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Curriculum for the master's programme in Computational Science (2022 version)

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§ 1 Objectives and qualification profile

(1) The term computational science designates the investigation of scientific issues by means of computational modelling and simulation. The objective of the master's programme in Computational Science at the University of Vienna is a sound education in computational and mathematical methods of this modern, interdisciplinary approach and their practical application in natural sciences (astronomy and astrophysics, biology, chemistry, meteorology, pharmacy and physics).

(2) Beyond a bachelor's qualification, graduates of the master's programme in Computational Science at the University of Vienna are qualified to develop solutions for complex problems in natural sciences aided by computers in interdisciplinary teams. They are able to capture problems in natural sciences in models, to develop algorithms and software to address these problems, to make computations on modern computer systems and to analyse and visualise data and models. For this, they are making use of knowledge of numerical mathematics, modern programming paradigms and high-performance computing acquired in the master's programme. Graduates are familiar with methods of data-driven research (data science and machine learning) and their application in natural sciences. They also have advanced knowledge in selected areas of natural sciences and are thus able to scrutinise and interpret results from computer simulations. The disciplinary and interdisciplinary knowledge and problem-solving competences acquired in the master's programme in Computational Science prepare graduates for a professional career at universities and non-university research institutions as well as industrial research and development and the services sector.

(3) The knowledge and skills acquired during the master's programme in Computational Science also prepare students for further degree programmes.

§ 2 Duration and scope

(1) The workload for the master's programme in Computational Science comprises 120 ECTS credits. This is equivalent to a degree programme duration of four semesters.

(2) The programme is deemed completed if 24 ECTS credits as defined in the provisions on alternative groups of compulsory modules, 69 ECTS credits as defined in the provisions on compulsory modules, 25 ECTS credits as defined in the provisions on the master's thesis and 2 ECTS credits as defined in the provisions on the master's examination have been obtained.

§ 3 Entry requirements

(1) To be admitted to the master's programme in Computational Science students must have completed an eligible bachelor's programme in the fields of computer science, natural sciences or mathematics or another eligible degree programme at the same level of university education in the fields of computer science, natural sciences or mathematics at a recognised Austrian or foreign post-secondary educational institution.

(2) The bachelor's programmes in Astronomy, or Biology, or Chemistry, or Computer Science, or Mathematics, or Meteorology, or Pharmacy, or Physics at the University of Vienna are certainly eligible subject to para. 3.

(3) As qualitative admission requirements, all applicants must provide the following evidence of knowledge, abilities and competences corresponding to at least 30 ECTS credits:

a) Knowledge of computer science in the following areas corresponding to at least 10 ECTS credits in total:

- Basics of programming and knowledge of one high-level programming language
- Object-oriented programming (functions, classes, inheritance)
- Database systems
- Algorithms and data structures (basic data structures, searching and sorting methods and basic graph and optimisation algorithms)

All areas must be covered.

b) Knowledge of mathematics in the following areas corresponding to at least 10 ECTS credits in total:

- Basics of mathematics (set theory, logic, functions, real and complex numbers, groups and bodies, elementary combinatorics)
- Linear algebra (matrix and vector analysis, inverting matrices, solving linear equations, defining determinants, eigenvalues and eigenvectors, linear optimisation, inner products, projections, orthonormal bases)
- Analysis (sequences and series, differential and integral calculus in multiple variables, Taylor series and Taylor expansion, linear ordinary differential equations)

All areas must be covered.

c) Knowledge of natural sciences in one area or several of the following areas corresponding to at least 10 ECTS credits in total:

- Basics of astronomy and astrophysics (characteristics of astrophysical objects and central astrophysical processes)
- Basics of biology (biochemistry; bioinformatics: sequence alignment and data base search, reconstruction of phylogenetic trees, prediction of the structure and function of proteins, molecular networks; mechanisms of molecular evolution; genetic and functional diversity of microorganisms; function of microorganisms, plants or animals in ecosystems, cell biology)
- Basics of chemistry (chemical structural formulas, functional groups and their reactivity, reaction mechanisms, thermodynamics, kinetics)
- Basics of meteorology (radiation, fluid dynamics and thermodynamics of the atmosphere)
- Basics of pharmacy (chemical basics of therapeutically relevant pharmacological substance classes, structure-activity relationships, methods of computer-assisted pharmacological substance development, pharmacodynamics, pharmacokinetics, risk assessment)
- Basics of physics (classical mechanics, oscillation and waves, electricity and magnetism, continuum mechanics: elasticity and hydrodynamics, thermodynamics and statistical mechanics, quantum mechanics)

Depending on the previous degree programme, the qualitative admission requirements can be fulfilled in combination with the completion of the extension curriculum in Computational Science.
If the applicant cannot prove their knowledge according to para. 3, subsections a), b) and c) in the form of an extension curriculum, they have to present a qualification description specifying the achievements completed prior to the submission of the application for admission and which are equivalent to the exams of the required extension curriculum. Based on this qualification description (together with the other documents submitted), the competent body for study matters examines whether the qualitative admission requirements are fulfilled. Detailed regulations on the qualification description are provided by the competent body for study matters.

