, Geometry and Applications (A)

Website: https://alga.win.tue.nl/

Contact person: dr. Wouter Meulemans

The ALGA cluster 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. In all cases, the goal is to understand the underlying principles of the developed solutions and to formally prove their properties. Our approaches frequently combine the rigorous methods

from algorithmic theory – which give performance guarantees with respect to both the quality of solutions and the running time of algorithms – with efficient engineering to achieve results of both theoretical and practical significance.

Within the broad field of algorithms, ALGA specializes in various areas:

- Computational Geometry
- Moving Object Analysis
- Parameterized Complexity
- Geovisualization
- Massive Data
- Mobile Agents
- Networks
- Digital Humanities

We offer a broad spectrum of possible projects in these areas: very fundamental and theoretical, purely experimental, and combinations of these. We recommend interested students to have a look at our webpage for more details on these topics, as well as an overview of recent theses.

Relevant courses are:

- Advanced algorithms (2IMA10)
- Geometric algorithms (2IMA15)
- Algorithms for geographic data (2IMA20)
- Massively Parallel Algorithms (2IMA35)
- Exact Algorithms for NP-hard Problems (2IMA25)
- Topological Data Analysis (2IMA30)
- Seminar Algorithms (2IMA00)

Other relevant courses:

- Visual analytics (2AMV10)
- Graphs and Algorithms (2MMD30)

9.1.2 Process Analytics (I)

Website: https://pa.win.tue.nl/

Contact person(s): See link above. For signing the study program contact the Secretary IS

The Process Analytics (PA) research group investigates methods, techniques and tools for the design and analysis of Process-Aware Information Systems (PAIS), i.e., systems that support business processes (workflows) inside and between organizations.

PA is not only interested in these information systems and their architecture, but also model and analyze the business processes and organizations they support. The group aims at results that are highly original and applicable in real-life situations. The main three research lines of AIS 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 further improve verification techniques to check various properties such as soundness, data/resource soundness, accordance, controllability, and selected temporal properties. Pattern-based approaches are used for correctness-by-design. Another goal is to develop innovative simulation approaches that better reflect reality and that can be used in an operational setting while using process mining results.
- 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., pro- vide warnings based on historic information (e.g., a case will be late or an error is likely to occur).
- PAIS Technology. PAISs are used to manage and execute operational processes involving people, applications, and/or information sources. Examples are WFM (Workflow Management), BPM (Business Process Management), and ERP (Enterprise Resource Planning) systems. Increasingly, these systems are driven by models and produce high-quality event logs. We are interested in the artifacts used and produced by these systems (i.e., models and logs) as these are essential for testing the techniques developed in the two other research lines. For example, it is interesting to convert and verify process models expressed in some particular industry language. The same holds of course for event logs. Service-orientation plays an important role here and this new architectural style poses new research questions.

Relevant courses are:

- Foundations of Process Mining (2AMI10)
- Advanced Process Mining (2AMI20)
- Seminar Process Analytics (2IMI00)
- Capita selecta Process Analytics (2IMI05)

9.1.3 Databases (D)

Website: https://www.win.tue.nl/db/doku.php

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, the interaction of programming and query languages, 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 database education. 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 Data Management (2IMD00)
- Capita selecta databases (2IMD05)
- Big Data Management (2AMD15)
- Engineering Data Systems (2IMD10)
- Knowledge Engineering (2AMD20)

9.1.4 Data Mining (M)

Website: https://www.win.tue.nl/dm/doku.php?id=start

Contact person: dr. Stiven Schwanz Dias

Datamining 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:

- Machine Learning Engineering (2AMM15)
- Research Topics in Data Mining (2AMM20)
- Deep learning (2AMM10)

- Seminar Data Mining (2IMM00)
- Capita selecta data mining (2IMM05)
- Text Mining (2AMM30)

9.1.5 Formal System Analysis (F)

Website: https://fsa.win.tue.nl

Contact person: prof.dr.ir. Tim Willemse (expertise group leader)

The focus of the specialization FSA is on modelling and verifying behavior of systems and programs. Behavior must be understood as all possible actions that a system can perform during its lifetime. The goal is to use this to improve the quality of the software in such systems.

The major techniques that are being used and studied within FSA are process algebraic specification, abstract data types and rewriting, behavioral equivalences, modal logic and model checking, semantics, SAT and SMT solving, program semantics, probabilistic behavior, streams, active and passive automata learning and proof checkers. Mathematical rigor is an important carrier for all the techniques that we apply.

