Eidgenössische Technische Hochschule Zürich
Ecole polytechnique fédérale de Zurich
Politecnico federale di Zurigo

# Department of Mathematics (D-MATH)

# Guidelines

# to the Master Program in

# Computational Science and Engineering

2022 Edition[1]
January 17

*Contents* *Page*



[1] These guidelines are not binding. Binding are the Study Regulations and the Course Catalog.

# 1. Computational Science and Engineering (CSE)

Solving **interdisciplinary science** and **engineering** problems using **computers**

The Computational Science and Engineering curriculum (Studiengang Rechnergestützte Wissenschaften (RW)) provides future-oriented education in Mathematics, Computer Science and at least two fields of application from the natural and engineering sciences. RW/CSE graduates will be able to understand a problem from the scientific and technological point of view and have the requisite skills to perform a computer-based analysis. They will be capable of working and thinking in an interdisciplinary way.

**Profile and educational objective**

Computational science and engineering means mathematical modelling, numerical solution techniques and the use of computers to analyse and solve scientific and technological problems. Besides studies in the fields of application from science and engineering, students will learn how to use the most important mathematical methods and computer tools. CSE is different from both computer science and the traditional science and engineering. It represents a third scientific way in addition to theory and experiment. In brief, computational science and engineering is interdisciplinary, application oriented, focused on problem solving, and based on computer simulation.

RW/CSE graduates are able to communicate with specialists from the areas of mathematics, physics, chemistry, biology, engineering and computer science and work together with them in finding solutions to complex practical problems.

The interdisciplinary education the RW/CSE curriculum provides in mathematics, computer science and application is an ideal basis for a career in industry and business.

# 2. General study information

### 2.1 Admission

Admission to all study programs at ETH is processed through the *Rektorat* (Rectorate). It provides students with all the relevant information, in particular on transferring from another university or switching from another study program, on the recognition of student credits already acquired, and on any specific admission requirements.

The RW/CSE Master Program in the department of Mathematics (D-MATH) is scheduled to last 1½ years.[2] RW/CSE Bachelor students can enrol directly in the RW/CSE Master program provided they need to acquire only a small number of credit (ECTS) points. Students from outside ETH must apply for enrolment at the ETH Zürich Rectorate. The application may be made before the required academic degree has actually been earned. The *Zulassungsausschuss RW (*CSE Admissions Committee) assesses the candidates' knowledge level in the relevant subjects and their suitability for the Master program. It then formulates a recommendation for admission or non-admission addressed to the ETH Admissions Office, together with information on credit points acquired and those still to be earned. Candidates with a university degree having to acquire 30 or more credit points cannot be admitted to the RW/CSE Master program. They may apply for admission to the RW/CSE Bachelor program.

### 2.2 Enrolment

The Master program requires regular enrolment for each coming semester and for the courses to be attended. Place of enrolment is the *Rektorat* (Rectorate):

www.lehrbetrieb.ethz.ch/myStudies

### 2.3 Course catalogue

The courses offered are published on the Internet each semester:

*www.vvz.ethz.ch*

The *Vorlesungsverzeichnis* (course catalogue) provides basic information on the individual courses:

| | |
|---|---|
| Curriculum > | Number > |
| Semester > | Room > |
| Type > | Time > |
| Lecturer > | Number of hours per week > |
| Title > | Language > |
| Content > | Objective > |
| Credit points > | Performance assessment (exam?) |

[2] Up to 2 years if special admission requirements need to be fulfilled

| | |
|---|---|
| *In case of exam:* | Conditions of admission > |
| Date (session?) > | Weight of grade > |
| Mode (written/oral?) > | Duration > |
| Exam aids permitted > | Examiner (if not lecturer) |

### 2.4 Credit system

The study program uses a credit system which corresponds to the *European Credit Transfer System (ECTS)*. The *credit points (KP)* awarded for each defined study achievement reflect the average real amount of work required to attain this achievement. One credit point is roughly equivalent to 30 hours of work. The entire amount of work required per semester for full-time studies is equivalent to 30 KP on average. The RW/CSE Master Program is designed to cover 3 semesters (2 semesters plus a subsequent Master thesis) during which students need to acquire 90 credit points in total.

### 2.5 Earning credit points

The credit points assigned to a course are awarded either in full or not at all. They are awarded if the performance assessment defined for the course in question has been passed. If grades are awarded for the performance assessment, the grade achieved must be at least 4.0.

All courses are evaluated independently, and a student is required to repeat only those performance assessments or courses for which he or she did not pass the performance assessment the first time.

Administration of credit points is carried out by the Study Administration Office D-MATH.

### 2.6 Visiting semesters at other universities

Students holding a Bsc degree from ETH Zurich are entitled to earn at another university (mobility) a maximum of 30 KP for the Master degree. Before they begin visiting semesters at other universities, students must draw up a written study plan in collaboration with the *Fachberater RW* (Advisor of Studies CSE). This plan shows the study achievements that the student expects to attain at the host university. The study plan must be approved by the Director of Studies CSE.