(4) The language of instruction of the master's programme in Computational Science is English. Students must have English language proficiency corresponding to level B2 (Common European Framework of Reference for Languages) and must complete the programme in English. In the modules with electives, courses allocated to other master's programme at the University of Vienna may also be held in German. For these, students must have German language proficiency corresponding to level B2 (Common European Framework of Reference for Languages).

§ 4 Academic degree

Graduates of the master's programme in Computational Science are awarded the degree "Master of Science", abbreviated as MSc. Where the academic degree is stated this must be after the name.

§ 5 Structure – Modules with allocated ECTS credits

(1) Overview

The master's programme in Computational Science includes a sound education in its core areas of numerical mathematics, programming and algorithms and one or several application subjects in natural sciences. In addition, modules in the field of data science are offered.

The master's programme consists of three parts:

The first part serves the purpose of aligning the level of knowledge of the students coming from different disciplines. It is the basis for further studies in computational science. The compulsory modules specified for this part comprise 30 ECTS credits in total. Depending on the previous education, students must complete an alternative group of compulsory modules comprising 24 ECTS credits. In addition, all students must complete an alternative compulsory module in the area of data science comprising 6 ECTS credits.

The second part of the master's programme in Computational Science consists of the group of compulsory modules *Core of Computational Science* comprising 30 ECTS credits. Students should acquire advanced knowledge of central contents and methods in computational science, in the core areas and various application subjects.

The third part of the degree programme comprises the 3rd and 4th semester. This part of the degree programme focusses on the consolidation and specialisation in a current field of research at the faculties involved as part of the compulsory module *Specialisation* comprising 20 ECTS credits. Additional 10 ECTS credits are for the compulsory module *Extension*. The 4th semester is dedicated to independent academic research for the master's thesis and the preparation of the thesis. The compulsory module *Academic Writing* and Presentation and *Ethics in Natural Sciences* in the 3rd semester prepare students for this.

Overview table of the degree programme:

PART I	
Alternative groups of compulsory modules:	
APMG-A *Foundations of Computational Science A* (for graduates holding a university degree in natural sciences):	**24 ECTS credits**
Compulsory module: *Numerical Mathematics 1*	**12 ECTS credits**
Group of compulsory modules: *Programming and Algorithms*:	**12 ECTS credits**
Compulsory module: *Programming*	6 ECTS credits
Compulsory module: *Programming Languages and Concepts*	6 ECTS credits
or	
APMG-B *Foundations of Computational Science B* (for graduates holding a university degree in mathematics):	**24 ECTS credits**

Group of compulsory modules: *Programming and Algorithms*:	**12 ECTS credits**
Compulsory module: *Programming*	6 ECTS credits
Compulsory module: *Programming Languages and Concepts*	6 ECTS credits
Group of elective modules: *Computational Natural Sciences*	**12 ECTS credits**
or	
APMG-C *Foundations of Computational Science C* (for graduates holding a university degree in computer science):	**24 ECTS credits**
Compulsory module: *Numerical Mathematics 1*	**12 ECTS credits**
Group of elective modules: *Computational Natural Sciences*	**12 ECTS credits**
For all students:	
Alternative compulsory modules: *Data Science*	**6 ECTS credits**
Alternative compulsory module: *Introduction to Machine Learning*	**6 ECTS credits**
or	
Alternative compulsory module: *Statistics for Data Science*	**6 ECTS credits**
PART II	
Group of compulsory modules: *Core of Computational Science*:	**30 ECTS credits**
Compulsory module: *Numerical Mathematics 2*	**8 ECTS credits**
Compulsory module: *Algorithms and Data Structures for Computational Science*	**4 ECTS credits**
Compulsory module: *Advanced Computational Science*	**18 ECTS credits**
PART III	
Compulsory module: *Academic Skills and Ethics*	**3 ECTS credits**
Compulsory module: *Specialisation*	**20 ECTS credits**
Compulsory module: *Extension*	**10 ECTS credits**
Master's Thesis	**25 ECTS credits**
Master's Examination	**2 ECTS credits**