Our modelling and verification find applications in many fields, varying from source code verification of the software in infrastructure (bridges, trains), heavy industry (Tata steel) to model based design of high-tech equipment (ASML, Philips, Canon). Many of our results, algorithms and methodologies are culminated in the mCRL2 verification toolset, which has become the verification workhorse for many companies and research institutes.

The research that is done in the group covers a wide spectrum. It ranges from finding the appropriate semantics of the combination of non-deterministic and probabilistic behavior, appropriate syntax and laws for variability analysis of product families, to building automatic software correctness proof engines for PLC code, analyzing games, and designing correct software for embedded equipment.

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)
- Domain Specific Language Design (2IMP20)

9.1.6 Interconnected Resource-aware Intelligent Systems (N)

Website: https://iris.win.tue.nl

Contact person: dr. Tanir Ozcelebi

Science and technology have changed the way we live, communicate, work, and even spend our free time. We are surrounded by systems of varying sizes and forms that sense, communicate, and try to make sense of what happens, with, within, and around us or where they operate (e.g. in a car or at a factory). The goal of all these systems is to create a safer, healthier, more pleasant, and more productive environment. As the scale, complexity, heterogeneity, and extent of usage of these systems increase, so do the performance challenges of these systems.

IRIS focuses on design, analyze, develop, and evaluate concepts, models, algorithms, protocols, and tools that optimize (distributed embedded) systems performance in terms of timing behavior, dependability, programmability, reliability, robustness, scalability, accuracy, energy and data computation efficiency, and trustworthiness. This is done within three research pillars, i.e., Pervasive networking (covering edge networking, (IoT) communication and interoperability, (IoT) network resource management), Pervasive computing (covering edge computing and federated learning, edge-driven data analytics and machine learning, embedded AI, and explainable AI), and Predictable performance (covering time-sensitive networks, realtime distributed systems, resource management and scheduling, formal modelling, analysis & verification, and model-based engineering of cyber physical systems).

Relevant courses are:

- Real-time systems (2IMN20)
- Architecture of distributed systems (2IMN10)
- Internet of things (2IMN15)
- Seminar Interconnected Resource-aware Intelligent Systems (2IMN00)
- Capita selecta Interconnected Resource-aware Intelligent Systems (2IMN05) (not always given)
- Quantitative Evaluation of Embedded Systems (2IMN25)
- VLSI programming (2IMN35)
- Deep Learning (2AMM10)
- Principles of data protection (2IMS25)
- Algorithms for model checking (2IMF35)
- Engineering Data Systems (2IMD10)
- System validation (2IMF30)

9.1.7 Security (S)

Website: https://security1.win.tue.nl/doku.php

Contact person: dr. Boris Skoric

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)
- Advanced Network Security (2IMS30)
- Software Security (2DMI20)
- Intrusion Detection Laboratory (2IMS40)

9.1.8 Software Engineering and Technology (P)

Website: https://www.tue.nl/en/research/research-groups/computer-science/software-engineering-and-technology/

Contact person: prof. Alexander Serebrenik

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 using 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. Common themes in answering these questions are software architecture, model driven software engineering (MDSE), software verification, and software evolution.

Software architecture captures the high-level organization of a system and represents this through multiple complementary views (including structure and behavior). The design of the architecture determines many of the quality properties of a system, such as cost, performance, reliability and maintainability. Some of the key questions in architecting are: i) to balance the many quality objectives, and ii) to ensure that the architecture and implementation are kept consistent with each other while the system evolves.

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 a starting point for simulation and verification. Finally, existing software can be analyzed and the underlying models can be extracted. The research focus of the research group SET is on model based software development and on software evolution. The field of model based software development is broad. One key research area is the development of tooling to support the development of models in domain specific formalisms using meta-modelling 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, the co-evolution of models and meta-models, and the correct generation of code. The ultimate goal is to create a tool set which provides high fidelity software generation. Our research in MDSE also includes the management and consistency checking of models, especially in the context of high-tech systems, where variability and the use of digital twins are two important aspects we consider.
Another key research area is *empirical studies* - i.e. the study of software- development and -evolution by observing projects in practice (either open source or in companies).

Software verification and correctness-by-construction address the functional correctness of software. Techniques such as model checking and program verification can be applied to prove correctness of both models and (generated) code, but also of model transformations. Particular attention is paid to the usability of those techniques, both regarding their

performance and their required expert-level. High-performance, easy to use techniques are most suitable to be adopted in MDSE workflows. To this end, research is being done to automate the verification process as much as possible, and to accelerate the involved computations (model checking, SAT solving) by means of multithreading and the use of graphics processors. In correctness-by-construction, research is being done to scale the approach, in particular to families of related programs.