Further information about visiting semesters (administrative matters, stipends, etc.) can be obtained from the Advisor of Studies CSE and the *Mobilitätsstelle des Rektorats* (Student Exchange Office of the Rectorate).

### 2.7 Graduation

Once the student has acquired the necessary number of credit points, an application can be made for a Master degree to be awarded. The application must be submitted to the Study Administration Office D-MATH and must list all the study performance that needs to be included in the final aca-

demic record (*Schlusszeugnis*). The sum of KP in each category must be at least equal to the required minimum number. The final academic record lists study performance and the associated grades, other evaluations of performance, and the grade average calculated from the grades achieved (without Science in Perspective).

Once the Master degree has been awarded, graduates receive a degree certificate and a diploma supplement.

### 2.8 Maximum duration of studies

Students must apply for a degree to be awarded within three years of starting the Master Program. If a student is admitted to the Master Program RW/CSE on the condition that additional KP are earned, this entitles the student to extend the maximum duration of studies by six months if an additional 21–30 KP need to be earned. A requirement to earn fewer than 21 additional KP does not entitle the student to extend the maximum duration of studies.

The Rector may extend the maximum duration on written request if there are sufficient reasons.

### 2.9 Breaking off studies

Students who will not be able to earn the necessary number of credit points because they have failed performance assessments twice or because they will be unable to complete the curriculum within the maximum permitted duration will be excluded from the curriculum. Those who break off their studies or are excluded from the curriculum will receive a certificate showing all the achievements during their studies which were assessed.

### 2.10 Performance assessment

The performance assessment stipulated for each course is shown in the course catalogue (www.vvz.ethz.ch) (see Section 2.3). The performance assessment for most courses is a written or oral exam. The form of performance assessment for a course is determined by the department offering the course.

*Grades*

Exams and the Master thesis are always graded, other performance assessments may be evaluated as passed/not passed. The best grade is 6.0, the poorest 1.0; half- and quarter-grades within this range may be awarded.

*Exams*

Exams are generally held during the *exam sessions*. There are two exam sessions each year, with exam dates determined for all ETH curricula. Exams held during the sessions are coordinated centrally by the Rectorate. An *interim certificate* is issued after each exam session, showing the grades achieved since the last interim certificate was issued. The details of the exam (written or oral, duration of exam) are shown in the examination plan.

Oral exams are held either by two examiners or by one examiner and an assessor.

- The exam for a course which is held regularly is always based on the most recently held course and is set by the lecturers who taught it. If students put off taking a certain exam, there is a risk that the lecturer will change, thus changing the course content. Students are not entitled to insist on a specific examiner for either a first or a repeat exam. For these reasons it is recommended that students should undergo performance assessments at the earliest opportunity whenever possible.

*Admission conditions*

Admission to an exam may be made conditional on the exercises allocated during the course in question. Conditions of this kind are announced at the start of the semester and are also listed in the course catalogue (see Section 2.3) (www.vvz.ethz.ch).

*Registration and withdrawal*

The Rectorate announces the place and deadline for registration for exams to be held in an exam session. Registration is carried out electronically around the middle of the preceding semester.

Students register directly with the lecturers concerned for exams scheduled outside the exam sessions and for other performance assessments.

*Interruption, absence, late submission*

An exam session may only be interrupted for important reasons such as illness or an accident. A student who interrupts an exam session must inform the registering office immediately and submit the necessary doctor's certificate.

*Repetition of performance assessments*

A performance assessment which has been passed cannot be repeated. A performance assessment which has been failed can be repeated only once. If the student fails twice, the performance assessment is considered to have been failed definitively. Students who fail definitively in mandatory courses will be excluded from the curriculum. Students who fail definitively in a non-mandatory course must choose another such course.

### 2.11 Ruling bodies

Decisions affecting the RW/CSE curricula are the responsibility of the Rectorate, the CSE Committee (*Ausschuss RW*), the Director of Studies CSE (*Studiendirektor RW*) and the Advisor of Studies CSE (*Fachberater RW*), the *Departement Conference* D-MATH, the Students/Teachers Commission CSE (*Unterrichtskommission RW*), Admission Committee (*Zulassungsausschuss RW*).

The Study Administration Office D-MATH is responsible for administrative matters.

For addresses see Chapter 7.

- The students elect representatives to the Students/Teachers Commission and other ruling bodies; these representatives participate and have voting rights.

# 3. Overview of the RW/CSE Master Program

The RW/CSE Master Program offered by D-MATH requires 1½ years of study[3] (2 semesters followed by six months to write a Master thesis). The 90 credit points required for a Master degree are earned in mandatory core courses, in elective courses and fields of specialization chosen by the students, as well as in a term paper and a Master thesis.

| | **The Master Program in RW/CSE** | | | |
|---|---|---|---|---|
| *Study period* | 1st/2nd semester | | Master thesis | |
| *Credit points* | 60 | | 30 | |
| *(minimum number,* | Core courses | 12 | 6 months | |
| *without Science in Perspective)* | | | Fields of specialization | 18 |
| | Elective courses | 6 | | |
| | Case studies | 6 | | |
| | Term paper | 8 | | |

| | |
|---|---|
| **Master degree:** | Master of Science ETH in Computational Science and Engineering<br>Abbreviated title: **MSc ETH CSE** |
| (German: | Master of Science ETH in Rechnergestützten Wissenschaften<br>Abbreviated title: **MSc ETH RW**) |

The **core courses** are of central importance in computational science and engineering.