(2) Module descriptions

Depending on their previous education, students complete one of the following alternative groups of compulsory modules:

(2.1) Alternative group of compulsory modules: *Foundations of Computational Science A*

Graduates holding a degree in natural sciences (such as Astronomy, Biology, Chemistry, Meteorology, Pharmacy, Physics) must complete the alternative group of compulsory modules *Foundations of Computational Science A*. It consists of the compulsory module *Numerical Mathematics 1* comprising 12 ECTS credits and the group of compulsory modules *Programming and Algorithms* comprising 12 ECTS credits in total.

APMG-A	**Alternative group of compulsory modules: *Foundations of Computational Science A***	**24 ECTS credits**
PM-NUM1	Compulsory module *Numerical Mathematics 1*	12
PMG-PA	Group of compulsory modules: *Programming and Algorithms*	12

(2.2) Alternative group of compulsory modules: *Foundations of Computational Science B*

Graduates holding a university degree in mathematics must complete the alternative group of compulsory modules *Foundations of Computational Science B*. It consists of the group of compulsory modules *Programming and Algorithms* comprising 12 ECTS credits and 2 elective modules comprising 12 ECTS credits in total from the group of elective modules *Computational Natural Sciences*.

APMG-B	**Alternative group of compulsory modules: *Foundations of Computational Science B***	**24 ECTS credits**
PMG-PA	Group of compulsory modules: *Programming and Algorithms*	12
WMG-NAT	Group of elective modules: *Computational Natural Sciences*	12

(2.3) Alternative group of compulsory modules: *Foundations of Computational Science C*

Graduates holding a university degree in computer science must complete the alternative group of compulsory modules *Foundations of Computational Science C*. It consists of the group of compulsory modules *Numerical Mathematics 1* comprising 12 ECTS credits and 2 elective modules comprising 12 ECTS credits in total from the group of elective modules *Computational Natural Sciences*.

APMG-C	**Alternative group of compulsory modules: *Foundations of Computational Science C***	**24 ECTS credits**
PM-NUM1	Compulsory module *Numerical Mathematics 1*	12
WMG-NAT	Group of elective modules: *Computational Natural Sciences*	12

(2.4) Module descriptions of the modules of the alternative groups of compulsory modules Compulsory module: *Numerical Mathematics 1* (12 ECTS credits)

Students who attend the alternative groups of compulsory modules *Foundations of Computational Science A & C* have to complete the following compulsory module:

PM-NUM1	***Numerical Mathematics 1*** (compulsory module)	**12 ECTS credits**
Prerequisites	none	
Module outcomes	Students acquire knowledge of the basic tasks of numerical mathematics and modelling, especially of the following topics: Error, condition, stability, order of convergence, efficiency of methods; 1D analysis: Interpolation, extrapolation, FFT, univariate zero of a function problems (bisection method, secant method, root secant method, Newton's method), numerical and algorithmic differentiation, numerical integration; numerical linear algebra: Matrix factorisations, solving linear equations, solving linear least squares problems, solving eigenvalue problems, calculating singular value decomposition; multidimensional non-linear equations.	
Module structure	VO on Numerical Mathematics 1: 6 ECTS credits, 4 SSt. (npi) UE on Numerical Mathematics 1: 6 ECTS credits, 4 SSt. (pi)	
Proof of performance:	Passing of the course examination (npi) (6 ECTS credits) and the continuous assessment course (pi) (6 ECTS credits) specified in the module	

SSt (Semesterstunde): hour per week per semester.
pi (prüfungsimmanent): continuous assessment.
npi (nicht prüfungsimmanent): non-continuous assessment.
Course types and their abbreviations: see § 9.

