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Appendices for the Master's degree programme(s) in Computing Science 2025-2026

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Appendix I. Learning outcomes of the degree programme (art. 3.1)

The Master graduate in Computing Science:

- Is fully acquainted with the advanced terms and techniques used in Computing Science, and is familiar with a number of classical problems and their solutions;
- Is experienced in the effective use of the tools available in solving Computing Science problems, such as compilers, theorem proofs, visualisation software, case-tools and domain specific software and hardware;
- Is familiar with Computing Science applications in several other scientific fields of study;
- Is capable of clear communication (both oral and in writing) on the subject of Computing Science and its applications;
- Is capable of working in a team and in various projects;
- Is sensitive to the social aspects of Computing Science applications and their own responsibilities therein;
- Has specialized knowledge of theories, methods and techniques in one of the following subfields of Computing Science:
    - Machine Learning and Visual Computing
    - Software Engineering and Distributed Systems
    - AI Engineering
    - Science, Business & Policy
- Is able, by using scientific data and assessments, to analyse problems in Computing Science or a related scientific field of study, to provide specified solutions to the problem, and – if possible – to materialise these solutions (in the shape of an algorithm or program or an implementation in software or hardware);
- Is able to critically read professional literature and to assess its correctness, usability and relevance;
- Is able to contribute to the enhancement of scientific understanding in a subfield of Computing Science;
- Has a proper understanding of the scientific relevance of problem definitions and results, and of the validity of the scientific method used.
- Has the ability to design and implement software, integrating and reusing existing components where necessary, into a solution or system that meets quality criteria agreed upon with interested parties.

The Master in Computing Science graduated in the subfield of Science, Business & Policy (SBP):

- Has a full understanding of the way in which businesses and policy organisations are functioning (governments and nongovernmental organisations, NGO's);
- Understands the connections between natural science research, trade and industry and governmental policies;
- Is able to integrate aspects of natural science, business and management;
- Is able to translate a concrete problem definition in business or management into a natural science problem definition;
- Is able to connect problem aspects of natural sciences to other relevant subject fields;
- Is able to put research data and conclusions into a business or policy context;
- Has developed their social and communicative skills**:**
- Is able to write texts that are effective and to the point;
- Is able to draw up an innovation plan or management plan for either a business or a government organisation;
- Is able to give convincing oral presentation;
- Is able to deliver an active contribution to plenary discussions;

- Familiar with techniques used in business meetings and is capable of chairing a meeting;
- Is able to work on a project as part of a team;
- Is able to give and receive feedback concerning their way of functioning in a team;
- Can work in a project;
- Is able to fully consider the interests or objectives of the ordering customer;
- Is able to plan a project independently;
- Is able to cooperate with the relevant parties involved in the project;
- Is able to adequately deal with limitations in time, information and means;
- Is able to prepare the implementation of a project result;
- Is capable of taking professional responsibility;
- Is able to take responsibility on behalf of the organisation;
- Is able to recognize the strategic aspects of their own project;
- Is able to provide practical solutions in matters concerning the ethical and professional codes of their own field of expertise and of the professional organisation.

Appendix II. Tracks/specializations (art. 3.6)

The Master Computing Science has four tracks:

1. Machine Learning and Visual Computing (MLVC)
2. Software Engineering and Distributed Systems (SEDS)
3. AI Engineering
4. Science, Business & Policy (SBP)

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Appendix III. Content of the degree programme (art. 3.8)

Course details, mode of assessment and examination are described in Ocasys.

1. The programme for **SBP** is:

Course unit	**Course code**	**ECTS**
Student Colloquium (CS)	WMCS019-05	5
In-company or Research Internship *	WMCS021-05	15
SBP mandatory courses Introduction Science and Business Introduction Science and Policy Work placement Business and Policy	 WMSE001-10 WMSE002-10 WMSE902-40	**60** 10 10 40
20 ECTS out of a course package from one of the tracks		20
10 ECTS out of any course package of the track chosen above		10
10 ECTS from any track		10
Total		**120**

*For the SBP-track this internship needs to take place in a CS research group (and not in a company)

2. For MLVC, SEDS and AI Engineering, **course packages** for a specific topic are available within each track.

The **mandatory programme** for MLVC, SEDS and AI Engineering is:

Course unit	**Course code**	**ECTS**
Student Colloquium (CS)	WMCS019-05	5
In-company or Research Internship	WMCS021-05	15
Master Thesis	WMCS901-30	30
Total		**50**

Furthermore, the remaining ECTS have to fulfill the requirements for **at least one** of the course packages in the chosen track as defined below.