*Informative list of core courses (VVZ contains the actual valid infomration):*

- *Advanced Numerical Methods for CSE* (might not be offered in HS22)
- *Optimization for Data Science*
- *Computational Statistics*
- *Advanced Systems Lab*
- either *Advanced Machine Learning* or *Probabilistic Artificial Inteligence*
- *Deep Learning in Scientific Computing*

The **fields of specialization** provide deeper understanding of the areas of application in computational science and engineering.

*List of fields of specialization:*

- Astrophysics
- Physics of the Atmosphere
- Chemistry
- Fluid Dynamics
- Control Theory
- Robotics
- Physics
- Computational Finance
- Electromagnetics
- Geophysics
- Biology

[3] Up to 2 years if an additional 30 KP (maximum) need to be earned subject to specified admission requirements

The **elective courses** provide students with more extensive and more in-depth knowledge of theory and methods.

In the **case studies** seminar internal ETH and external speakers present examples from their own fields of application – from modelling to computer-based problem solving. Students have to give a short presentation on some scientific paper.

The **term paper** (Semesterarbeit) enables students to deepen their knowledge of a certain field, to come into closer contact with applications, and to tackle the problems arising from such applications using computers. In addition, the purpose of term papers is to teach students to collaborate with an existing scientific group. The subject for the term paper is usually taken from a core course or from a field of specialization.

The **Master thesis** is the conclusion of the program. Its purpose is to allow students to demonstrate their ability to carry out scientific work in an independent and structured manner. The subject for the Master thesis is usually taken from a core course or from a field of specialization.

The RW/CSE Master Program follows on from the RW/CSE Bachelor Program offered by ETH. Its objective is to make new, computer-based career profiles accessible to students. The interdisciplinary training in mathematics, computer science and applications is excellent preparation for a career in business and industry.

# 4. The RW/CSE Master Program

### 4.1 Admission to the RW/CSE Master Program

*Admission requirements*

Individuals requesting admission to the RW/CSE Master Program will generally have to meet the following requirements:

a. They have a RW/CSE Bachelor degree from D-MATH.

b. They have a Bachelor degree comprising at least 180 credit points (ECTS) from a university or from a Swiss university of applied science, or a university qualification of at least equivalent value in a subject which qualifies them for admission to the RW/CSE Master Program. The subject background required (*Requirement Profile*) is detailed in the appendix to the Study Regulations for the RW/CSE Master Program. Moreover, they must demonstrate that their knowledge of the teaching language –English – is adequate.

The Rector decides on exceptions based on the recommendation of the Director of Studies CSE.

*Admission procedure*

RW/CSE Bachelor students from D-MATH can enrol directly in the RW/CSE Master Program provided they need to acquire no more than 30 credit points to gain a Bachelor degree. The dates and deadlines for enrolment apply as issued by ETH. Admission is conditional on the student gaining the Bachelor degree. The right of admission lapses if the student does not gain the Bachelor degree or cannot gain it because he or she has failed performance assessments or has exceeded the maximum permitted study duration for the Bachelor Program. The Rector decides on exceptions based on the recommendation of the Director of Studies CSE.

All other candidates must apply for admission to the RW/CSE Master Program at the ETH Zürich Rectorate. The application may be registered before the required academic degree has been earned. The procedure for this is determined by the Rector. The CSE Admissions Committee (*Zulassungsauschuss RW*) assesses the candidates' knowledge level in the relevant subjects and their suitability for the Master Program. It then formulates a recommendation for admission or non-admission which is submitted to the ETH Admissions Office, together with information on credit points acquired and those still to be earned. The Rector decides, based on the recommendation of the CSE Admissions Committee, on admission or non-admission, as well as on the number of credit points acknowledged and those still to be earned. The student may not join the Master Program until the required university degree or certificates of achievement have been acquired.

Important *links* for students from outside ETH:

Master studies at ETH Zurich: www.ethz.ch/en/studies/prospective-masters-degree-students

Admissions: www.ethz.ch/en/studies/registration-application/master

*Refusal of admission*

Candidates with a university degree will not be admitted to the RW/CSE Master Program if they still need to complete studies accounting for more than 30 credit points to qualify for admission. These candidates may apply for admission to the RW/CSE Bachelor Program. The details of the admission procedure are regulated in the Rules on Admission to Studies at ETH (*Zulassungsverordnung ETHZ*).

### 4.2 Core courses

The *core courses* are courses[4] which are of central importance in computational science and engineering.

