UNIVERSITÄT KOBLENZ · LANDAU

module handbook

for the study programme

Master of Science (M.Sc.)

Mathematical Modelling, Simulation and Optimisation

Version number: 20194-2
Valid from winter semester 2021/22
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at the

Koblenz

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Course description:

Master's programme "Mathematical Modelling, Simulation and Optimisation - MMSO"

1. Contact persons for individual sections of the Master's programme

Mathematical Modelling: Prof. Dr. T. Götz

Mathematics: Prof. Dr. M. Hinze Computer Science:

Prof. Dr. M. Wimmer

2. Modules of the Master's programme

Compulsory modules: 03MA2501; 03MA2502; 03MA2503; 03MA2504; 03XX2501;03XX2590;03XX2599

Optional compulsory sections: Advanced Mathematics; Physics in Applications; Computer-based Methods

It is strongly recommended to inform oneself about the actual opportunities already in the first semester of the Master programme.

Modules equivalent to at least 39 LP could be chosen freely from the three fields "Advanced Mathematics", "Physics in Applications" and "Computer-based Methods" as long as the topics were not part of the Bachelor's programme.

In "Computer-based methods", the modules from the Master's programmes "Computer Visualistics" and "Web Science", listed below, can also be chosen.

Some optional compulsory modules are taught exclusively in German, while all compulsory modules are taught in English.

3. Course Guide Master's Programme (M.Sc.) "Mathematical Modelling, Simulation and Optimisation" for students starting in the winter term

The following course plan allows compliance with the standard period of study, as the compulsory modules planned for each term are coordinated by the examination board without any overlap. Variable are the times of the internship (possible in each term break) and the elective modules.

term	Identification number	module	LP
1 (winter semester)	03MA2501	Applied Differential Equations	9
1 (winter semester)		Physics in applications	6
1 (winter semester)		Computer-based methods	5-8
1 (winter semester)		Advanced Mathematics	9
1 (winter semester)		possibility for studying abroad	
		total	**29**
2 (SS)	03MA2502	Optimisation	9
2 (SS)	03MA2503	Numerics for Partial Differential Equations	9
2 (SS)	03XX2501	Project seminar (part 1)	3
2		Physics in applications	6
2 (SS)		Computer-based methods	5-8
2 (SS)		Advanced Mathematics	9
2 (SS)		possibility for studying abroad	
		total	**26-32**
3 (winter semester)	03MA2504	Optimisation 2	9
3 (WS)	03XX2501	Project seminar (part 2)	12
3 (winter semester)		Physics in applications	6
3 (winter semester)		Computer-based methods	5-8
3 (winter semester)		Advanced Mathematics	9
		Total	**26-30**
4 (SS)	03XX2590	Master's thesis	27
4 (SS)	03XX2599	Final oral exam	3
		Total	**30**
		Overall total	**120**

In the following sections, all modules and the included courses are listed together with the maximum number of credit points attainable for each module of the master's programme.

The number of credit points per module sums up the students' workload, contact time and private studies following the formula 1 LP = 30 hours.

Since the workload of the students varies in different teaching forms in terms of preparation and training/reworking, no fixed factor between credit points (CP) and contact time (SWS) is possible. The listed contact time is converted in time following the estimate 1 SWS = 15 hours.

In this master's programme, 52 SWS (51 LP) of pure contact time, 26 SWS (at least 39 LP) in compulsory modules, equal 90 LP. In addition, 30 LP are given for the master's thesis.

Depending on the module, the certificates of achievement for the individual courses can be provided by final module examinations or partial module examinations in the form of written exams, oral examinations or study papers (for details see examination regulations). The type of module examination is defined in this module manual. The form of the module examination is described in the module manual and its date will be announced at the beginning of the first course of the module. Students are required to take their first attempt either directly after completing the course or before the start of the next term. A failed examination can be repeated twice. If the second repetition is not rated at least as "adequate" (4.0), the academic performance is finally considered as not fulfilled; a renewed repetition of the same study performance is usually excluded. If this happens with a compulsory module, the degree can no longer be achieved.

The headers of the following module descriptions contain information on the type and title of the module, the credit points to be earned (LP), the number of semester hours per week (SWS), the workload in hours (hours) and the course duration. The courses are differentiated according to lectures (V), laboratory exercises (LÜ), internships (P) and seminars (S). Section 2 describes the expected learning outcomes as well as the subject-related competences that students should acquire by the end of their studies, with each module contributing in a specific way to their acquisition. Section 3 "Contents" contains a brief description of the main subjects of the courses. Further details on frequency, prerequisites for participation, forms of examination, the language of instruction, literature, participating teaching units and those responsible for the module follow.

Participation in compulsory modules does not require any content-related prerequisites beyond the knowledge acquired in the bachelor's programme, while some compulsory elective Modules require the successful completion of other modules or the otherwise proven necessary knowledge.

The modules are abbreviated according to the following pattern into a module code:

- The first two characters are the numbers of the faculty: "03" Faculty 3: Mathematics / Science and "04" Faculty 4: Computational Science.
- The next two characters indicate the institute in charge for this module: "CV" Institute for Computervisualistics, "IN" Institute for Computational Science "MA" Mathematical Institute,

"PH" Department of Physics, "WI" Institute for Information Systems Reseach; for soft skills as well as the thesis, "XX" is used instead.

- The fifth character indicates whether the module was initially designed for a bachelor's programme ("1") or a master's programme ("2").
- The last three characters are provided by the teaching unit in charge.

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Module description Mathematical Modelling, Simulation and Optimisation
Table of Contents

Compulsory modules

Compulsory modules (81 LP – including Master's thesis and final oral examination)

module 01 **Applied Differential Equations** 9 credit points
03MA2501 Compulsory module

One of the optional compulsory subjects has to be chosen, depending on provision.
(One of the following compulsory courses has to be chosen, depending on provision.)

Workload 270 hours	**semester** 1st term (recommended)	**Duration** 1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	1.1	V	Applied Differential Equations	3625011	Compulsory	4 hours per week 60 hours	120 hours	30	6
	1.2	Ü	Applied Differential Equations	3625012	Elective	2 hours per week 30 hours	60 hours	30	3
	1.3	S	Applied Differential Equations	3625013	Elective	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3625011 - Applied Differential Equations (V)

The students

- know the fundamental definitions, theorems and methods related to the theory and numerical methods for differential equations
- apply known results from calculus, linear algebra and numerics,
- can tackle advanced problems, analyse them mathematically and solve them numerically.

3625012 - Applied Differential Equations (Ü)

The students

- broaden their analytical and problem-solving skills in the field of differential equations
- are able to acquire, adapt and apply current research results.

3625013 - Applied Differential Equations (S)

The students

- broaden their analytical and problem-solving skills in the field of differential equations
- are able to acquire, adapt and apply current research results.