Group of compulsory modules: *Programming and Algorithms* (12 ECTS credits)

Students who attend the alternative groups of compulsory modules *Foundations of Computational Science A & B* have to complete the following compulsory modules:

PROG	***Programming*** (compulsory module)	**6 ECTS credits**
Prerequisites	none	
Module outcomes	Students know advanced concepts of imperative and object-oriented development and are able to assess their different realisation in various programming languages with regard to their suitability for certain usage scenarios. They are able to independently implement programming systems for complex tasks in different imperative and object-oriented languages and are proficient in basic techniques for testing and debugging these programming systems.	
Module structure	VU on Programming: 6 ECTS credits, 4 SSt. (pi)	
Proof of performance:	Passing of the continuous assessment course (pi) (6 ECTS credits) specified in the module	

PLC	***Programming Languages and Concepts*** (compulsory module)	**6 ECTS credits**
Prerequisites	none	
Module outcomes	Upon completion of this module, students know different paradigms and advanced concepts of programming languages and are able to make informed decisions when using suitable programming methods. They know the essential approaches to designing and implementing selected language features and have a basic understanding of translation, static analysis and run-time support. Students can apply this knowledge in programming exercises.	
Module structure	VU on Programming Languages and Concepts: 6 ECTS credits, 4 SSt. (pi)	
Proof of performance:	Passing of the continuous assessment course (pi) (6 ECTS credits) specified in the module	

Group of elective modules: *Computational Natural Sciences* (12 ECTS credits)

Subject to availability, students attending the alternative groups of compulsory modules *Foundations of Computational Science B & C* must select 2 elective modules comprising 12 ECTS credits in total, subject to availability, from this group of elective modules.

ICA	***Introduction to Computational Astrophysics*** (elective module)	**6 ECTS credits**
Prerequisites	none	
Module outcomes	Upon completion of this module, students are proficient in the basic methods in computational astrophysics and are able to apply these to problems in different areas of astrophysics (planets - stars - galaxies - cosmology). Students are familiar with the following concepts and methods: Data processing, N-body dynamics, hydrodynamics, statistical methods.	
Module structure	VO on Introduction to Computational Astrophysics: 3 ECTS credits, 2 SSt. (npi) UE on Introduction to Computational Astrophysics: 3 ECTS credits, 2 SSt. (pi)	

SSt (Semesterstunde): hour per week per semester.
pi (prüfungsimmanent): continuous assessment.
npi (nicht prüfungsimmanent): non-continuous assessment.
Course types and their abbreviations: see § 9.

Proof of performance:	Passing of the course examination (npi) (3 ECTS credits) and the continuous assessment course (pi) (3 ECTS credits) specified in the module

ICBD	***Introduction to Computational Biology and Drug Discovery*** (elective module)	**6 ECTS credits**
Prerequisites	none	
Module outcomes	Students know basic concepts and methods in bioinformatics and pharmacoinformatics. The contents include: Analysis, prediction and modelling of biological macromolecules (proteins, DNA, RNA), biological databases, sequence analysis, phylogenetic analysis, gene annotation, comparative genomics, quantitative structure-activity relationships, molecular docking, virtual screening, data integration, hit-to-lead processes in drug research.	
Module structure	VO on Introduction to Computational Biology and Drug Discovery: 3 ECTS credits, 2 SSt. (npi) UE on Introduction to Computational Biology and Drug Discovery: 3 ECTS credits, 2 SSt. (pi)	
Proof of performance:	Passing of the course examination (npi) (3 ECTS credits) and the continuous assessment course (pi) (3 ECTS credits) specified in the module	

ICCP	***Introduction to Computational Chemistry and Physics*** (elective module)	**6 ECTS credits**
Prerequisites	none	
Module outcomes	Students know the basic concepts and methods in computational modelling of atoms, molecules, fluids and solid bodies. The contents include: Basics of quantum mechanics (Schrödinger equation, atomic orbitals, wave functions), theory of chemical bonds (valence bond theory, molecular orbital theory), electronic structure methods (variation method, Hartree-Fock method, density-functional theory), basics of nuclear motion (molecular dynamics), basics of statistical mechanics (ensembles, Monte Carlo simulation).	
Module structure	VO on Introduction to Computational Chemistry and Physics: 3 ECTS credits, 2 SSt. (npi) UE on Introduction to Computational Chemistry and Physics: 3 ECTS credits, 2 SSt. (pi)	
Proof of performance:	Passing of the course examination (npi) (3 ECTS credits) and the continuous assessment course (pi) (3 ECTS credits) specified in the module	

ICM	***Introduction to Computational Meteorology*** (elective module)	**6 ECTS credits**
Prerequisites	none	
Module outcomes	Upon completion of this module, students have a basic understanding of atmospheric processes and their modelling. They can apply it to problems in different fields of meteorology and climate research. Students are familiar with several of the following concepts and methods: Data processing, numerical methods for prognostic partial differential equations, parametrisation of physical processes, data assimilation and ensemble methods, atmospheric transport modelling.	
Module structure	VO Introduction to Computational Meteorology: 3 ECTS credits, 2 SSt. (npi) UE on Introduction to Computational Meteorology: 3 ECTS credits,	