*The core courses:*

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| Advanced Numerical Methods for CSE (might not be offered in HS22) | 4V 2U 1P | HS | RW | 9 |
| Advanced Machine Learning | 3V 2U 4A | HS | INFK | 10 |
| Probabilistic Artificial Inteligence | 3V+2U+2A | HS | INFK | 8 |
| Optimization for Data Science | 3V 2U 4A | FS | INFK | 10 |
| Computational Statistics | 3V 2U | FS | MATH/RW | 8 |
| Advanced Systems Lab | 3V 2U 2A | FS | INFK/RW | 8 |
| Deep Learning in Scientific Computing | 2V+1U | FS | RW | 6 |

Two core courses must be attended and examinations must be taken in both. Either *Advanced Machine Learning* or *Probabilistic Artificial Inteligence* might be considered as a core course, but not both.

- The information in these tables may no longer be up to date. Students are advised to refer to the course catalogue (*www.vvz.ethz.ch*) published on the Internet.
- The students are advised to attend the core courses at the beginning of their Master studies.
- 'Advanced Systems Lab' starts in FS20 and replaces 'How To Write Fast Numerical Code'

### 4.3 Fields of specialization

The fields of specialization provide in-depth knowledge of applications in computational science and engineering.

[4] *Key to the tables in these guidelines:*

SWS Number of hours per week during semesters
Sem. Semester in which the course is held (HS: autumn semester; FS: spring semester)
D- Main department for which the course is offered
KP Number of credit points
V Lectures (number of hours)
U Exercise classes (number of hours)
G Lectures and/or exercise classes (number of hours)
O Mandatory course
E Recommended course

Five courses must be attended in the category "Fields of specialization", one of them a seminar. In the seminar a semester project must be completed. In the other courses exams have to be taken and passed.

Students who did not go through the D-MATH RW/CSE Bachelor Program have to take the five courses in the same field of specialization *("major specialization")*[5].
Students who have completed the D-MATH RW/CSE Bachelor Program can choose between two options:

a. The five courses, including the seminar, belong to the same field of specialization – one which the student did not study in the RW/CSE Bachelor Program *("major specialization")*[5].

b. Three courses, including the seminar, come from the field of specialization that the student studied in the RW/CSE Bachelor Program *("major specialization")*[5]; two courses come from a different field of specialization *("minor specialization")*[5].

- Students on the RW/CSE Bachelor Program must select a "minor specialization"[5] (two courses). This can be expanded into a "major specialization"[5] (four courses and one seminar) on the RW/CSE Master Program; alternatively, the student may choose a new "major specialization" on the RW/CSE Master Program.

- The following applies to students who have already attended courses in the fields of specialization and sat the associated exams as part of the RW/CSE Bachelor Program:
  - Students who have failed an exam once can only re-sit the exam for the corresponding course once on the RW/CSE Master Program.
  - Students who have failed an exam twice cannot take the corresponding course on the RW/CSE Master Program.
  - Students who have passed an exam but have not put the KP earned in the process towards their Bachelor degree can use these KP to acquire the Master degree by having them credited to the category "Fields of specialization" or the category "Elective courses".

- In justified exceptional cases, the Director of Studies CSE may, at the student's request, approve attendance of courses other than those available in the fields of specialization.

**The fields of specialization**

| | | |
|---|---|---|
| **a.** | Astrophysics | (minor) |
| **b.** | Physics of the Atmosphere | (major) |
| **c.** | Chemistry | (major) |
| **d.** | Fluid Dynamics | (major) |
| **e** | Systems and Control | (major) |
| **f.** | Robotics | (major) |

[5] *All* fields of specialisation are eligible for a “minor specialisation” but only those in the list below labelled as major are eligible for a “major specialisation”.

| | | |
|---|---|---|
| **g.** | Physics | (major) |
| **h.** | Computational Finance | (major) |
| **i.** | Electromagnetics | (major) |
| **k**. | Geophysics | (major) |
| **l.** | Biology | (minor) |

**Courses in the fields of specialization**

**a. Astrophysics** (*Contact:* Mayer L., Astrophysics, Zurich University)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| Theoretical Astrophysics | 4V 2U | HS | UZH | 10 |
| Theoretical Cosmology | 4V 2U | FS | PHYS | 10 |
| Computational Astrophysics | 2V | HS | UZH | 6 |

**b. Physics of the Atmosphere** (*Contact:* Schär Ch., D-USYS)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| Atmosphäre | 2V | HS | USYS | 3 |
| Weather and Climate Models | 3G | FS | USYS | 4 |
| Boundary Layer Meteorology | 3G | HS | ERDW | 4 |
| High Performance Computing for Weather and Climate | 3G Block Course | FS | USYS | 3 |
| Dynamics of Large-Scale Atmospheric Flow | 2V 1U | HS | USYS | 4 |
| Radiation and Climate Change | 2G | FS | USYS | 3 |
| Cloud Dynamics: Hurricanes | 3G | FS | USYS | 4 |
| Seminar in Physics of the Atmosphere for CSE | | HS/FS | RW | 4 |