3 **Contents**

3625011 - Applied Differential Equations (V)

- Elementary methods for initial value problems of ordinary differential equations
- Existence and uniqueness results for initial value problems
- Qualitative behaviour and stability
- Linear first and higher order systems of differential
- One-step methods for initial value problems, consistency and convergence
- Runge-Kutta methods and adaptive step size selection
- Classification of partial differential equations and elementary cases

3625012 - Applied Differential Equations (Ü)

- Elementary methods for initial value problems of ordinary differential equations
- Existence and uniqueness results for initial value problems
- Qualitative behaviour and stability
- Linear first and higher order systems of differential
- One-step methods for initial value problems, consistency and convergence
- Runge-Kutta methods and adaptive step size selection
- Classification of partial differential equations and elementary cases

3625013 - Applied Differential Equations (S)

- Elementary methods for initial value problems of ordinary differential equations
- Existence and uniqueness results for initial value problems
- Qualitative behaviour and stability
- Linear first and higher order systems of differential
- One-step methods for initial value problems, consistency and convergence
- Runge-Kutta methods and adaptive step size selection
- Classification of partial differential equations and elementary cases

4 **Frequency of offering**

Only in the winter semester

3625011 - Applied Differential Equations (V)
Only in the winter semester

3625012 - Applied Differential Equations (Ü)
Only in the winter semester

3625013 - Applied Differential Equations (S)
only in the winter semester

5 **Language of instruction**

3625011 - Applied Differential Equations (V)
English

3625012 - Applied Differential Equations (Ü)
English

3625013 - Applied Differential Equations (S)
English

6 **Individual course requirements**

None

7 **Examination**

Module exam Applied Differential Equations as an exam or oral

exam

(written or oral – 90/30 min.)

3625012 - Applied Differential Equations (Ü)

coursework:

The type of study achievement is determined by the lecturer according to the learning goals, the workload and the financial possibilities and will be announced at the beginning of the course at the latest.

	(written or oral – 1 term) **3625013 - Applied Differential Equations (S)** coursework: The type of study achievement is determined by the lecturer according to the learning goals, the workload and the financial possibilities and will be announced at the beginning of the course at the latest. (written or oral – 1 term)
8	**Requirements for the award of credit points** Passing the module exam **3625012 - Applied Differential Equations (Ü)** Passing the study achievement **3625013 - Applied Differential Equations (S)** Passing the study achievement
9	**Significance of the final grade** 9/120 of the study programme
10	**Module coordinator** Prof. Dr. Thomas Götz
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625011 - Applied Differential Equations (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625012 - Applied Differential Equations (Ü)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625013 - Applied Differential Equations (S)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Eng. Applied Physics (91) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Compulsory module

module 02 **Optimisation** 9 credit points
03MA2502 Compulsory module

One of the optional compulsory subjects has to be chosen, depending on provision.
(One of the following compulsory courses has to be chosen, depending on provision.)

Workload	**semester**	**Duration**
270 hours	2nd term (recommended)	1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	2.1	V	Optimisation	3625021	Compulsory	4 hours per week 60 hours	120 hours	30	6
	2.2	Ü	Optimisation	3625022	Elective	2 hours per week 30 hours	60 hours	30	3
	2.3	S	Optimisation	3625023	Elective	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3625021 - Optimisation (V)

The students

- know fundamental methods and algorithms for optimisation problems
- are able to model small real-world problems and to apply optimisation techniques to solve those problems.

3625022 - Optimisation (Ü)

The students

- know fundamental methods and algorithms for optimisation problems
- are able to model small real-world problems and to apply optimisation techniques to solve those problems
- broaden their analytical and problem-solving skills
- are able to acquire, adapt and apply current research results.

3625023 - Optimisation (S)

The students

- know fundamental methods and algorithms for optimisation problems
- are able to model small real-world problems and to apply optimisation techniques to solve those problems
- broaden their analytical and problem-solving skills
- are able to acquire, adapt and apply current research results.

3 **Contents**

3625021 - Optimisation (V)

- Linear programmes in standard form, fundamental theorem of linear optimisation, simplex method
- Duality theorem, degenerate problems
- Interior-point methods
- Optimality conditions for unconstrained and constrained problems
- One-dimensional minimisation; direct methods
- Descent methods in higher dimensions, CG methods

	• Basics of graph theory, optimisation on graphs **3625022 - Optimisation (Ü)** • Linear programmes in standard form, fundamental theorem of linear optimisation, simplex method • Duality theorem, degenerate problems • Interior-point methods • Optimality conditions for unconstrained and constrained problems • One-dimensional minimisation; direct methods • Descent methods in higher dimensions, CG methods • Basics of graph theory, optimisation on graphs **3625023 - Optimisation (S)** • Linear programmes in standard form, fundamental theorem of linear optimisation, simplex method • Duality theorem, degenerate problems • Interior-point methods • Optimality conditions for unconstrained and constrained problems • One-dimensional minimisation; direct methods • Descent methods in higher dimensions, CG methods • Basics of graph theory, optimisation on graphs
4	**Frequency of offering** Only in the summer semester **3625021 - Optimisation (V)** Only in the summer semester **3625022 - Optimisation (Ü)** only in the summer semester **3625023 - Optimisation (S)** only in the summer semester
5	**Language of instruction** **3625021 - Optimisation (V)** English **3625022 - Optimisation (Ü)** English **3625023 - Optimisation (S)** English
6	**Individual course requirements** None
7	**Examination formats** Module exam Optimisation as an exam or oral exam (written or oral – 90/30 minutes) **3625022 - Optimisation (Ü)** coursework:

	The type of study achievement is determined by the lecturer according to the learning goals, the workload and the financial possibilities and will be announced at the beginning of the course at the latest. (written or oral - 1 term) **3625023 - Optimisation (S)** coursework: The type of study achievement is determined by the lecturer according to the learning goals, the workload and the financial possibilities and will be announced at the beginning of the course at the latest. (written or oral - 1 term)
8	**Requirements for the award of credit points** Passing the module exam **3625022 -** **Optimisation (Ü)** Passing the study achievement **3625023 - Optimisation (S)** Passing the study achievement
9	**Significance of the final grade** 9/120 of the study programme
10	**Module coordinator** Prof. Dr. Michael Hinze
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625021 - Optimisation (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625022 - Optimisation (Ü)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625023 - Optimisation (S)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Eng. Applied Physics (91) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualisation (2019)
14	**Other information** Compulsory module

module 03 **Numerics for Partial Differential Equations** 9 credit points
03MA2503 Compulsory module

One optional compulsory subject must be chosen, depending on availability.
(One of the following compulsory courses has to be chosen, depending on provision.)

Workload	**semester**	**Duration**
270 hours	2nd term (recommended)	1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	3.1	V	Numerics for Partial Differential Equations	3625031	Compulsory	4 hours per week 60 hours	120 hours	40	6
	3.2	Ü	Numerics for Partial Differential Equations	3625032	Elective	2 hours per week 30 hours	60 hours	25	3
	3.3	S	Numerics for Partial Differential Equations	3625033	Elective	2 hours per week 30 hours	60 hours	25	3

2 **Learning outcomes / Competences**

3625031 - Numerics for Partial Differential Equations (V)

The students

- know the fundamental definitions, theorems and methods related to the theory and numerical methods for partial differential equations (PDEs).

3625032 - Numerics for Partial Differential Equations (Ü)

The students

- know the fundamental definitions, theorems and methods related to the theory and numerical methods for partial differential equations (PDEs).

3625033 - Numerics for Partial Differential Equations (S)

The students

- Know the fundamental definitions, theorems and methods related to the theory and numerical methods for partial differential equations (PDEs).