The track **Machine Learning and Visual Computing** offers the following course packages:

- Visual Computing
- Applied Data Science
- Machine Learning Theory

The programme for **MLVC- Visual Computing** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Perception for Visual Computing Scientific Visualization Advanced Computer Graphics Geo-Visualization Computer Vision Multi-Scale and Advanced Image Analysis	 WMCS029-05 WMCS018-05 WMCS006-05 WMCS035-05 WMCS015-05 WMCS047-05	**20** 5 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

The programme for **MLVC - Applied Data Science** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Introduction to Data Science Social Network Analysis Modelling and Simulation Scientific Visualization Pattern Recognition for CS	 WMCS002-05 WMCS028-05 WMCS003-05 WMCS018-05 WMCS011-05	**20** 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

The programme for **MLVC- Machine Learning Theory** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Introduction to Data Science Neural Networks and Computational Intelligence Advanced Machine Learning Theory of Machine Learning Robotic State Estimation Multimodal Mobile Sensing Intelligent Mobile Perception in Practice	 WMCS002-05 WMCS010-05 WMAI030-05 WMCS038-05 WMCS040-05 WMCS041-05 WMCS042-05	**20** 5 5 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

The track **Software Engineering and Distributed Systems** offers the following course packages

- Theoretical Computing Science
- Software Engineering
- Large-Scale Software Systems
- Cybersecurity
- Advanced Computer Architecture

The programme for **SEDS - Theoretical Computing Science** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Modal Logic and Proof Theory Logical Aspects of Multi-Agent Systems Software Language Engineering Models and Semantics of Computation Programs and Interactive Proofs Algorithms for Computationally Challenging Problems	 WMCS027-05 WMAI020-05 WMCS037-05 WMCS026-05 WMCS033-05 WMCS049-05	**20** 5 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

The programme for **SEDS - Software Engineering** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Cloud Computing and Cloud-based Applications Software Architecture Software Maintenance and Evolution Evidence-Based Software Engineering Software Analytics	 WMCS032-05 WMCS004-05 WMCS013-05 WMCS024-05 WMCS031-05	**20** 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

The programme for **SEDS - Large-Scale Software Systems** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Cloud Computing and Cloud-based Applications Enterprise Application Integration Information Systems Scalable Computing Performance Engineering Advanced Distributed Systems	 WMCS032-05 WMCS007-05 WMCS009-05 WMCS017-05 WMCS045-05 WMCS044-05	**20** 5 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

The programme for **SEDS - Cybersecurity** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Advanced Topics in Security and Privacy Ethical Hacking Software and System Security Network Security Analytics Hardware Security	 WMCS001-05 WMCS030-05 WMCS034-05 WMCS036-05 WMCS043-05	**20** 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30

Total		**70**

The programme for **SEDS - Advanced Computer Architecture** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Embedded Systems Performance Engineering Emerging Computer Architectures Hardware Security	 WMCS050-05 WMCS045-05 WMCS046-05 WMCS043-05	**20** 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

The track **AI Engineering** offers the following course packages:
- Engineering of AI Systems
- Robotics

The programme for **AI Engineering - Engineering of AI Systems** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Introduction to Data Science Cloud Computing and Cloud-based Applications Scientific Visualization Advanced Machine Learning Scalable Computing Machine Learning Systems Deployment and Operations Data Challenges in AI Systems Human- Centered Artificial Intelligence Deep Learning Trustworthy and Explainable AI	 WMCS002-05 WMCS032-05 WMCS018-05 WMAI030-05 WMCS017-05 WMCS039-05 WMCS048-05 WMCC023-05 WMAI017-05 WMAI032-05	**20** 5 5 5 5 5 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

The programme for **AI Engineering - Robotics** is:

Course unit	**Course code**	**ECTS**
20 ECTS out of: Introduction to Data Science Robotic State Estimation	 WMCS002-05 WMCS040-05	**20** 5 5

Course unit	Course code	ECTS
Robotics for AI Intelligent Mobile Perception in Practice Cognitive Robotics Multimodal Mobile Sensing Control Methods for Robotics Human-Robot Interaction for Social Robots	WMAI011-05 WMCS042-05 WMAI003-05 WMCS041-05 WMAI037-05 WMAI027-05	5 5 5 5 5 5
10 ECTS out of any course package in same track		10
10 ECTS out of any track		10
30 ECTS electives (see App. IV)		30
Total		**70**

Appendix IV. Electives (art. 3.9.1)

Course details, mode of assessment and examination are described in Ocasys.

1. Optional modules in the programme **MLVC, SEDS and AI Engineering** are:

   30 ECTS are chosen from Master level courses. For courses not mentioned in the course packages nor the pre-approved electives of the MSc CS, the student needs to request the formal approval of the Board of Examiners. Based on a motivated request by a student, the Board of Examiners may grant permission to choose electives other than those offered in the MSc Computing Science. These courses can be from the University of Groningen or another university in the Netherlands or abroad and must be Master level courses (at the discretion of the Board of Examiners).

Course code	Course name
WBMA064-05 *	Project Number Theory *
WMPH007-05	Computational Physics
WMMA015-05	Contemporary Statistics with Applications
LIX016M05	Learning from Data
WMIE005-05	Robotics for IEM
LIX021M05	Computational Semantics
WMIE007-05	Fitting Dynamical Models to Data
WMAS011-05	Statistical Signal Processing
WMIE021-05	Systems Engineering

** The Bachelor's course WBMA064-05 Project Number Theory has been deemed of appropriate level for CS Master's students and may therefore be taken as an elective as part of the 30 ECTS electives space in the MSc CS.*

Appendix V. Entry requirements and compulsory order (art. 4.4)

The entry requirement for the **Master Thesis [WMCS901-30]** is successful completion of at least 60 ECTS of the Computing Science master's degree programme, including the In-company or Research Internship (CS) [WMCS021-15] . The supervisor of the Master Thesis reserves the right to require successful completion of specific courses.