**c. Chemistry** (*Contact:* Hünenberger P., D-CHAB)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| Classical Simulation of (Bio)Molecular Systems | 4G | HS | CHAB | 6 |
| Quantenchemie | 3G | FS | CHAB | 6 |
| Computer Applications: Finite Elements in Solids and Structures | 2V 2U | FS | MATL | 4 |
| Advanced Quantum Chemistry | 3G | HS | CHAB | 6 |
| Molecular and Materials Modelling | 2V 2U | FS | MATL/RW | 6 |
| Seminar in Chemistry for CSE | | HS/FS | RW | 4 |

**d. Fluid Dynamics** (*Contact:* Jenny P., D-MAVT)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* | * |
|---|---|---|---|---|---|
| Fluid Dynamics II | 2V 1U | HS | MAVT | 3 | Oa |
| Turbulent Flows | 2V 1U | HS | MAVT | 4 | Oa |
| Computational Methods for Flow, Heat and Mass Transfer Problems | 4G | FS | MAVT | 4 | Ob |
| Advanced CFD Methods | 2V 1U | FS | MAVT | 4 | Ob |
| Nonlinear Dynamics and Chaos I | 2V2U | HS | MAVT | 4 | |
| (Fundamentals of CFD Methods) | 3G | HS | MAVT | 4 | |
| Compressible Flows | 2V 1U | FS | MAVT | 4 | |

| | | | | |
|---|---|---|---|---|
| Quantitative Flow Visualisation | 2V 1U | HS | MAVT | 4 |
| Stochastic Methods for Engineers & Nat. Sci. | 4G | HS | MAVT | 4 |
| Hydrodynamics and Cavitation | 3G | HS | MAVT | 4 |
| Fluid Dynamics with the Lattice Boltzmann Method | 3G | HS | MAVT | 4 |
| Computational Multiphase Thermal Fluid Dynamics | 2V1U | FS | MAVT | 4 |
| Seminar in Fluid Dynamics for CSE | | HS/FS | RW | 4 |

- Oa: One of the two courses is mandatory; Fluid Dynamics II is recommended for German speaking students.
  Ob: One of the two courses is mandatory.
  E: Strongly recommended

**e. Systems and Control** (*Contact:* Lygeros J., D-ITET)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| Control Systems I (Regelsysteme) | 2V 2U | HS | ITET | 6 |
| Control Systems II | 4G | FS | ITET | 6 |
| Linear System Theory | 5G | HS | ITET | 6 |
| Stochastic Systems | 2V 1U | FS | ITET | 4 |
| Signals and Systems | 2V 2U | HS | MAVT | 4 |
| Dynamic Programming and Optimal Control | 2V 1U | HS | ITET | 4 |
| Nonlinear Dynamics and Chaos I | 2V 2U | HS | MAVT | 4 |
| Advanced Machine Learning | 3V+2U+4A | HS | INFK | 10 |
| Advanced Topics in Control | 2V 2U | FS | ITET | 4 |
| Seminar in Systems and Control for CSE | | HS/FS | RW | 4 |

**f. Robotics** (*Contact:* Siegwart R., D-MAVT)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* | * |
|---|---|---|---|---|---|
| Theory of Robotics and Mechatronics | 3G | HS | MAVT | 4 | |
| Autonomous Mobile Robots | 4G | FS | MAVT | 5 | |
| Probabilistic Artificial Intelligence | 3V 2U 2A | HS | INFK | 8 | |
| Deep Learning | 3V 2U 2A | HS | INFK | 8 | |
| Computer Vision | 3V 1U 3A | HS | INFK | 8 | C |
| Image Analysis and Computer Vision | 3V 1U | HS | ITET | 6 | C |
| Dynamic Programming and Optimal Control | 2V 1U | HS | MAVT | 4 | |
| Recursive Estimation | 2V 1U | FS | MAVT | 4 | |
| Robot Dynamics | 2V 1U | HS | MAVT | 4 | |
| Machine Learning | 3V 2U 2A | HS | INFK | 8 | |
| Introduction to Machine Learning | 4V 2U 1A | FS | INFK | 8 | |
| 3D Vision | 3G | FS | INFK | 4 | |
| Soft and Biohybrid Robotics | 3G | FS | MAVT | 4 | |
| Seminar in Robotics for CSE | | HS/FS | RW | 4 | |

- C: Only one of the two courses may be credited for the field of specialization ‘Robotics’.

**g. Physics** (*Contact:* Adelmann A., D-PHYS)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* | * |
|---|---|---|---|---|---|
| Introduction to Computational Physics | 2V 2U | HS | PHYS/RW | 8 | E |
| Computational Statistical Physics | 2V 2U | FS | PHYS/RW | 8 | |
| Computational Quantum Physics | 2V 2U | FS | PHYS/RW | 8 | |
| Molecular and Materials Modelling | 2V 2U | FS | MATL/RW | 4 | |
| Quantenmechanik I | 3V 2U | HS | PHYS | 10 | |
| Quantenchemie | 3G | FS | CHAB | 6 | |
| Quantum Information Theory | 3V 1U | HS | PHYS | 8 | |
| Quantum Information Processing I | 2V 1U | FS | PHYS | 5 | |
| Particle Accelerator Physics and Modeling I | 2V 1U | HS | PHYS | 6 | |
| Particle Accelerator Physics and Modeling II | 2V 1U | FS | PHYS | 6 | |
| Seminar in Physics for CSE | | HS/FS | RW | 4 | |

- For the field of specialization 'Physics' basic knowledge in quantum mechanics is required.