3 **Contents**

3625031 - Numerics for Partial Differential Equations (V)
- Elementary theory of PDEs (first and second order)
- Method of characteristics for first-order PDEs
- Finite difference methods
- Finite element methods

3625032 - Numerics for Partial Differential Equations (Ü)
- Elementary theory of PDEs (first and second order)
- Method of characteristics for first order PDEs
- Finite Difference Methods
- Finite Element Methods

3625033 - Numerics for Partial Differential Equations (S)
- Elementary theory of PDEs (first and second order)

	• Method of characteristics for first order PDEs • Finite difference methods • Finite element methods
4	**Frequency of offering** Only in the summer semester **3625031 - Numerics for Partial Differential Equations (V)** Only in the summer semester **3625032 - Numerics for Partial Differential Equations (Ü)** Only in the summer semester **3625033 - Numerics for Partial Differential Equations (S)** only in the summer semester
5	**Language of instruction** **3625031 - Numerics for Partial Differential Equations (V)** English **3625032 - Numerics for Partial Differential Equations (Ü)** English **3625033 - Numerics for Partial Differential Equations (S)** English
6	**Individual course requirements** Passed module exam 03MA2501
7	**Examination** module exam Numerics for Partial Differential Equations as an exam or oral exam (written or oral – 90/30 min.)
8	**Requirements for awarding credit points** Passing the module exam
9	**Significance of the final grade** 9/120 of the study programme
10	**Module coordinator** Prof. Dr. Thomas Götz
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625031 - Numerics for Partial Differential Equations (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625032 - Numerics for Partial Differential Equations (Ü)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute

	3625033 - Numerics for Partial Differential Equations (S) FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Web and Data Science (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Compulsory module

module 04 **Optimisation 2** 9 credit points
03MA2504 Compulsory module

One of the optional compulsory subjects has to be chosen, depending on provision.
(One of the following compulsory courses has to be chosen, depending on provision.)

Workload	**semester**	**Duration**
270 hours	3rd term (recommended)	1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	4.1	V	Optimisation 2	3625041	Compulsory	4 hours per week 60 hours	120 hours	40	6
	4.2	Ü	Optimisation 2	3625042	Elective	2 hours per week 30 hours	60 hours	25	3
	4.3	S	Optimisation 2	3625043	Elective	2 hours per week 30 hours	60 hours	25	3

2 **Learning outcomes / Competences**

3625041 - Optimisation 2 (V)

The students

- know the fundamental definitions, theorems and methods related to the theory and algorithmic methods for optimisation of complex systems which are modelled by e.g. ODE and/or PDE systems.

3625042 - Optimisation 2 (Ü)

The students

- apply known results from calculus, linear algebra, numerics and optimisation, they can tackle advanced problems, analyse them mathematically and solve them algorithmically.

3625043 - Optimisation 2 (S)

The students

- apply known results from calculus, linear algebra, numerics and optimisation, they can tackle advanced problems, analyse them mathematically and solve them algorithmically.

3 **Contents**

3625041 - Optimisation 2 (V)

- Principles of convex analysis
- Modelling with equality and/or inequality constrained quadratic programmes
- Lagrange calculus and optimality conditions
- Solution strategies: descent methods in Banach spaces, relaxation techniques for constrained problems, active set methods, discretisation techniques, approximation algorithms
- Special topics: nonlinear ODE and/or PDE constraints, error control solution algorithms, use of surrogate models

3625042 - Optimisation 2 (Ü)

- Principles of convex analysis
- Modelling with equality and/or inequality constrained quadratic programmes
- Lagrange calculus and optimality conditions

	• Solution strategies: descent methods in Banach spaces, relaxation techniques for constrained problems, active set methods, discretisation techniques, approximation algorithms • Special topics: nonlinear ODE and/or PDE constraints, error control solution algorithms, use of surrogate models **3625043 - Optimisation 2 (S)** • Principles of convex analysis • Modelling with equality and/or inequality constrained quadratic programmes • Lagrange calculus and optimality conditions • Solution strategies: descent methods in Banach spaces, relaxation techniques for constrained problems, active set methods, discretisation techniques, approximation algorithms • Special topics: nonlinear ODE and/or PDE constraints, error control solution algorithms, use of surrogate models
4	**Frequency of offering** Only in the winter semester **3625041 - Optimisation 2 (V)** Only in the winter semester **3625042 - Optimisation 2 (Ü)** Only in the winter semester **3625043 - Optimisation 2 (S)** only in the winter semester
5	**Language of instruction** **3625041 - Optimisation 2 (V)** English **3625042 - Optimisation 2 (Ü)** English **3625043 - Optimisation 2 (S)** English
6	**Individual course requirements** Passed module exam 03MA2502
7	**Types of examination** Module exam Optimization 2 as an exam or oral exam (written or oral - 90/30 min.) **3625042 - Optimisation 2 (Ü)** coursework: The type of study achievement is determined by the lecturer according to the learning goals, the workload and the financial possibilities and will be announced at the beginning of the course at the latest. (written or oral – 1 term) **3625043 - Optimisation 2 (S)**

	coursework: The type of study achievement is determined by the lecturer according to the learning goals, the workload and the financial possibilities and will be announced at the beginning of the course at the latest. (written or oral – 1 term)
8	**Requirements for the award of credit points** Passing the module exam **3625042 -** **Optimisation 2 (Ü)** Passing the study achievement **3625043 - Optimisation 2 (S)** Passing the study achievement
9	**Significance of the final grade** 9/120 of the study programme
10	**Module coordinator** Prof. Dr. Michael Hinze
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625041 - Optimisation 2 (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625042 - Optimisation 2 (Ü)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625043 - Optimisation 2 (S)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Compulsory module

module 05 **Project seminar** 15 credit points
03XX2501 Compulsory module

Two of the following compulsory elective courses must be chosen together. Either the two courses 3525015 and 3525016 or the two courses 3625015 and 3625016, depending on availability.

(Optional compulsory courses: Two of the following compulsory courses have to be chosen. Either the two courses 3525015 and 3525016 or the two courses 3625015 and 3625016, depending on availability.)

Workload 450 hours	**semester** 2nd term (recommended)	**Duration** 2 terms

1 **Courses**

				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
5.1	Pro	Project	3525015	Elective	0 hours per week 0 hours	360 hours	10	12
5.2	S	seminar	3525016	Elective	2 hours per week 30 hours	60 hours	10	3
5.3	Pro	Project	3625015	Elective	0 hours per week 0 hours	360 hours	10	12
5.4	S	seminar	3625016	Elective	2 hours per week 30 hours	60 hours	10	3

2 **Learning outcomes / Competences**

3525015 - Project (Pro)

The students

- are able to acquire, adapt and apply current research results
- are able to utilise computing and/or experimental facilities for the purpose of modelling, understanding and solving complex systems.

3525016 - seminar (S)

The students

- are able to present scientific results in the form of presentations
- train their team player as well as communication and social skills through peer-group discussions.

3625015 - Project (Pro)

The students

- are able to acquire, adapt and apply current research results
- are able to utilise computing and/or experimental facilities for the purpose of modelling, understanding and solving complex systems.

3625016 - seminar (S)

The students

- are able to present scientific results in the form of presentations
- train their team player as well as communication and social skills through peer-group discussions.