	2 SSt. (pi)
Proof of performance:	Passing of the course examination (npi) (3 ECTS credits) and the continuous assessment course (pi) (3 ECTS credits) specified in the module

(2.5) Alternative compulsory modules: *Data Science (6 ECTS credits)*

Subject to availability, all students must choose one of the following two alternative compulsory modules:

IML	***Introduction to Machine Learning*** (alternative compulsory module)	**6 ECTS credits**
Prerequisites	none	
Module outcomes	Upon completion of this module, students know modern conceptual principles to solve different problems of machine learning and their practical implementation.	
Module structure	VU on Introduction to Machine Learning: 6 ECTS credits, 4 SSt. (pi)	
Proof of performance:	Passing of the continuous assessment course (pi) specified in the module (6 ECTS credits)	

or

SDS	***Statistics for Data Science*** (alternative compulsory module)	**6 ECTS credits**
Prerequisites	none	
Recommended prerequisite	Introduction to Machine Learning	
Module outcomes	Upon completion of this module, students are familiar with the following concepts and methods and are able to apply these independently in practice. Models and methods for special data structures (e.g. temporal or spatial information, waiting times, groups, images and graphs). Models as approximations and as projections. Information vs dimension (classical asymptotes and alternative approaches). Statistical learning by means of correctly specified models and under possible misspecification. Validation of estimates and predictors. Inference with estimates and predictors for model-based and model-less approaches.	
Module structure	VU on Statistics for Data Science: 6 ECTS credits, 4 SSt. (pi)	
Proof of performance:	Passing of the continuous assessment course (pi) specified in the module (6 ECTS credits)	

(2.6) Group of compulsory modules: *Core of Computational Science (30 ECTS credits)*

All students must complete the group of compulsory modules *Core of Computational Science*. It consists of a compulsory module on advanced numerical mathematics (8 ECTS credits), a compulsory module on algorithms and data structures (4 ECTS credits) and the compulsory module *Advanced Computational Science,* including a selection of advanced alternative courses in the areas of application subjects in natural sciences, programming and algorithms as well as data science comprising 18 ECTS credits.

PM-NUM2	***Numerical Mathematics 2*** (compulsory module)	**8 ECTS credits**
Prerequisites	none	
Recommended prerequisite	Numerical Mathematics 1	

Module outcomes	Students acquire knowledge of the advanced tasks of numerical mathematics and modelling, especially of the following topics: Numerical linear algebra: Krylov subspaces and iteration methods (Arnoldi, Lanczos, CG, GMRES, etc.), sparse linear algebra; basics of the Monte Carlo simulation; analysis: Interpolation of curves and areas, multi-dimensional integration (Monte Carlo method, quasi-Monte Carlo methods); linear optimisation; numerical solution of ordinary differential equations (method of successive displacement, linear multi-step methods, boundary value problems); numerical solution of partial differential equations (FEM, difference method).
Module structure	VO on Numerical Mathematics 2: 5 ECTS credits, 3 SSt. (npi) UE on Numerical Mathematics 2: 3 ECTS credits, 2 SSt. (pi)
Proof of performance:	Passing of the course examination (npi) (5 ECTS credits) and the continuous assessment course (pi) (3 ECTS credits) specified in the module

PM-ADS	***Algorithms and Data Structures for Computational Science*** (compulsory module)	**4 ECTS credits**
Prerequisites	none	
Module outcomes	Upon completion of this module, students are familiar with the following concepts and methods and are able to apply these independently in practice. Development and analysis of algorithms and their runtime, specifically for graph and clustering problems; efficient exact and approximate algorithms for optimisation problems, such as greedy algorithms and linear programmes with rounding techniques; algorithms for large amounts of data, such as external memory algorithms, streaming algorithms and online algorithms.	
Module structure	VU on Algorithms and Data Structures for Computational Science: 4 ECTS credits, 3 SSt. (pi)	
Proof of performance:	Passing of the continuous assessment course (pi) specified in the module (4 ECTS credits)	

PM-ACS	***Advanced Computational Science*** (compulsory module)	**18 ECTS credits**
Prerequisites	none	
Module outcomes	Students acquire advanced knowledge of central contents and methods in computational science.	