**h. Computational Finance** (*Contact:* Schwab Ch., D-MATH)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| Mathematical Foundations for Finance | 3V 2U | HS | MATH/RW | 4 |
| Computational Methods for Quantitative Finance - Monte Carlo and Sampling Methods | 3 V 1U | HS | MATH/RW | 6 |
| Financial Engineering | 4G | HS | UNIZ | 6 |
| Computational Methods for Financial Market Risks | 2G | HS | MTEC | 3 |
| Quantitative Finance - PDE methods | 3V 1U | FS | MATH/RW | 6 |
| Machine Learning in Finance | 3V1U | FS | MATH/RW | 6 |
| Continuous Time Quantitative Finance | 3V | FS | UNIZ | 3 |
| Seminar in Comput. Finance for CSE | | HS/FS | RW | 4 |

**i. Electromagnetics** (*Contact:* Smajic J., D-ITET)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| Physical Modelling and Simulation | 4G | HS | ITET | 6 |
| Optimization Methods for Engineers | 2G | FS | ITET | 3 |
| Elektromagnetic Waves | 2V 2U | HS | ITET | 6 |
| Organic and Nanostructured Optics and Electronics | 2G+2A | FS | ITET | 6 |
| Optical Communication Fundamentals | 2V 1U 1P | HS | ITET | 6 |
| Mathematical and Computational Methods in Photonics | 4G | HS | MATH | 8 |
| Semiconductor Devices: Transport Theory and Monte Carlo Simulation | Block | HS | ITET | 4 |
| Seminar in Electromagnetics for CSE | | HS/FS | RW | 4 |

**k. Geophysics** *(Contact:* Tackley P., D-ERDW)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| 1) Continuum Mechanics | 2V | HS | ERDW | 3 |
| 2) Numerical Modelling I and II | 4G | HS | ERDW | 6 |
| 3) Dynamics of the Mantle and Lithosphere | 2G | FS | ERDW | 3 |
| 4) Numerical Modelling for Applied Geophysics | 2G | FS | ERDW | 5 |
| 5) Tomographic Imaging | 2G | FS | ERDW | 3 |
| 6) Seismology of the Spherical Earth | 2G | FS | ERDW | 3 |
| 7) Inverse Theory I+II | 2V 2G | FS | ERDW | 6 |
| 8) Numerical Modelling in Fortran | 2V | HS | ERDW | 3 |
| Seminar in Geophysics for CSE | | HS/FS | RW | 4 |

- Recommended combinations:2)+5)+6)+7); 2)+4)+5)+6)+8); 2)+5)+6)+[1) or 3)].

**l. Biology** *(Contact:* Stelling J., D-BSSE)

| *Course* | *SWS* | *Sem.* | *D-* | *KP* |
|---|---|---|---|---|
| Computational Systems Biology | 3V 2U | HS | BSSE | 6 |
| Statistical Models in Computational Biology | 2V 1U 2A | FS | BSSE | 6 |
| Spatio-Temporal Modelling in Biology | 3G | HS | BSSE | 4 |
| Introduction to Neuroinformatics | 2V 1U 1A | HS | ITET | 6 |
| Computational Biology | 3G 2A | HS | BSSE | 6 |
| Infectious Disease Dynamics | 2V | FS | BSSE | 4 |
| Bayesian Phylodynamics | 2G 2A | FS | BSSE | 4 |
| Deep Learning in Artificial and Biological Neuronal Networks | 3G | HS | ITET | 4 |
| Introduction to Bioinformatics | 4G | HS | BIOL | 6 |
| Translational Neuromodeling | 3V 2U 1A | FS | ITET | 8 |
| Modelling Course in Population and Evolutionary Biology | 6P | FS | USYS | 4 |

- The information in these tables may no longer be up to date. Students are advised to refer to the course catalogue (*www.vvz.ethz.ch*) published on the internet.
- Fields of specialization without a seminar may only be selected as a "minor specialization".
- Since most courses are offered only every other semester courses may have to be taken in an order not matching recommendations in the course catalogue.

### 4.4 Elective courses

Elective courses provide students with more extensive and more in-depth knowledge of theory and methods.

Students must take at least two elective courses and sit exams in these subjects.

The courses from which students may select are listed in the published course catalogue (*www.vvz.ethz.ch*). Courses in the fields of specialization may also be chosen as elective courses provided that they are not already part of the student's chosen fields of specialization. The Director of Studies CSE may approve additional elective courses on request.

- The following applies to students who have already sat exams in elective courses as part of the RW/CSE Bachelor Program:
    - Students who have failed an exam once can only re-sit the exam for the corresponding course once on the RW/CSE Master Program.
    - Students who have failed an exam twice cannot attend the corresponding course on the RW/CSE Master Program.
    - Students who have passed an exam but have not put the KP earned in the process towards their Bachelor degree can use these KP to acquire the Master degree.