3 **Contents**

	3525015 - Project (Pro) • work on a given scientific problem subsuming components from computer science, mathematics and/or physics • reviewing relevant research results, adapting them to the problem at hand and deriving a suitable model • simulations, experiments and/or theoretical analysis have to be carried out based on the knowledge gained in the previous course of studies • validation and interpretation of research results. **3525016 - seminar (S)** • presentation of current research literature • presentation and discussion of research results. **3625015 - Project (Pro)** • work on a given scientific problem subsuming components from computer science, mathematics and/or physics • reviewing relevant research results, adapting them to the problem at hand and deriving a suitable model • simulations, experiments and/or theoretical analysis must be carried out based on the knowledge gained in the previous course of studies • validation and interpretation of research results. **3625016 - seminar (S)** • presentation of current research literature • presentation and discussion of research results.
4	**Frequency of offering** Every term **3525015 - Project (Pro)** Every term **3525016 - seminar (S)** every term **3625015 - Project (Pro)** Every term **3625016 - seminar (S)** Every term
5	**Language of instruction** **3525015 - Project (Pro)** English **3525016 - seminar (S)** English **3625015 - Project (Pro)** English **3625016 - seminar (S)** English
6	**Individual course requirements**

7	**Examination** module exam Project seminar as Seminar presentation in accordance with §12 of the examination regulations. (oral - 30 min.) **3525015 - Project (Pro)** Coursework: Portfolio (written – 2 weeks) **3625015 - Project (Pro)** Coursework: Portfolio (written - 2 weeks)
8	**Requirements for the award of credit points** Passing the module exam **3525015 -** **Project (Pro)** Passing the coursework **3625015 - Project (Pro)** Passing the coursework
9	**Weighting of the final grade** 15/120 of the study programme
10	**Module coordinator** Prof. Dr. Thomas Götz
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3525015 - Project (Pro)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3525016 - seminar (S)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3625015 - Project (Pro)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625016 - seminar (S)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20184)
14	**Other information** Compulsory module

	The module exam is the seminar presentation " " in accordance with § 12 of the examination regulations for the Bachelor's degree programme in Mathematical Modelling and Master's degree programme in Mathematical Modelling of Complex Systems at the University of Koblenz-Landau: Oral exam (duration: 30 minutes).

Advanced Mathematics

Elective area:

Modules worth at least 39 CP must be completed from the following areas (Advanced Mathematics; Physics in Applications; Computer-based Methods), provided that their content has not already been covered in the Bachelor's programme in Mathematical Modelling.

module 06 **Special Topics in Mathematics** 9 credit points
03MA2508 Elective module

One of the optional compulsory subjects has to be chosen, depending on provision.
(One of the following compulsory courses has to be chosen, depending on provision.)

Workload	**semester**	**Duration**
270 hours	2nd term (recommended)	1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	6.1	V	Special topics in mathematics	3625081	Compulsory	4 hours per week 60 hours	120 hours	30	6
	6.2	Ü	Special topics in mathematics	3625082	Elective	2 hours per week 30 hours	60 hours	30	3
	6.3	S	Special topics in mathematics	3625083	Elective	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3625081 - Special topics of Mathematics (V)

The students

- know the basic concepts and results of the respective field of mathematics.
- have an understanding of the definitions, theorems and methods presented in the lecture.
- are able to acquire, adapt and apply current research results.

3625082 - Special topics in mathematics (Ü)

The students

- are familiar with the basic concepts and results of the respective field of mathematics.
- have learnt in the tutorials how to handle the definitions, theorems and methods presented in the lecture precisely, soundly and independently.
- broaden their analytical skills in one special topic of mathematics. They are able to acquire, adapt and apply current research results.

3625083 - Special topics in mathematics (S)

The students

- know the basic concepts and results of the respective field of mathematics.
- have learned in the tutorials a precise, solid and autonomous handling of the definitions, theorems and methods presented in the lecture.
- broaden their analytical skills in one special topic of mathematics. They are able to acquire, adapt and apply current research results.

3	**Contents** **3625081 - Special Topics in Mathematics (V)** One field of modern mathematics related to applications, e.g. • applied algebra and computer algebra • differential geometry • functional analysis and inverse problems • number theory and its relevance for cryptography • Data analytics • Machine learning • Neural networks **3625082 - Special topics in mathematics (Ü)** One field of modern mathematics related to applications, e.g. • applied algebra and computer algebra • differential geometry • functional analysis and inverse problems • number theory and its relevance for cryptography • data analytics • Machine learning • Neural networks **3625083 - Special topics in mathematics (S)** One field of modern mathematics related to applications, e.g. • applied algebra and computer algebra • differential geometry • functional analysis and inverse problems • number theory and its relevance for cryptography • Data analytics • Machine learning • Neural networks
4	**Frequency of offering** Every term **3625081 - Special topics of Mathematics (V)** Every term **3625082 - Special topics of Mathematics (Ü)** Every term **3625083 - Special topics of Mathematics (S)** Every term
5	**Language of instruction** **3625081 - Special topics of Mathematics (V)** English **3625082 - Special topics of Mathematics (Ü)** English

	3625083 - Special topics of Mathematics (S) English
6	**Individual course requirements**
7	**Examination** Module exam Special topics of Mathematics as an exam or oral exam (written or oral – 90/30 min.)
8	**Requirements for the award of credit points** Passing the module exam
9	**Significance of the final grade** 9/120 of the study programme
10	**Module coordinator** Prof. Dr. Thomas Götz
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625081 - Special Topics in Mathematics (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625082 - Special topics of Mathematics (Ü)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625083 - Special Topics in Mathematics (S)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20184)
14	**Other information**

module 07 **Special topics of Applied Mathematics** 9 credit points
03MA2509 Compulsory elective
module

One optional compulsory subject must be chosen, depending on availability.
(One of the following compulsory courses has to be chosen, depending on provision.)

Workload	**semester**	**Duration**
270 hours	2nd term (recommended)	1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	7.1	V	Applied Mathematics	3625091	Compulsory	4 hours per week 60 hours	120 hours	30	6
	7.2	Ü	Applied Mathematics	3625092	Elective	2 hours per week 30 hours	60 hours	30	3
	7.3	S	Applied Mathematics	3625093	Elective	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3625091 - Applied Mathematics (V)

The students

- are familiar with the basic concepts and results of the respective field of applied mathematics
- have learnt in the tutorials how to handle the definitions, theorems, methods and algorithms presented in the lecture in a precise, solid and autonomous manner
- have broadened their analytical and problem-solving skills in one field of applied mathematics
- are able to acquire, adapt and apply current research results

3625092 - Applied Mathematics (Tutorial)

The students

- know the basic concepts and results of the respective field of applied mathematics
- have learned in the tutorials a precise, solid and autonomous handling of the definitions, theorems and methods and algorithms presented in the lecture
- broaden their analytical and problem-solving skills in one field of applied mathematics
- are able to acquire, adapt and apply current research results

3625093 - Applied Mathematics (S)

The students

- know the basic concepts and results of the respective field of applied mathematics
- have learnt in the tutorials a precise, solid and autonomous handling of the definitions, theorems and methods and algorithms presented in the lecture
- have broadened their analytical and problem-solving skills in one field of applied mathematics
- are able to acquire, adapt and apply current research results

3 **Contents**

3625091 - Applied Mathematics (V)

One field of applied mathematics, e.g.

