

# Curriculum: Master Computational Science and Engineering

List of all courses offered in the Master program Computational Science and Engineering, including temporary or recent changes. Especially for Section D (Application Area) and E (Further Electives) further courses may be accepted – please contact the coordinators in such cases.

## Colorcode

- Permanent and regularly offered modules are listed in black colour, without any highlighting.
- Modules that have been added to this list for the first time are highlighted in green and by a filled circle (**Example**•)
- Modules that are accepted, *but are not regularly offered* **or** require *special consideration* (are taught in German, or may require additional prerequisites, or can be especially challenging, ...). are highlighted in teal and by a section symbol (*Example*<sup>§</sup>)
- Catalogs or modules that have recently been renamed/modified are highlighted in dark red, the old name/values is/are crossed (~~Old~~ New )

## Publishing

This PDF version extends the CSE curriculum as published on the following website:  
<http://www.cse.tum.de/modules/>.

*Last revision: after examination board SS2024*

# Curriculum

## Section A: Computer Science - Mandatory (10 ECTS)

The following modules are mandatory in Section A:

Modulname	ECTS	Modulnr.
Advanced Programming	5	IN1503
Parallel Programming	5	IN2147

## Section A: Computer Science - Electives (10 ECTS)

From the following elective modules, at least 10 ECTS have to be earned ( $\geq 2$  modules).

Modulname	ECTS	Modulnr.
Advanced Computer Architecture <b>OR</b> <i>Computer Architecture and Networks</i> <sup>§</sup>	6 <b>OR</b> 5 <sup>§</sup>	IN2076 <b>OR</b> IN2189 <sup>§</sup>
Fundamental Algorithms	5	IN2157
Patterns in Software Engineering	5	IN2081
Visual Data Analytics	5	IN2026

## Section B: Numerical Analysis - Electives (16 ECTS)

From the following elective modules, at least 16 ECTS have to be earned ( $\geq 2$  modules).

Modulname	ECTS	Modulnr.
Numerical Programming I	8	MA3305
Numerical Programming II	8	MA3306
Numerical Algorithms for High Performance Computing	8	IN2398

## Section C: Scientific Computing (31 ECTS)

The following modules are mandatory in Section C:

Modulname	ECTS	Modulnr.
Scientific Computing I	5	IN2005
Scientific Computing II	5	IN2141
Scientific Computing Lab	6	IN2182
Advanced Practical Course Computational Science and Engineering	10	IN2397
CSE Seminar Scientific Computing	5	IN2183

For the modules CSE Seminar Scientific Computing and Advanced Practical Course Computational Science and Engineering please refer to the tables CSE Seminar Scientific Computing and Advanced Practical Course Computational Science and Engineering below.

## Advanced Practical Course Computational Science and Engineering

For the module *Advanced Practical Course Computational Science and Engineering*, one course has to be chosen from the following list:

Modulname	Modulnr.	Angeboten in
Efficient Programming of Multicore Processors and Supercomputers	IN4048	summer
Experimental Evaluation of modern Computing Systems and Accelerators	IN4294	winter/summer
<b>Machine Learning in Crowd Modeling &amp; Simulation<sup>•</sup></b>	<b>IN4267<sup>•</sup></b>	winter/summer
Modern Wave Propagation - Discontinuous Galerkin & Julia	IN4280	summer
Scientific Computing - Computational Fluid Dynamics	IN2186/ IN4085	summer
Scientific Computing - High Performance Computing	IN4230	winter
<i>Applied Optimization Methods for Inverse Problems<sup>§</sup></i>	IN4349	summer

The list in its current state is published on this website:  
<http://www.cse.tum.de/modules/#c3836>.

## CSE Seminar Scientific Computing

For the module *CSE Seminar Scientific Computing*, one seminar has to be chosen from the following list:

Name	Modulnr.	Angeboten in
Advanced Topics in Quantum Computing	<b>IN2183</b>	winter/summer
Case Studies: Scientific Computing	MA4306	winter/summer
Computational Aspects of Machine Learning	<b>IN2183</b>	winter
<b>Computational Methods for Operator-Based Analysis<sup>•</sup></b>	<b>ED140016<sup>•</sup></b>	winter/summer
Computational Photonics and Nanoelectronics	EI7775	winter/summer
Deep Learning for Medical Application	IN4860	winter/summer
<b>Deep Learning for the Natural Sciences<sup>•</sup></b>	<b>IN45051<sup>•</sup></b>	winter/summer
Deep Learning in Computer Graphics	IN4858	winter/summer
Deep Learning in Physics	IN4939	winter
Fundamentals of Wave Simulation - Solving Hyperbolic Systems of PDEs	<b>IN2183</b>	winter
High Dimensional Methods in Scientific Computing	<b>IN2183</b>	summer
<b>Methods for Molecular Dynamics<sup>•</sup></b>	<b>IN2183<sup>•</sup></b>	winter
Modern Trends in High Performance Computing	<b>IN2183</b>	summer
Next-Gen Programming Interfaces and Compilers	IN4590	winter
Next Generation AI Hardware	IN4471	winter