Software evolution encompasses the entire life cycle of a software system, from inception to phase out. As a research domain, software evolution aims at obtaining insights in how and why software evolves as well as at translating those insights into techniques for assessing system evolvability and facilitating evolution. Software evolution is an activity carried out by humans. Therefore, in addition to technical aspects, such as inter-system dependencies and source code vulnerabilities research in software evolution also considers social (e.g., team diversity, mentoring, emotion in developer communication) and socio-technical ones (e.g., social debt and technical debt). Similarly to studies of models, the lion's share of software evolution research is empirical in nature.

Relevant courses are:

- Program verification techniques (2IMP10)
- Software project management (2IMP15)
- Domain Specific Language Design (2IMP20)
- Software evolution (2IMP25)
- System design engineering (2IMP30)
- Empirical Methods in Software Engineering (2IMP40)
- Seminar Software Engineering and Technology (2IMP00)
- Capita Selecta Software Engineering and Technology (2IMP05)

Other relevant courses:

- Research Topics in Data Mining (2AMM20)
- Advanced Process Mining (2AMI20)
- Architecture of distributed systems (2IMN10)

9.1.9 Uncertainty in AI (U)

Contact person: dr. Stiven Schwanz Dias

The 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. We are greatly interested in probabilistic graphical models, generative models and causality. There is also an important focus on approaches that are not only accurate but efficient, interpretative, robust and fair.

Relevant courses are:

- Generative AI Models (2AMU20)
- Foundations of Artificial Intelligence (2AMU10)
- Uncertainty Representation and Reasoning (2AMU30
- Seminar Uncertainty in AI (2IMU00)
- Capita Selecta Uncertainty in AI (2IMU05)

9.1.10 Visualization (V)

Website: https://vis.win.tue.nl/

Contact person: prof. dr. Anna Vilanova

Contact person Master projects: dr.ir. Huub van de Wetering

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 Visualization cluster focuses on the development of new methods and techniques to explore and present large data sets. The focus is on data visualization and visual analytics. We study how to provide insight in large, heterogeneous data sets, such as combinations of multivariate data, high dimensional data, complex imaging data, network data, event data, and geospatial data, all often time varying. We study how to incorporate methods from statistics and AI to support human analysis, understanding, and decision making. Visual analytics for AI can provide more effective and efficient model development, and more trust and confidence on AI based decisions.

We develop novel approaches that go from fundamental research to application oriented visual designs. We cooperate with experts from a variety of application domains, including health care, machine learning, bioinformatics, forensics, and fraud detection; both from academia and industry (e.g., Philips).

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:

- Visual Analytics (2AMV10)

- Geometric algorithms (2IMA15)
- Visual computing project (2IMV10)
- Simulation in computer graphics (2IMV15)
- Interactive virtual environments (2IMV25)
- Seminar visualization (2IMV00)
- Capita selecta visualization (2IMV05)

Other relevant courses:

- Machine Learning Engineering (2AMM15)

9.2 Electrical Engineering Research groups

This section describes Research Groups in the Electrical Engineering (EE) department that are relevant for Embedded Systems Master students. Students in the ES program can do a graduation project in any of the Computer Science research groups mentioned earlier in this chapter. In addition, they have the option to do the graduation project in the electronic systems research group of the EE department.

Website: http://www.es.ele.tue.nl

Contact address: Secretariaat ES (Secretariaat.ES@tue.nl)

The mission of the electronic systems section 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 multi- media 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.

Relevant courses are:

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

9.3 Additional Research Groups for IST

Students in the IST program can do a graduation project in any of the Computer Science research groups mentioned earlier in this chapter. But it is also possible for IST students to do a graduation project in the Coding & Cryptology group (Discrete Mathematics cluster, Mathematics and Computer Science Department).

Website: https://www.tue.nl/en/research/research-groups/mathematics/discrete-mathematics/coding-theory-and-cryptology/

Contact Person: Prof Dr T. Lange

10 Academic Administration

10.1 Education and Student Affairs (ESA)

The Education and Student Affairs helpdesk is your contact point for general information and inquiries about tuition and financing, admissions, enrollment at TU/e, course registration exam regulations etc.