- Fourier transforms

	• Financial mathematics • Mathematical models in natural sciences • Asymptotic analysis • Data-driven model order reduction • Approximation theory • Reduced basis methods **3625092 - Applied Mathematics (Ü)** One field of applied mathematics, e.g. • Fourier transforms • Financial mathematics • Mathematical models in natural sciences • Asymptotic analysis • Data-driven model order reduction • Approximation theory • Reduced basis methods **3625093 - Applied Mathematics (S)** One field of applied mathematics, e.g. • Fourier transforms • Financial mathematics • Mathematical models in natural sciences • Asymptotic analysis • Data-driven model order reduction • Approximation theory • Reduced basis methods
4	**Frequency of offering** Every term **3625091 - Applied Mathematics (V)** Every term **3625092 - Applied Mathematics (Ü)** Every term **3625093 - Applied Mathematics (S)** Every term
5	**Language of instruction** **3625091 - Applied Mathematics (V)** English **3625092 - Applied Mathematics (Ü)** English **3625093 - Applied Mathematics (S)** English
6	**Individual course requirements**
7	**Examination**

	Module exam Special Topics in Applied Mathematics as an exam or oral exam (written or oral – 90/30 min.)
8	**Requirements for the award of credit points** Passing the module exam
9	**Significance of the final grade** 9/120 of the study programme
10	**Module coordinator** Prof. Dr. Thomas Götz
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625091 - Applied Mathematics (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625092 - Applied Mathematics (Ü)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625093 - Applied Mathematics (S)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant events
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20184)
14	**Other information**

module 08 **Specialisation in Mathematics** 9 credit points
03MA2510 Elective module

One of the optional compulsory subjects has to be chosen, depending on provision.
(One of the following compulsory courses has to be chosen, depending on provision.)

Workload	**semester**	**Duration**
270 hours	2nd term (recommended)	1 term

1	**Courses**				**Compulsory/elective**	**Contact time**	**Self-study**	**Planned group size**	**LP**
	8.1	V	Specialisation in Mathematics	3625101	Compulsory	4 hours per week 60 hours	120 hours	30	6
	8.2	Ü	Specialisation in Mathematics	3625102	Elective	2 hours per week 30 hours	60 hours	30	3
	8.3	S	Specialisation in Mathematics	3625103	Elective	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3625101 - Specialisation in Mathematics (V)

The students

- specialise their knowledge in a field of mathematics.
- have learned in the tutorials a precise, solid and autonomous handling of the definitions, theorems and methods presented in the lecture
- broaden their analytical and problem-solving skills in one specialised field of mathematics. They are able to acquire, adapt and apply current research results.

3625102 - Specialisation in Mathematics (Ü)

The students

- specialise their knowledge in a field of mathematics.
- have learnt in the tutorials how to handle the definitions, theorems and methods presented in the lecture precisely, confidently and independently
- broaden their analytical and problem-solving skills in one specialised field of mathematics. They are able to acquire, adapt and apply current research results.

3625103 - Specialisation in Mathematics (S)

The students

- specialise their knowledge in a field of mathematics.
- have learned in the tutorials a precise, solid and autonomous handling of the definitions, theorems and methods presented in the lecture
- broaden their analytical and problem-solving skills in one specialised field of mathematics. They are able to acquire, adapt and apply current research results.

3 **Contents**

3625101 - Specialisation in Mathematics (V)

One field of modern applied mathematics specialising and/or continuing the contents of one of the modules 03MA2501 or 03MA2502

	3625102 - Specialisation in Mathematics (Ü) One field of modern applied mathematics specialising and/or continuing the contents of one of the modules 03MA2501 or 03MA2502 **3625103 - Specialisation in Mathematics (S)** One field of modern applied mathematics specialising and/or continuing the contents of one of the modules 03MA2501 or 03MA2502
4	**Frequency of offering** Every term **3625101 - Specialisation in Mathematics (V)** Every term **3625102 - Specialisation in Mathematics (Ü)** Every term **3625103 - Specialisation in Mathematics (S)** Every term
5	**Language of instruction** **3625101 - Specialisation in Mathematics (V)** English **3625102 - Specialisation in Mathematics (Ü)** English **3625103 - Specialisation in Mathematics (S)** English
6	**Individual course requirements**
7	**Examination** Module exam Specialisation in Mathematics as an exam or oral exam (written or oral – 90/30 min.)
8	**Requirements for the award of credit points** Passing the module exam
9	**Significance of the final grade** 9/120 of the study programme
10	**Module coordinator** Prof. Dr. Thomas Götz
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625101 - Specialisation in Mathematics (V)**

	FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625102 - Specialisation in Mathematics (Ü)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3625103 - Specialisation in Mathematics (S)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20184)
14	**Other information**

Physics in Applications

module 09 03PH2110 module			**Theoretical Physics 2: Quantum Theory, Statistical Physics and Thermodynamics**				6 credit points Compulsory elective		
Workload 180 hours			**semester** 1st term (recommended)				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	9.1	V	Theoretical Physics 2	3521101	Compulsory	3 hours per week 45 hours	75 hours	36	4
	9.2	Ü	Theoretical Physics 2	3521102	Compulsory	1 SWS 15 hours	45 hours	36	2

2 **Learning outcomes / Competences**

3521101 - Theoretical Physics 2 (V)

Students

- have a command of the fundamental concepts, methods and ways of thinking in theoretical physics in the areas of quantum theory, statistical physics and thermodynamics;
- understand the interplay between theoretical physics and experimental physics in the fields of quantum theory, statistical physics and thermodynamics, in particular the contribution of theoretical physics to concept formation and conceptual history, the most important working strategies and ways of thinking in theoretical physics in the fields of quantum theory, statistical physics and thermodynamics, as well as the cultural interrelationships and the contribution of theoretical physics to culture and civilisation in the fields of quantum theory, statistical physics and thermodynamics
- are able to illustrate the specific role of theory in the development of physics, its intellectual arsenal of working strategies and ways of thinking, and its cultural interrelationships using relevant (school-relevant) examples in the fields of quantum theory, statistical physics and thermodynamics.

3521102 - Theoretical Physics 2 (seminar)

Students

- can apply the fundamental concepts and methods of theoretical physics to solve physical problems in the fields of quantum theory, statistical physics and thermodynamics.

3 **Contents**

Together with Module 03PH1109, Module 03PH2110 aims to teach students how theoretical physicists think. Training in theoretical physics has two objectives: on the one hand, mastery of the fundamental concepts, methods and ways of thinking; on the other hand, understanding of the specific role of theory in the structure of physics, its intellectual arsenal of working strategies and ways of thinking, and its cultural interconnections. The second objective in particular is fundamental to teacher training. In addition to covering familiar individual topics within the structure of theoretical physics (main topics: mechanics, thermodynamics, electrodynamics, quantum mechanics), it requires a broader perspective in order to understand the essence of physics.