Parallelisation of Physics Calculations on GPUs with CUDA	PH1351	summer
(Performance) Portable Programming of HPC Applications	IN4472	summer
<b>Quantum Information Processing Devices•</b> <b>Quantum Networks•</b>	<b>CIT432005•</b> <b>CIT4320003•</b>	summer winter/summer
Recent Trends in 3D Computer Vision and Deep Learning	IN4826	winter
<i>Data Analytics and Intelligent Systems in Energy Informatics<sup>§</sup></i>	IN4725	winter
<i>Emerging Topics in advanced computing<sup>§</sup></i>	IN4994	winter/summer
<i>Linear Operators for Machine Learning<sup>§</sup></i>	IN4479	winter
<i>Partitioned Fluid-Structure Interaction<sup>§</sup></i>	IN2183	summer
<i>Recent Advances in 3D Computer Vision<sup>§</sup></i>	IN4780	winter/summer

The list in its current state is published on this website:  
<http://www.cse.tum.de/modules/#c3837>.

## Section D catalogs: Application area (8 ECTS)

From section D, at least 8 ECTS have to be earned from the same catalog. Further courses can be taken from any catalog.

The following modules are accepted for the D catalogs:

### D1 Computational Structural Mechanics:

Modulname	ECTS	Modulnr.
Advanced Finite Element Methods	3	BV010010
Boundary Element Method	3	BV020007
Computational Material Modeling 1	6	BV330009
Computational Mechanics for Car Body Design	3	BGU33011
Discontinuous Galerkin Methods for Computational Mechanics	3	MW2453
Explicit Finite Element Methods and Transient Analysis	3	BV330008
Finite Elements	5	MW0612
Finite Element Method (FEM) in Aerospace Structures	4	MW1268
Finite Element Methods 1	6	BV320016
Finite Elements Practical Course	4	MW0286
Isogeometric Elements	6	BV440005
Isogeometric Structural Analysis and Design	3	BV320007
Multibody Simulation	3	MW0866
Multidisciplinary Design Optimization	5	MW0085
Multiscale Modeling	5	MW2359
Nonlinear Finite Element Methods	6	BV320009
Optimization	6	BV320017
Structural Dynamics	6	BV430008
Structural Dynamics Computer Lab	4	MW2296
The Finite Element Method for Fluid-Structure Interaction with Open-Source Software	5	BGU32024
Theory of Plates and Shells	6	BGU32021T2
<i>Computational Contact and Interface Mechanics<sup>§</sup></i>	3	MW2335

### D2 Computational Fluid Mechanics:

Modulname	ECTS	Modulnr.
An Introduction to Microfluidic Simulations	3	MW0642
Biofluid Mechanics	5	MW0376
Computational Acoustics	5	MW2323
Computational Aerodynamics	5	LRG0110
Computational Fluid Dynamics (CFD)	6	BGU41028
Computational Thermo-Fluid Dynamics	4	MW2134

Finite Elements in Fluid Mechanics	5	MW2452
Numerical Methods for Conservation Laws	3	MW2337
Particle-Simulation methods for Fluid Dynamics	3	MW0696
The Finite Element Method for Fluid-Structure Interaction with Open-Source Software	5	BGU32024
Turbulent Flow Simulation on HPC-Systems	5	IN2311
<hr/>		
<i>Computational Methods for Operator-Based Analysis</i> <sup>§</sup>	6	ED140016
<i>Lattice Boltzmann Methods</i> <sup>§</sup>	6	CIT4130009

### D3 Mathematics in Bioscience:

Modulname	ECTS	Modulnr.
Applications of Mathematical Biology	9	MA3602
Case Studies Life Science Mathematics	7	MA5616
Mathematical Models in Biology	9	MA3601
<hr/>		
<i>Computational Modeling for System Genetics</i> <sup>§</sup>	6	CIT4230001
<i>Introduction to Computational Neuroscience</i> <sup>§</sup>	5	EI7322

### D4 Computational Physics:

Modulname	ECTS	Modulnr.
Computational and Analytical Methods in Electromagnetics	6	EI73181
Computational Methods in Many-Body Physics	10	PH2264
Computational Plasma Physics	5	MA4304
Computational Physics 2	5	PH2090
Geometric Methods for Physics of Magnetized Plasmas	5	MA5333
Image Processing in Physics	5	PH2181
Molecular Dynamics Simulations	5	PH2019
<hr/>		
<i>Computational Astrophysics</i> <sup>§</sup>	5	PH2077
<i>Computational Materials Physics</i> <sup>§</sup>	5	PH2289

### D5 Computational Electronics:

Modulname	ECTS	Modulnr.
Analysis, Modeling and Simulation of Communication Networks	6	EI7450
<b>Atomistic Simulation of Nanomaterials and Electronic Devices</b> <sup>•</sup>	5	<b>CIT431011</b> <sup>•</sup>
Computational Materials Design	5	EI71055