### 4.5 Case studies

In the case studies seminar internal ETH and external speakers present examples from their own fields of application – from modelling to computer-based problem solving. Students have to give a short presentation on some scientific paper. One course per semester is offered.

The case studies seminar is assessed as passed/not passed and is equivalent to 3 KP.

Students must attend the case studies seminar twice. The Director of Studies CSE may approve exceptions for students on an exchange program.

### 4.6 Term paper

The purpose of the term paper (Semesterarbeit) is to deepen knowledge in a certain subject, to bring students into closer contact with applications, and to enable students to take a computational approach to problems encountered in these applications. In addition, students will learn to collaborate in an existing scientific group. The term paper is typically written on a subject from a core course or a field of specialization and can be supervised by any lecturer at ETH Zurich. However, *a* term paper in CSE must involve the application of core CSE techniques and must have a strong software implementation component. Algorithm development and implementation, numerical or discrete modeling, or simulations must constitute the main contribution of the student to the project. Approval of the Director of Studies CSE or the Advisor of Studies CSE is required. To that end, a detailed request including a one page project description has to be submitted via an online form on the web page of the CSE program.

The term paper requires approximately 240 hours of work. This is equivalent to about three afternoons of four hours each per semester week or four to five weeks of full-time work.

The supervisor responsible for the term paper defines the task and determines the start and the submission date.

The term paper concludes with a written report and a presentation. It is assessed as passed/not passed and earns the student 8 KP.

- In order to be allowed to start the work on the term paper, the lecture unit Scientific Works in Mathematics or in Physics has to be completed already.

### 4.7 Science in Perspective

Students must attend courses of a general educational nature from the humanities, social sciences and political sciences (Science in Perspective); required attendance is 2 KP. For more detailed information see *www.gess.ethz.ch*.

### 4.8 Master thesis

The Master thesis concludes the curriculum. In their Master thesis, students should demonstrate their ability to carry out independent, structured scientific work.

To be admitted to the Master thesis students have to have fulfilled the following requirements: They have completed their Bachelor studies in full; they have complied with any requirements for admission to the RW/CSE Master Program; they have passed all performance assessments in the categories “Core courses”, “Fields of specialization” (with seminar), “Term paper” (cf. Subsections 4.9 and 5.1).

The Master thesis can be supervised by any lecturer of ETH Zurich. It is the student responsibility to get in touch with potential supervisors or to obtain information on master thesis projects offered by research groups at ETH Zurich.

The **Master Thesis** takes 6 months, which is a strict deadline for its completion, and is supposed to be full-time work. It concludes the CSE Master studies and should train students for independent work on a particular topic. 30 ECTS credits are awarded for an accepted thesis.

The master thesis project is usually supervised and graded by a lecturer in charge of teaching a Core Course or a course in a Field of Specialization, but any other lecturer of ETH Zurich, who is entitled to supervise master thesis in her or his own department is also eligible. If a master thesis project is conducted at an institution or company outside ETH Zurich, an authorized lecturer of ETH Zurich must take responsibility as in-house supervisor.

The topic of a master thesis project **must be approved** by the Director of Studies CSE. To that end, a detailed request including a one page project description has to be submitted via an online form on the web page of the CSE program. That description must convey that the following requirements are satisfied:

*A project in CSE must involve the application of core CSE techniques and must have a strong software implementation component. Algorithm development and implementation, numerical or discrete modeling, or simulations must constitute the main contribution of the student to the project.*

The supervisor responsible for the Master thesis defines the task, the start and the submission date. The Master Thesis concludes with a written report. The Master thesis is graded. It is equivalent to 30 KP

In order to be allowed to start the work on the master thesis, the lecture unit S**cientific Works in Mathematics** or in **Physics** has to be completed **already**.

### 4.9 Performance assessment

A student has passed a performance assessment in the categories “Core courses”, “Fields of specialization” (without seminar), “Elective courses” and “Science in Perspective” if his or her grade is at least 4.0 or his/her performance is assessed as "passed". A performance assessment which is not passed can be repeated once.

A semester project in the category “Case studies” which is not passed cannot be repeated. The student must attend a further course in the category “Case studies”.

A seminar in the field of specialization or a term paper which has not been passed cannot be repeated. A further seminar must be attended, or a further term paper must be written.
The Master thesis is passed if the grade achieved is at least 4.0. A Master thesis which is not passed can be repeated once. If it is repeated, a new topic must be selected.

# 5. The RW/CSE Master degree

### 5.1 Credit points

In order to attain the CSE Master degree, students must acquire 90 KP[6] in the following categories, including at least the number of KP shown for each category:

| | | |
|---|---|---|
| a. | Main areas<br>1) Core Courses (12 KP)<br>2) Fields of specialization (18 KP)<br>3) Elective courses (6 KP) | 44 KP |
| b. | Case studies | 6 KP |
| c. | Term paper | 8 KP |
| d. | Science in Perspective | 2 KP |
| e. | Master thesis | 30 KP |

- The minimum number of KP required in the category a. is 36. If there are still KP missing to 44 KP after having earned the KP in the subcategories 1), 2), 3) the missing KP have to be acquired in the subcategory 3).