3521101 - Theoretical Physics 2 (V)

Quantum Theory:

- Postulates and mathematical formalism of quantum theory
- Schrödinger equation
- Eigenvalues and eigenstates
- Temporal development
- Location and momentum representation
- Schrödinger picture
- Heisenberg picture
- One-dimensional problems
- Unitary transformations and symmetries
- Angular momentum
- Spin
- Addition of angular momenta
- Spin-orbit coupling
- Hydrogen atom
- Harmonic oscillator
- Path integral formulation
- Identical particles
- Interpretation and information in quantum physics
- Quantum mechanics of charged particles
- Connection to classical physics
- Perturbation theory
- Scattering amplitude and cross section

Statistical physics and thermodynamics:

- Degeneracy function and entropy
- Connection to thermodynamic variables
- Boltzmann and Maxwell distributions
- Bose-Einstein and Fermi-Dirac distributions
- Non-equilibrium thermodynamics and dissipative structures Cross-cutting topics:

- Approximation methods in theoretical physics
- Variational calculus

3521102 - Theoretical Physics 2 (seminar)

Quantum theory:

- Postulates and mathematical formalism of quantum theory
- Schrödinger equation
- Intrinsic values and states
- Temporal development
- Position and momentum representation
- Schrödinger picture
- Heisenberg picture
- One-dimensional problems
- Unitary transformations and symmetries
- Angular momentum
- Spin
- Addition of angular momenta
- Spin-orbit coupling

- Hydrogen atom

- Harmonic oscillator

	• Path integral formulation • Identical particles • Interpretation and information in quantum physics • Quantum mechanics of charged particles • Connection to classical physics • Perturbation theory • Scattering amplitude and cross section Statistical physics and thermodynamics: • Degeneracy function and entropy • Connection to thermodynamic variables • Boltzmann and Maxwell distributions • Bose-Einstein and Fermi-Dirac distributions • Non-equilibrium thermodynamics and dissipative structures Cross-cutting topics: • Approximation methods in theoretical physics • Variational calculus
4	**Frequency of offering** Only in the winter semester **3521101 - Theoretical Physics 2 (V)** only in the winter semester **3521102 - Theoretical Physics 2 (Ü)** only in the winter semester
5	**Language of instruction** **3521101 - Theoretical Physics 2 (V)** German **3521102 - Theoretical Physics 2 (Ü)** German
6	**Individual course requirements** Competences from modules 03PH1101 (3511011 - 3511014), 03PH1102 (3511021 - 3511024), 03PH1106 (3511061 - 3511063) and 03PH1109 (3511091 and 3511092)
7	**Examination formats** Module exam Physics M10 - Koblenz as an exam (written - 90 minutes)
8	**Requirements for the award of credit points** Passing the module exam
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Dr Christian Fischer
11	**Responsible institution**

	FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3521101 - Theoretical Physics 2 (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3521102 - Theoretical Physics 2 (Ü)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Ed. GY Physics (20103) B.Sc. Applied Natural Sciences (20117) 2-subject B. Basic Knowledge of Physics (20124) 2-subject B. Experimental and Theoretical Physics (20124) B.Sc. Mathematical Modelling (20142) M.Sc. Mathematical Modelling of Complex Systems (20142) B.Sc. Applied Natural Sciences (20181) M.Eng. Applied Physics (91) M.Sc. Mathematical Modelling of Complex Systems (20184) B.Sc. Mathematical Modelling (20184)
14	**Other information**

module 10 **Current Issues in Physics** 6 credit points
03PH2402 Compulsory elective
module

Elective options:

a) Two optional compulsory subjects worth 6 CP must be selected, depending on availability.

Workload 180 hours	**semester** 2nd term (recommended)	**Duration** 2 terms

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	10.1	V	Optional compulsory subject of physics with topics changing each semester	3521163	Elective	2 hours per week 30 hours	60 hours	30	3
	10.2	V	Elective lectures with topics changing each term	3521165	Elective	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3521163 - Optional compulsory subject in physics with topics changing each semester (V)

Students

- gain insight into a field of current physics research **3521165 - Elective lectures with**

term-changing topics (V) The students

- have in-depth knowledge of physics

3 **Contents**

3521163 - Optional compulsory subject in physics with topics changing each semester (V)
- Insight into a field of current physics research

3521165 - Elective lectures with term-changing topics (V)
- In-depth specialist knowledge of physics
- Specialised English terminology of physics

4 **Frequency of offering**

Every term

3521163 - Optional compulsory subject in physics with topics changing each semester (V)
Every term

3521165 - Elective lectures with topics changing each term (V)
Every term

5 **Language of instruction**

3521163 - Optional compulsory subject in physics with topics changing each semester (V)
German

3521165 - Elective lectures with topics changing each term (V)

	English
6	**Individual course requirements** None
7	**Examination formats** Module exam Current issues in physics as an exam or oral exam (written or oral – 90/30 minutes)
8	**Requirements for the award of credit points** Passing the module exam
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Dr Christian Fischer
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3521163 - Optional compulsory subject in physics with topics changing each semester (V)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3521165 - Elective lectures with topics changing each term (V)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Chemistry and Physics of Functional Materials (20145) M.Sc. Mathematical Modelling of Complex Systems (20142) B.Sc. Applied Natural Sciences (20181) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Chemistry and Physics of Functional Materials (20183)
14	**Other information** **3521163 - Optional compulsory subject in physics with topics changing each semester (V)** This includes, for example, the following courses, depending on availability: 3524021 - Current issues in materials analysis 3524022 - Processes at material boundaries 3524023 - Physical basis of medical technology in diagnostics and therapy 3524026 - Concepts and methods of mathematical physics

module 11 **03PH2501** module	**Solid State Physics**							6 credit points Compulsory elective
Workload 180 hours			**semester** 2nd term (recommended)			**Duration** 1 term		

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	11.1	V	Solid State Physics	3525011	Compulsory	3 hours per week 45 hours	75 hours	40	4
	11.2	Ü	Solid State Physics	3525012	Compulsory	1 SWS 15 hours	45 hours	40	2

2 **Learning outcomes / Competences**

3525011 - Solid State Physics (V)

The students

- know basic ideas, fundamental experiments and methods of solid state physics
- understand macroscopic material properties on the basis of microscopic interactions
- are able to describe different kinds of matter mathematically and can predict material properties, both electronic and thermal, in solids.
- become familiar with the language of condensed matter and key theories and concepts.

3525012 - Solid State Physics (Ü)

The students

- broaden their analytical and problem-solving skills.
- are able to acquire, adapt and apply current research results.

3 **Contents**

3525011 - Solid State Physics (V)

- crystal structure
- binding mechanisms
- mechanical, thermal and electronic properties
- semi-conductors

3525012 - Solid State Physics (Ü)

- crystal structure
- binding mechanisms
- mechanical, thermal and electronic properties
- semi-conductors

4 **Frequency of offering**

Only in the summer semester

3525011 - Solid State Physics (V)

Only in the summer semester

3525012 - Solid State Physics (Ü)

Only in the summer semester

5 **Language of instruction**

	3525011 - Solid State Physics (V) English **3525012 - Solid State Physics (Ü)** English
6	**Individual course requirements** None
7	**Examination** Module exam in Solid State Physics as an exam (written - 90 minutes)
8	**Requirements for awarding credit points** Passing the module exam
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Dr Christian Fischer
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3525011 - Solid State Physics (V)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3525012 - Solid State Physics (Ü)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Chemistry and Physics of Functional Materials (20145) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Eng. Applied Physics (91) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Chemistry and Physics of Functional Materials (20183)
14	**Other information**

module 12 **03PH2503**	**Surface Science**						6 credit points Elective module	
Workload 180 hours			**semester** 1st term (recommended)				**Duration** 1 term	
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	12.1	V	Vacuum Technology	3525031	Compulsory	2 hours per week 30 hours	60 hours	30	3
	12.2	V	Fundamentals of Surface Science	3525032	Compulsory	2 SWS 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3525031 - Vacuum Technology (V)

The students

- know the physical basis of vacuum technology,
- can explain the basic concepts and ideas of vacuum,
- develop an understanding of the countervailing effects relevant in the realisation of vacuum and are able to evaluate technical problems on the basis of the resulting limitations,
- can transfer their knowledge to technical solutions and develop their own experimental schemes.