Computational Methods for Nanoelectronics: Semiclassical Models	5	EI71094
Computational Methods in Nanoelectronics	5	EI7319
Computational and Analytical Methods in Electromagnetics	6	EI73181
Computational Photonics Lab	5	EI7469
Laboratory on "Simulation and Characterization of Microdevices"	6	EI7202
Practical Course Design and Simulation of Nanodevices	5	EI7274
Simulation of Quantum Devices	5	EI70760
<hr/>		
<i>Nanoelectric Devices Lab<sup>§</sup></i>	5	EI72731
<i>Nano-Optoelectronic Joint Simulation/Experimental Lab<sup>§</sup></i>	6	EI7482
<i>Scientific Computing in Circuit Simulation<sup>§</sup></i>	5	IN2306

### D6 Computational Chemistry:

Due to the very limited offer of courses within the D6 catalog, please contact the coordinators so that an individual plan can be agreed upon.

Modulname	ECTS	Modulnr.
Advanced Electronic Structure	5	CH3333
Methods of Molecular Simulation	5	CH3334

## Section E catalogs: Further Electives (15 ECTS)

From section E, further ECTS can be earned to reach the necessary 120 ECTS. It is also possible to completely skip courses from Section E, if desired.

*Catalog numbers E1, E2, ... are kept for historic reasons – they are only relevant for students who are studying according to older examination regulations. (Typically students who started before winter 2021/22.)*

The following modules are accepted for the E catalogs:

### E1 Algorithms in Scientific Computing:

Modulname	ECTS	Modulnr.
Algorithms for Scientific Computing	8	IN2001
Algorithmic Game Theory	5	IN2239
<i>Algorithms for Scientific Computing 2<sup>§</sup></i>	4	IN2002
<i>Time Integration and Differential Equations<sup>§</sup></i>	5	IN2387

### E2 Numerical Methods:

Modulname	ECTS	Modulnr.
Introduction to Functional Analysis	5	MA9304
Numerical Methods for Partial Differential Equations	9	MA3303
<i>Advanced Finite Element Methods<sup>§</sup></i>	5	MA4303
<i>Discontinuous Galerkin Methods<sup>§</sup></i>	9	MA5343
<i>Numerical Methods for Hyperbolic Systems<sup>§</sup></i>	5	MA5090

### E3 Parallel and Distributed Computing, High Performance Computing:

Modulname	ECTS	Modulnr.
Advanced Parallel Computing and Solvers for Large Problems in Engineering	5	MW1746
Advanced Seminar Course Code Generation Techniques and Innovative Programming Models	5	IN4590
Cloud Computing	4	IN2073
Distributed Systems	5	IN2259
Parallel Programming Systems	3	IN2365
<i>Parallel Program Engineering<sup>§</sup></i>	5	IN2310



**E4 Vision and Visualization:**

Modulname	ECTS	Modulnr.
Augmented Reality	6	IN2018
Basic Mathematical Methods for Imaging and Visualization	5	IN2124
Computer Aided Medical Procedures	6	IN2021
Computer Aided Medical Procedures 2	5	IN2022
Computer Vision I: Variational Methods	8	IN2246
Geometry Processing	6	IN2297
Image Synthesis	5	IN2015
<i>Convex Optimization for Computer Vision<sup>§</sup></i>	6	IN2330
<i>Probabilistic Graphical Models in Computer Vision<sup>§</sup></i>	5	IN2329

**E5 Probabilistic Methods in CSE:**

Modulname	ECTS	Modulnr.
Algorithms of Uncertainty Quantification	5	IN2345
Applied Regression	5	MA4401
Generalized Linear Models	9	MA3403
Probability Theory and Uncertainty Quantification	5	MW2360
<i>Computational Statistics<sup>§</sup></i>	5	MA3402

**E6 Data Driven Simulation and Computing:**

Modulname	ECTS	Modulnr.
Advanced Deep Learning for Physics	6	IN2298
Information Retrieval in High Dimensional Data	6	EI7223
Introduction to Deep Learning	6	IN2346
Machine Learning	8	IN2064
Machine Learning for Graphs and Sequential Data	5	IN2323
TUM Data Innovation Lab	10	MA8113
<i>Probabilistic Techniques and Algorithms in Data Analysis<sup>§</sup></i>	6	MA4803

**E7 Quantum Computing:**

Modulname	ECTS	Modulnr.
Advanced Concepts of Quantum Computing	5	IN2400
Introduction to Quantum Computing	5	IN2381

QST Theory: Quantum Information	10	PH1010
Quantum Computers and Quantum Secure Communications	5	EI71073
Quantum Entrepreneurship Laboratory	6	PH8128
Tensor Networks	5	IN2388
<hr/>		
<i>Applications of Quantum Computing</i> <sup>§</sup>	5	NAT7022
<i>Mathematical Introduction to Quantum Information Processing</i> <sup>§</sup>	9	MA5057