- Mandatory (once during the BSc or MSc studies) is the lecture „Scientific Works in Mathematics“.

- KP from courses offered on both the Bachelor and the Master Program can only be credited towards the Master degree if they have not been used to earn the Bachelor degree.

### 5.2 Graduation

Once the requirements listed in Section 5.1 have been fulfilled, students may apply to D-MATH to graduate within the maximum permitted duration of study. The Rector can extend this time limit on application if there are sufficient reasons.

The application to graduate must list the performance achieved in the categories shown in 5.1 which the student wishes to have included in the graduation certificate. The sum of KP in each category must be at least equivalent to the minimum required in each.

Other study achievements, not credited for the Master degree, will be listed on a separate sheet attached to the graduation certificate at the student's request.

[6] Not including the KP (30 maximum) that may need to be earned subject to specific admission requirements

### 5.3 Grades and grade point average

Interim grade certificates are issued at the end of each exam session and document the performance that has been achieved and evaluated since the last interim grade certificate was issued.

The graduation certificate contains the following:

a. Grades and other assessments carried out in performance assessments and the grade average determined on the basis of these grades;
b. On a separate sheet attached to the graduation certificate, a record of any core courses that were not passed as well as of any other evaluations of performance that were carried out.

The grade average is calculated as a weighted average from the following grades:

| | | |
|---|---|---|
| a. | The two grades in the core courses | weight for each: 2 |
| b. | The four grades from the fields of specialization | weight for each: 1 |
| c. | The grades from the elective courses | weight for each: 1 |
| d. | The grade for the Master thesis | weight: 4 |

Once the Master degree has been conferred, graduates receive a *Degree Certificate* and a *Diploma Supplement*. The Diploma Supplement is a document that is intended to facilitate and improve the evaluation and classification of the academic degree for both study and career purposes. It contains a description of the curriculum that has been studied and successfully concluded and a *Qualification Profile* of the curriculum.

The attainment of the Master degree is published by the Rectorate.

# 6. Doctoral studies

ETH offers the opportunity to follow the Master Program with doctoral studies. Doctoral studies and the doctoral thesis introduce students to current research. Students require a Master degree from ETH or an equivalent degree from another university in order to gain *admission to doctoral studies*. The most important requirement is that a professor at ETH must be willing to supervise the doctoral thesis *(Doctoral Thesis Supervisor)*.

- For more detailed information please refer to the Rules on Doctoral Studies at ETH (*Doktoratsverordnung der ETHZ*).

# 7. Relevant documents and addresses

***Documents***

Study Regulations 2014 for the Master Program in Computational Science and Engineering https://rechtssammlung.sp.ethz.ch/Dokumente/324.1.0900.52.pdf

Further documents: http://www.rw.ethz.ch/documents.html

***Addresses***

*Director of Studies CSE*

Prof. Dr. Ralf Hiptmair
Seminar for Applied Mathematics
ETH Zürich, HG G 58.2
CH-8092 Zürich
Tel.: ++41 (0) 44-63 23404
E-mail: hiptmair@sam.math.ethz.ch

*Advisor of Studies CSE*

Dr. Vasile Gradinaru
Seminar for Applied Mathematics
ETH Zürich, HG GO 52.2
CH-8092 Zürich
Tel.: ++41 (0) 44-63 23448
E-mail:
vasile.gradinaru@sam.math.ethz.ch

*Study Administration Office D-MATH*

ETH Zürich, HG G 33.1
CH-8092 Zürich
Tel.: ++41 (0) 44-63 24383
E-mail: studiensekretariat@math.ethz.ch

*Rectorate*

ETH Zürich, HG F19
Tel.: ++41 (0) 44-63 23000

E-mail: kanzlei@rektorat.ethz.ch

*Student Exchange Office*

ETH Zürich, HG F23.1
Tel.: ++41 (0) 44-632 6161

www.mobilitaet.ethz.ch

***Internet***

The homepage of ETH (*www.ethz.ch*) provides general information about studying at ETH, in particular the documents listed under a) above, and the course catalogue for the RW/CSE Master Program (*Vorlesungsverzeichnis*): *www.vvz.ethz.ch*

Detailed information on the RW/CSE Master Program and the RW/CSE Bachelor Program can be found on the RW/CSE homepage: *www.cse.ethz.ch*

The documents listed under b) above can be read on the RW/CSE homepage or downloaded as PDF files.

*Other important websites*

Important links for students: www.ethz.ch/students

Student Administration der ETH Zürich: www.ethz.ch/de/die-eth-zuerich/organisation/abteilungen/akademische-dienste/studienadministration

Enrolment: www.lehrbetrieb.ethz.ch/myStudies

International student information: www.ethz.ch/en/studies/international-immigration-housing