3525032 - Fundamentals of Surface Science (V)

The students

- know the basics of reaction kinetics and other phenomena on surfaces
- can explain the particular characteristics of surfaces and discuss related problems
- are able to describe and analyse common detection techniques and evaluate their limitations
- can evaluate existing experimental setups
- are able to transfer their knowledge to experiments for specific tasks and develop their own experimental schemes.

3 **Contents**

3525031 - Vacuum Technology (V)

- equations of state
- motion in diluted gases
- transport
- flow
- conductance and pumping speed
- calculating conductance
- design of vacuum systems
- pumps
- measuring pressure
- materials for HV and UHV
- flange systems and components

3525032 - Fundamentals of Surface Science (V)

- surface structure
- diffraction on surfaces
- microscopy on surfaces
- scattering methods

	• chemical surface analysis • electronic states on surfaces • vibrations on surfaces • gas adsorption on surfaces • surface reactions
4	**Frequency of offering** Only in the winter semester **3525031 - Vacuum Technology (V)** only in the winter semester **3525032 - Fundamentals of Surface Science (V)** Only in the winter semester
5	**Language of instruction** **3525031 - Vacuum Technology (V)** English **3525032 - Fundamentals of Surface Science (V)** English
6	**Individual course requirements** None
7	**Examination formats** Module exam in Surface Science as an exam (written - 90 minutes)
8	**Requirements for the awarding of credit points** Passing the module exam
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Dr Christian Fischer
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3525031 - Vacuum Technology (V)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3525032 - Fundamentals of Surface Science (V)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Chemistry and Physics of Functional Materials (20145) M.Sc. Mathematical Modelling of Complex Systems (20142)

	M.Eng. Applied Physics (91) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Chemistry and Physics of Functional Materials (20183)
14	**Other information**

module 13 **03PH2504** module	**Applied Theoretical Physics**							6 credit points Compulsory elective
Workload 180 hours			**semester** 1st term (recommended)			**Duration** 2 terms		

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	13.1	V	Applied Theoretical Physics 1	3525041	Compulsory	2 hours per week 30 hours	60 hours	30	3
	13.2	V	Applied Theoretical Physics 2	3525042	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3525041 - Applied Theoretical Physics 1 (V)

The students:

- can name various fields where modern concepts of theoretical physics are important for describing real-world problems in nature and technology
- know the fundamental definitions, theorems and methods related to the application of theoretical physics
- can analyse the relationship between parameters in given systems
- can apply mathematical methods to solve problems in these fields
- can evaluate suggested solutions and develop own solving schemes

3525042 - Applied Theoretical Physics 2 (V)

The students:

- can name various fields where modern concepts of theoretical physics are important for describing real-world problems in nature and technology
- know the fundamental definitions, theorems and methods related to the application of theoretical physics
- can analyse the relationship between parameters in given systems
- can apply mathematical methods to solve problems in these fields
- can evaluate suggested solutions and develop own solving schemes

3 **Contents**

3525041 - Applied Theoretical Physics 1 (V)

- modern concepts in theoretical physics
- Reaction-diffusion systems
- nonlinear physics
- non-equilibrium thermodynamics
- applications of theoretical physics in nature and technology

3525042 - Applied Theoretical Physics 2 (V)

- modern concepts in theoretical physics
- reaction-diffusion systems
- nonlinear physics
- non-equilibrium thermodynamics
- applications of theoretical physics in nature and technology

4 **Frequency of offering**

	From winter semester **3525041 - Applied Theoretical Physics 1 (V)** only in the winter semester **3525042 - Applied Theoretical Physics 2 (V)** Summer semester only
5	**Language of instruction** **3525041 - Applied Theoretical Physics 1 (V)** English **3525042 - Applied Theoretical Physics 2 (V)** English
6	**Individual course requirements** None
7	**Examination formats** Applied Theoretical Physics module exam as an exam (written - 90 minutes)
8	**Requirements for awarding credit points** Passing the module exam
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Dr Christian Fischer
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3525041 - Applied Theoretical Physics 1 (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **3525042 - Applied Theoretical Physics 2 (V)** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Chemistry and Physics of Functional Materials (20145) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Eng. Applied Physics (91) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Chemistry and Physics of Functional Materials (20183)
14	**Other information**

module 14 03PH2505	Polymer Science	6 credit points Elective module
Workload 180 hours	**semester** 2nd term (recommended)	**Duration** 1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	14.1	V	Polymer Physics	3525051	Compulsory	2 hours per week 30 hours	60 hours	30	3
	14.2	V	Characterisation methods in polymer science	3525052	Compulsory	2 SWS 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

3525051 - Polymer Physics (V)

The students

- can independently explain basic models describing the properties of different types of polymers and in different states
- are able to understand how the peculiarities of the polymer structure, such as connectivity, affect their physical properties and how relevant these are for applications
- develop their own problem-solving strategies based on the basic concepts covered
- are able to transfer the discussed basic concepts to actual, scientific topics in polymer science.

3525052 - Characterisation methods in polymer science (V)

The students

- can independently explain the characterisation method covered in this course
- can identify the correct characterisation methods for the most important physical properties of polymer materials (Course 1)
- are aware of the technical realisation and application potential of the different methods,
- can provide an overview of representative results for typical polymer systems
- develop strategies for data analysis, presentation and interpretation
- are able to transfer the discussed basic concepts to actual, scientific topics in polymer science

3 **Contents**

3525051 - Polymer Physics (V)

- Synthesis & molecular weight distributions
- Chain models
- Polymer solutions, polymer blends, block copolymers
- Semi-crystalline state
- Polymer dynamics & viscoelasticity
- Networks
- Glassy state

3525052 - Characterisation methods in polymer science (V)

- Determination of molecular weights
- Thermal characterisation
- Mechanical testing
- Dielectric spectroscopy & electrical characterisation
- Scattering methods
- Microscopy

4	**Frequency of offering** Only in the summer semester **3525051 - Polymer Physics (V)** Only in the summer semester **3525052 - Characterisation Methods in Polymer Science (V)** Only in the summer semester
5	**Language of instruction** **3525051 - Polymer Physics (V)** English **3525052 - Characterisation Methods in Polymer Science (V)** English
6	**Individual course requirements** None
7	**Examination** Module exam in Polymer Science as an exam (written - 90 minutes)
8	**Requirements for awarding credit points** Passing the module exam
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Silke Rathgeber
11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3525051 - Polymer Physics (V)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **3525052 - Characterisation Methods in Polymer Science (V)** FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Chemistry and Physics of Functional Materials (20145) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Eng. Applied Physics (91) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Chemistry and Physics of Functional Materials (20183)
14	**Other information**

Computer-based methods

All modules from the compulsory areas of the Master's programmes "Web & Data Science" and "Computer Visualistics" can be selected. In addition, modules from the compulsory elective area of the Master's programme "Computer Visualistics" can be selected from the subcategories: "Elective Computer Visualistics", "Elective Computer Sciences", "Elective Computer Visualistics or Computer Sciences", "Elective Theoretical Computer Science and Mathematics", but without the mathematics component (modules with the code 03MA….) and without the research projects (04CV2101 and 04IN2101) of faculty 4. The study of the modules is governed by the provisions of the Joint Examination Regulations for Bachelor's and Master's degree programmes in the faculty of Computer Sciences at the University of Koblenz-Landau dated XX October 2019 (Newsletter XX/2019 of the University of Koblenz-Landau, p. XX) in the currently valid version.