Module structure	Subject to availability, students select courses comprising 18 ECTS credits in total from the following areas, whereas they have to obtain a minimum number of ECTS credits in each area: 1. At least 8 ECTS credits in subjects of natural sciences. Students can select from the master's programmes at the University of Vienna: • Courses from the master's programme in Astronomy in the areas of numerical methods and data science in astronomy and astrophysics. • Courses from the master's programmes in Biology and Molecular Biology in the areas of structural biology and computational biology, bioinformatics, molecular biology, genetics and developmental biology, microbiology and immunobiology, theoretical biology, evolutionary biology, ecology, microbial ecology as well as behavioural biology, neurobiology and cognitive biology. • Courses from the master's programme in Chemistry in the area of theoretical (bio)chemistry: quantum chemistry, reaction dynamics, molecular dynamics and cheminformatics. • Courses from the master's programme in Meteorology in the areas of modelling the atmosphere, the climate system and data analysis. • Courses from the master's programme in Drug Discovery and Development in the areas of pharmacoinformatics, data science in drug discovery, biophysics in drug discovery. • Courses from the master's programme in Physics-Core with relation to computational physics. 2. At least 6 ECTS credits from Programming and Algorithms and/or Data Science. Students can select from the master's programmes at the University of Vienna: • Courses from the master's programme in Computer Science in the areas of algorithms, data analysis and parallel computing. • Courses from the master's programme in Data Science in the areas of machine learning, statistics, mathematics, optimisation methods, if the student has not already completed these in part I of the degree programme in the form of an alternative compulsory module in the area of data science. The courses that can be selected for this module will be announced in the course directory.
Proof of performance:	Passing of all course examinations (npi) and/or continuous assessment courses (pi) specified in the module (18 ECTS credits in total)

(2.7) Compulsory module: *Academic Skills and Ethics (3 ECTS credits)*

All students must complete the following compulsory module:

PM-ASE	***Academic Skills and Ethics*** (compulsory module)	**3 ECTS credits**
Prerequisites	none	
Module outcomes	Students acquire abilities in academic publishing and presenting, know the principles of good academic practice and have a basic understanding of ethics and its application in research.	

Module structure	Subject to availability, students choose courses with non-continuous assessment (npi) and/or courses with continuous assessment (pi) comprising 3 ECTS credits in total. The courses currently eligible for this module are listed in the course directory.
Proof of performance:	Passing of all course examinations (npi) and/or continuous assessment courses (pi) specified in the module (3 ECTS credits)

(2.8) Compulsory module: *Specialisation (20 ECTS credits)*

All students must complete the following compulsory module:

PM-SPEC	***Specialisation*** (compulsory module)	**20 ECTS credits**
Prerequisites	none	
Module outcomes	According to their choice, students acquire further specialised knowledge of topics in current computational science research at the involved faculties. They acquire skills to address an academic question by means of modern computational methods. They are prepared for independent academic research as part of their master's thesis. Students may also take specialised internships and conduct independent project work. In this module, students also have the opportunity to complete research internships. They acquire profound knowledge of the independent use of modern computational methods to address concrete academic questions.	
Module structure	Subject to availability, students select lectures, seminars, combined lectures and exercises, practical laboratory courses, internships and/or research internships comprising 20 ECTS credits in total. Students may obtain no more than 10 ECTS credits by completing practical laboratory courses or a research internship.	
	The courses currently eligible for this module are listed in the course directory. The courses offered may be adjusted to the demand of the students and the development of current interdisciplinary key research areas. Research internships (*Forschungspraktika*, PR Forschung): Students can take research internships at the involved faculties of the University of Vienna or foreign universities/research institutions. For the recognition of research internships at external research institutions, students must obtain approval from the competent directorate of studies in advance. The student requesting prior approval must enclose a recommendation by a teacher from one of the faculties involved in the master's programme as part of local quality assurance.	
Proof of performance:	Passing of all course examinations (npi) and/or continuous assessment courses (pi) specified in the module (20 ECTS credits in total)	

To promote international exchange, students also have the opportunity to replace this module with a suitable course programme at another Austrian or foreign university following prior approval from the directorate of studies.