Location: first floor of MetaForum

Email: ESA@tue.nl or ESAhelpdesk@tue.nl

Phone: 040 247 4747

10.2 Departmental Student Administration (CSA)

You can contact the departmental student administration with your forms, questions about graduation or your diploma, transcripts, statements on expected graduation, and other topics.

Email: CSA.MCS@tue.nl

Office: MF 3.090

CSA desk is open: Monday-Friday 12:00-14:00 (closed during some holidays)

10.3 Academic Advisor

The Academic Advisor is a non-academic staff member who knows the details of your program's curriculum and how the regulations apply to various situations. They can also tell you about the diverse array of resources offered to students at our university.

You can approach your Academic Advisor with questions about study planning, but also with other topics. For example, you can contact them if you have a personal issue that is affecting your studies or simply can't figure out where to start with a question. They will either help you themselves or refer you to another staff member when necessary.

You can reach them by:

- Email
- Making an appointment (see Student Guidance page of the Education Guide for link to make an appointment)
- Drop-in (contact academic advisor for your program's weekly drop-in hours)

Contact info:

Program:	**Name and email address:**
DS&AI:	Jet Verbeeten and Katie MacLeod Email: Academic.Advisor.DSAI@tue.nl

CSE, IST, ES, EIT, BDMA: Angie Lammen and Sofie Linskens

Email: Academic.Advisor.MCS@tue.nl

All Pre-Master Programs: Katie MacLeod

Email: Academic.Advisor.Premaster.MCS@tue.nl

10.4 Examination committee

The Departmental Board appoints an Examination Committee for each program. There is one for CS master programs combined: CSE, ES, IST and DSIE, and one for DS&AI. The Examination Committee is responsible for organizing and coordinating the examinations, and for appointing examiners. 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.

When a student has a request related to the Program and Examination Regulations, they make that request through the Examination Committee. The process is as follows: The student should contact the Academic Advisor (section 10.3) about their request. The Academic Advisor then advises the student on the request and directs the student to the webform that is used to make a request to the Examination Committee.

10.5 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 Program Examination Regulations (PER)
- to annually evaluate the implementation of the PER
- to advise on all issues relevant to the academic program

10.6 Study Associations: GEWIS and D.S.A. Pattern

The study association GEWIS (union of math- and computer-science students) was founded over 40 years ago. GEWIS champions student rights, promotes student interests and offers students extracurricular activities. It organizes weekly lunch lectures by mathematics or computer science related 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. GEWIS provides a discount for books, free coffee and tea, as well as a big room to have a break, play games and eat your lunch. In addition, the GEWIS- website offers old exams and summaries. The educational officer 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 http://www.gewis.nl, and e-mail: board@gewis.nl.

Pattern is the study association for all Data Science students at the Eindhoven University of Technology (TU/e), Tilburg University (TiU), and the Jheronimus Academy of Data Science (JADS, Den Bosch).

For more information and contact, see https://dsapattern.nl/.

The Study Associations also play an important role for students and the quality of education in the master programs. If students have comments or concerns, they can contact the study association (contact info above)

10.7 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 Program and Examination Regulations (see Appendix A).

Personal contact at the department:

- Academic advisors (see section 10.3)
- Student Administration (CSA) (see section 10.2)
- International exchange coordinator: Mrs. M. Kappe – Mes: Exchange.MCS@tue.nl
- The Study Association GEWIS (see section 10.6).

Several internet sources of information are available:

- The website https://www.tue.nl/en/ provides general TU/e information.
- Information about the department, academic counseling, etc. can be found on the Education Guide https://educationguide.tue.nl/
- The electronic course catalog can be accessed at https://tue.osiris-student.nl/#/onderwijscatalogus/extern/start?taal=en and contains current course information. Also, examinations and course schedules are available at this webpage.
- Video recordings of lectures: http://videocollege.tue.nl/
- Information about TU/e Online systems: https://educationguide.tue.nl/practical-info/it-services/online-systems/?L=2
- Directive Double Diplomas. These are the regulations for students doing a double degree. The details can be found on the Education Guide

Appendix A
Program and Examination regulations

The Program and Examination Regulations (PER) is a document that contains all the information on education and examination for a program. This includes the content of the program (curriculum) and the testing within the program. The PER for all master programs can be found at the following link:

https://educationguide.tue.nl/practical-info/regulations-codes-of-conduct-and-guidelines/program-and-examination-regulations-per/?L=2

To supplement the PER, the examination committees have made the Regulations of the Examination committee. This document clarifies and specifies details of the regulations within a program. The Regulations of the Examination Committee for your master program can be found on the Education Guide pages of your master program.