The entry requirements for **Work placement Business and Policy [WMSE902-40]**: Research project (of the Master CS), Introduction Science and Policy [WMSE002-10] are Introduction Science and Business [WMSE001-10].

There are no additional entry requirements for computing science courses.

The entry requirements of optional modules are not always met by Computing Science students. Entry requirements are specified on Ocasys and have to be checked by students themselves.

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Appendix VI. Admission to the degree programme (art. 2.1A.1 + 2.1B.1)

Holders of the following Bachelor's degrees from the University of Groningen are considered to have sufficient knowledge and skills and will be admitted to the Master's degree programme in Computing Science on that basis:
- BSc Computing Science

Appendix VII. Pre-master programmes

a. FSE offers Pre-Master's programmes of *60 EC, 45 EC or 30 ECTS*, for access to the MSc Computing Science and individually determined Pre-Master's programmes. The overview below shows:

- Which NVAO-accredited HBO diploma grants access to the MSc Computing Science ;
- The content and student workload for these fixed programmes.

Below are listed the standard Pre-Master's programmes for HBO Bachelor ICT graduates per Computing Science Master track offered at the University of Groningen. Students are able to apply for these pre-master programmes based on a Bachelor's degree in HBO ICT with croho 30020.

a. Bachelor 30020- HBO ICT

Track MSc Computing Science: Software Engineering and Distributed Systems

Semester	Course Unit	Course Code	ECTS
1a	Introduction to Logic	WBCS030-05	5
1a	Advanced Algorithms	WBCS052-05	5
1b	Computer Architecture	WBCS010-05	5
1b	Statistics and Probability	WBCS049-05	5
2a	Operating Systems	WBCS023-05	5
2b	Languages and Machines	WBCS027-05	5
Total			30

Track MSc Machine Learning and Visual Computing

Semester	Course Unit	Course Code	ECTS
1a	Advanced Algorithms	WBCS052-05	5
1a	Advanced Programming	WBCS053-05	5
1a	Calculus 2	WBCS054-05	5
1b	Statistics and Probability	WBCS049-05	5
2a	Introduction to Machine Learning	WBCS032-05	5
2b	Introduction to Computer Graphics and Visualization	WBCS056-05	5
Total			30

Track MSc Computing Science: AI Engineering

Semester	Course Unit	Course Code	ECTS
1a	Advanced Algorithms	WBCS052-05	5
1a	Advanced Programming	WBCS053-05	5
1a	Calculus 2	WBCS054-05	5
1b	Statistics and Probability	WBCS049-05	5
2a	Introduction to Machine Learning	WBCS032-05	5
2b	Fundamentals of Distributed Systems	WBCS057-05	5
Total			30

- Starting date 1 September

Please note that the above mentioned course packages are tailored to one of the MSc Computing Science tracks and that successful completion of any of the three Pre-Master packages grants access to the Master Computing Science (regardless of which track).

b. For HBO programmes not listed above, the Board of Admissions decides:
    i. The content and the student workload of a tailor-made Pre-Master's programme.

    or

    ii. Admission is not accepted.

Appendix VIII. Transitional provisions (art. 7.1)

Students that started their Master's in academic year 2023-2024 or earlier are allowed to choose the new programme or may opt to continue with their track as per the TER of 2023-2024. The 2024-2025 academic year is the last one under which students can graduate under the old programme.

Students who have already successfully finished [WBCS016-05] Software Language Engineering are not allowed to take [WMCS037-05] Software Language Engineering.

WMCS012-05 Process Aware Information Systems has been removed from the Master's programme starting 2024-2025. There will be an exam and resit for those who have taken but not passed the course in 2023-2024.

WMCS008-05 Image Processing has been removed from the Master's programme starting 2024-2025. There will be an exam and resit for those who have taken but not passed the course in 2023-2024. Students in the ISVC track who started their Master's in 2023-2024 or earlier and who will continue with the old curriculum can take any course they have not yet passed from the ISVC track's course packages as a replacement.

Web and Cloud Computing [WMCS005-05] has been removed from the programme starting 2023-2024. From 2023-2024 onwards, it has been replaced with Cloud Computing and Cloud-based Applications [WMCS032-05].
Students that have already successfully finished Web and Cloud Computing are not allowed to take Cloud Computing and Cloud-based Applications as an elective course. For students that have not successfully finished Web and Cloud Computing before September 1st 2023, the course Cloud Computing and Cloud-based Applications is mandatory.

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Appendix IX. Additional Requirements Open degree Programmes (art. 3.10)

In exceptional circumstances students wishing to pursue an open degree programme may file a request with the Board of Examiners. The Board of Examiners will evaluate whether the proposed curriculum meets the learning outcomes of the degree programme and can determine further conditions in their Rules and Regulations.