(2.9) Compulsory module: *Extension (10 ECTS credits)*

All students must complete the following compulsory module:

PM-EXT	***Extension*** (compulsory module)	**10 ECTS credits**
Prerequisites	none	
Module outcomes	According to their choice, students acquire profound knowledge in disciplines that complement their degree programme in a meaningful way. Students may use this module either for an interdisciplinary extension in core and application subjects of the master's programme in Computational Science or related topics with reference to natural sciences, technology, mathematics or computer science or for a further subject-related specialisation.	
Module structure	Subject to availability, students choose courses with non-continuous assessment (npi) and/or courses with continuous assessment (pi) comprising 10 ECTS credits in total. Students may select: • Courses not already completed from the PM-ACS module of the master's programme in Computational Science at the University of Vienna. • Courses not already completed from the PM-SPEC module of the master's programme in Computational Science at the University of Vienna. • Courses from other master's curricula of the University of Vienna (or other Austrian or foreign universities) with a subject relation (technology, mathematics, natural sciences or computer science). • No more than 5 ECTS credits from topics not related to the subject (other courses at the University of Vienna or at other universities).	
Proof of performance	Passing of all course examinations (npi) and/or continuous assessment courses (pi) specified in the module (10 ECTS credits in total)	

§ 6 Master's thesis

(1) The master's thesis serves to demonstrate the student's ability to achieve adequate standards of content and methodology when independently addressing academic topics. The assignment for the master's thesis must be chosen in a way that the student can reasonably be expected to complete it within six months.

(2) (2) The topic of the master's thesis must be taken from one of the compulsory modules and/or alternative compulsory modules. If a different topic is selected or if there is uncertainty regarding the allocation of the selected topic, the competent body responsible for study matters decides on whether or not it is admissible.

(3) The master's thesis comprises 25 ECTS credits.

§ 7 Master's examination

(1) To be admitted to a master's examination the student must have successfully passed all required modules and examinations and the master's thesis must have been positively assessed.

(2) The master's examination is a public defence and consists of a defence and an examination on the academic disciplines related to the master's thesis. Grading will be conducted as stipulated in the Statutes of the University of Vienna.

(3) The master's examination is conducted before an examination committee in accordance with the

section of the University's Statutes governing university studies.

(4) The master's examination comprises 2 ECTS credits.

§ 8 Mobility during the master's programme

The completion of modules abroad is permitted. It is recommended that students take courses with equivalent content from the modules PMG-ACS, or PM-SPEC or PM-EXT abroad, either in the 2nd semester or the 3rd semester as part of a semester abroad. The competent body responsible for study matters is responsible for the recognition of academic achievements completed abroad.

§ 9 Course classification

(1) All courses with non-continuous assessment (npi) have to be offered as one of the following types of courses:

Lectures (***Vorlesungen*, VO) [non-continuous assessment]** serve the purpose of imparting knowledge primarily through lectures by a teacher that can be combined with interactive elements. Students must consolidate the course contents beyond the classes through self-study. Instructions for self-study and/or supplementary literature facilitate continuous and detailed learning. In lectures, the proof of performance is a written or an oral examination.

(2) All courses with continuous assessment (pi) have to be offered as one of the following types of courses:

Combined lectures and exercises (*Vorlesungen verbunden mit Übungen*, VU) [continuous assessment] are courses with continuous assessment that combine the acquisition of subject-specific knowledge and/or methodological knowledge in the lecture part with their application in the exercise part. A VU is a lecture (VO) accompanied by exercises. The lecturer decides on the temporal sequence of lecture-type and exercise-type parts as needed. The lecture part and the exercise part must be completed simultaneously. Achieving the learning outcomes of a VU also requires independent study outside the designated course hours. The proof of performance is based on multiple written or oral student assignments during the course or on independently completing and submitting assignments.

Exercises (*Übungen, UE*) [continuous assessment] are courses with continuous assessment that serve the application of already acquired knowledge and the consolidation of skills that are required for understanding the course contents. Students work independently or as a team on concrete tasks and issues. Students are supervised in small groups. Lecturers are mainly tasked with guiding and monitoring students' work and implementing a sophisticated feedback culture. The proof of performance are multiple independent written or oral partial achievements during the course.

Research internships (*Forschungspraktika*, PR Forschung) [continuous assessment] allow students to get an insight into academic work of researchers in research groups at faculties involved in the master's programme in Computational Science or at non-university research institutions. This can take the form of participation in a current research project or a small student project. Research internships may take no longer than 6 months and are assessed only with "participated with success"/ or "participated without success". The scope of the research internship is 10 ECTS credits, for which the institution at which the student completed the research internship must provide a written proof of performance, including 250 working hours. For the recognition of research internships at external research institutions or other universities, students must obtain approval from the competent directorate of studies in advance. The student requesting prior approval must enclose a recommendation by a teacher from one of the faculties involved as part of local quality assurance.

§ 10 Courses with a limited number of participants and registration procedure

(1) The following general limits on the number of students apply in the following courses:
Students may participate in courses with continuous assessment subject to availability of places. The following general limits on the number of students apply in the different courses:

Combined lectures and exercises (*Vorlesung verbunden mit Übungen,* VU)	25
Exercises (*Übungen*, UE)	25

(2) For courses allocated to other degree programmes, the limits on the number of students specified in the relevant curricula apply.

(3) Modalities concerning the registration for courses and examinations as well as the allocation of places in courses are governed by the stipulations of the Statutes of the University of Vienna.

§ 11 Examination regulations

(1) Proof of performance in courses

The lecturer of a course is responsible for making the necessary announcements according to the stipulations in the Statutes.

(2) Examination content
The examination content relevant to preparing and holding examinations must be in line with the required number of ECTS credits. This also applies to module examinations.

(3) Examination procedure

The examination procedure is subject to the stipulations of the Statutes of the University of Vienna.

(4) No double recognition and no dual use
Courses taken and examinations passed in the degree programme, which constitute entry requirements for the master's programme, cannot be recognised again in the master's programme. If courses taken in the degree programme, which constitute an entry requirement for the degree programme, are compulsory according to the Curriculum, the competent body responsible for study matters can determine what courses must be attended in place of the others. Courses taken and examinations passed from another compulsory or elective module of the degree programme cannot be recognised within another module within the same degree programme. This also applies to recognition procedures.

(5) Examination results must be allocated to the relevant module by the stated ECTS figure and must not be allocated to different proofs of performance.

§ 12 Entry into force

(1) This Curriculum will enter into force upon announcement in the University Gazette of the University of Vienna as of 1 October 2022.

(2) The amendments to the Curriculum as stated in the University Gazette of 26 June 2023, number 134, 30th edition enter into force on 1 October 2023.

§ 13 Transitional provisions

(1) This Curriculum applies to all students who commence their degree programme as of the winter semester of 2022/2023.

(2) If, at a later stage of the degree programme, courses are no longer offered which were compulsory under the original curricula, the competent body responsible for study matters decides ex officio (equivalence regulation) or at the request of the student which courses and examinations have to be completed instead.

(3) Students who have started the master's programme in Computational Science before that date may voluntarily accept the provisions of this Curriculum by simple confirmation.

(4) Students who started the master's programme in Computational Science, which entered into force prior to this Curriculum (University Gazette of 15 May 2013, 25th edition, number 150 as amended) are entitled to complete their degree programme by 31 October 2024.

(5) The competent body responsible for study matters specified in the organisational regulations is entitled to determine in general or on a case-by-case basis which of the courses taken and examinations passed will be recognised for this Curriculum.

Appendix

Recommended path through the master's programme:

<table>
<tr><th colspan="3">1st semester
30 ECTS credits</th><th rowspan="2">2nd semester
30 ECTS credits</th><th rowspan="2">3rd semester
33 ECTS credits</th><th rowspan="2">4th semester
27 ECTS credits</th></tr>
<tr><th>Path A</th><th>Path B</th><th>Path C</th></tr>
<tr><td rowspan="2">PM-NUM1
Compulsory module
12 ECTS credits</td><td rowspan="2">PMG-PA
Group of compulsory modules
12 ECTS credits</td><td rowspan="2">PM-NUM1
Compulsory module
12 ECTS credits</td><td>PM-NUM2
Compulsory module
8 ECTS credits</td><td>PM-ASE
Compulsory module
3 ECTS credits</td><td rowspan="4">Master's Thesis
Compulsory module
25 ECTS credits</td></tr>
<tr><td>PM-ADS
Compulsory module
4 ECTS credits</td><td rowspan="2">PM-SPEC
Compulsory module
20 ECTS credits</td></tr>
<tr><td rowspan="3">PM-ACS
Compulsory module
18 ECTS credits</td></tr>
<tr><td>PMG-PA
Group of compulsory modules
12 ECTS credits</td><td>WMG-NAT
Group of elective modules
12 ECTS credits</td><td>WMG-NAT
Group of elective modules
12 ECTS credits</td><td>PM-EXT
Compulsory module
10 ECTS credits</td></tr>
<tr><td colspan="3">Data Science
Alternative compulsory modules
6 ECTS credits</td><td>Master's Examination
Compulsory module
2 ECTS credits</td></tr>
</table>

SSt (Semesterstunde): hour per week per semester.
pi (prüfungsimmanent): continuous assessment.
npi (nicht prüfungsimmanent): non-continuous assessment.
Course types and their abbreviations: see § 9.