module 15 **04CV1005** module	**Introduction to Computational Linguistics**								6 credit points Compulsory elective
Workload 180 hours				**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	15.1	V	Introduction to computational linguistics	04CV100501	Compulsory	2 hours per week 30 hours	60 hours	30	3
	15.2	Ü	Introduction to computational linguistics	04CV100502	Compulsory	2 hours per week 30 hours	60 hours	30	3
2	**Learning outcomes / competences** Students should be able to independently recognise the potential and limitations of natural language components. If the application domain of available products needs to be adapted, the concepts from the two lectures will enable them to do so adequately.								
3	**Contents** Introduction to Computational Linguistics (ECL) I presents knowledge-based approaches in language processing: - pattern matching, • morphological analysis and generation, • syntactic analysis, • word semantics, • sentence semantics, • pragmatic concepts, and • natural language generation. ECL II introduces statistical methods: - definition of basic terms, - the problem of part-of-speech tagging using hidden Markov models, - Probabilistic context-free grammars for parsing and chunking, - Shannon's information theory for defining perplexity, cross entropy, and noisy channel, - spell checking using noisy channel modelling,								

	- Sentiment analysis using Naive Bayes and maximum entropy, - Clustering in general and in sentiment analysis, - Other methods in text categorisation, as well as - deep learning in general and in sentiment analysis and parsing.
4	**Frequency of offering** **04CV100501 - Introduction to Computational Linguistics (V)** only in the summer semester **04CV100502 - Introduction to Computational Linguistics (tutorial)** Summer semester only
5	**Language of instruction** **04CV100501 - Introduction to Computational Linguistics (V)** German **04CV100502 - Introduction to Computational Linguistics (Ü)** German
6	**Individual course requirements**
7	**Examination** Introduction to Computational Linguistics as not specified (written - 90)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Ms Karin Harbusch
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV100501 - Introduction to Computational Linguistics (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV100502 - Introduction to Computational Linguistics (seminar)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** J. Allen. 1995. Natural Language Understanding. Second Edition, The Benjamin/Cummings Publishing Company, Menlo Park, CA, USA. D. Jurafsk & J.H. Martin (2000). Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition Prentice Hall, Upper Saddle River, NJ, USA. Further specialised literature will be provided chapter by chapter during the lecture.

	C. Manning and H. Schütze, Foundations of Statistical Natural Language Processing, MIT Press. Cambridge, MA: May 1999 and various new editions (see http://nlp.stanford.edu/fsnlp/) P. Jackson and I. Moulinier. 2002. Natural Language Processing for Online Applications: Text Retrieval, Extraction and Categorisation John Benjamins, Amsterdam, NL/Philadelphia, PA, USA. (now also available in a new edition). S. Jekat, R. Klabunde, H. Langer. Computer Linguistics and Language Technology: An Introduction, 2nd revised edition, Elsevier, Munich, 2004.
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** ECL I and II can be taken independently of each other and in any order, as the necessary nomenclature is introduced in each course. There is very little redundancy between the courses. **Literature on ECLI** J. Allen (1997). Natural Language Understanding. 2nd Edition, Benjamin Cummings, Menlo Park, CA/ USA. S. Bird, E. Klein, and E. Loper (2009). Natural Language Processing with Python. O'Reilly, Gravenstein, CA/USA. K.-U. Carstensen, C. Ebert, C. Ebert, S. Jekat, R. Klabunde, and H. Langer (Eds.) (2009). Computational Linguistics and Language Technology – An Introduction, Second Edition, Spektrum Akademischer Verlag, P. Eisenberg (2013). Grundriss der deutschen Grammatik: Band 1: Das Wort. 4th edition, Springer, Berlin/etc. **Literature on ECLII** C.D. Manning and H. Schütze (2003). Foundations of Statistical Natural Language Processing. 6th edition. MIT Press, Cambridge, MA/USA. (First edition: http://ics.upjs.sk/~pero/web/documents/pillar/Manning_Schuetze_StatisticalNLP.pdf I. Goodfellow, Y. Bengio, and A. Courville (2016). Deep Learning. MIT Press, Cambridge, MA/USA (see http://www.deeplearningbook.org). D. Jurafsky, and J.H. Martin (2009). Speech and Language Processing: An introduction to natural language processing, computational linguistics, and speech recognition. , Second Edition, Prentice Hall, Eaglewood Cliffs, NJ/USA (Draft of third edition (2018): https://web.stanford.edu/~jurafsky/slp3/used in the lecture).

module 16 04CV2001	Fundamentals of Autonomous Mobile Systems	6 credit points Elective module
Workload 180 hours	**semester** 3rd term (recommended)	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	16.1	V	Fundamentals of Autonomous Mobile Systems	04CV200101	Compulsory	2 hours per week 30 hours	60 hours	30	3
	16.2	Ü	Fundamentals of Autonomous Mobile Systems	04CV200102	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students understand the impact of incorrect control systems on uncontrolled behaviour. They can program and use real robots. They can trace the effect of robot use back to its theoretical foundations. They can use their basic theoretical knowledge to improve incorrectly controlled robots. They can develop active vision by combining image analysis and robotics. They can assess the usefulness of special programming languages (e.g. Matlab (Octave)).

3 **Contents**

04CV200101 - Fundamentals of Autonomous Mobile Systems (V)

Fundamentals of visual navigation are taught. Mono and stereo camera systems with grey-scale, colour or infrared sensors are used as input data. Central problems of sensor data processing (filtering and fusion) are presented. The course teaches current techniques used in autonomous systems. Practical tutorials on several robot types with different sensors give an impression of the real problems.

1. Fundamentals
   - Basic concepts, terminology, statistics
   - Areas of application
2. Sensors and their properties, pre-processing
   - Colour, infrared
   - Radar, laser range finder
   - Stereo systems and distance measurement
   - Compass, (differential) GPS
   - Odometry and vehicle sensors (inertial sensors)
3. Sensor data analysis
   - Localisation
   - Object recognition
   - Motion estimation
4. Sensor data fusion
   - Kalman filter and condensation algorithm
   - Bayes filter
   - Democratic integration
   - Map creation and map representation
   - SLAM (Simultaneous Localisation and Mapping)
5. Application examples
   - Motor vehicles, service robotics
   - Exploration, disaster relief

04CV200102 - Fundamentals of Autonomous Mobile Systems (Ü)

	The fundamentals of visual navigation are taught. Mono and stereo camera systems with grey-scale, colour or infrared sensors serve as input data. Central problems of sensor data processing (filtering and fusion) are presented. The course teaches current stereo camera systems with grey-scale, colour or infrared sensors are used as input data. Key problems in sensor data processing (filtering and fusion) are presented. The course teaches current techniques used in autonomous systems. Practical tutorials on several types of robots with different sensors give an impression of the real-world problems. 1. Fundamentals • Basic concepts, terminology, statistics • Areas of application 2. Sensors and their properties, pre-processing • Colour, infrared • Radar, laser range finder • Stereo systems and distance measurement • Compass, (differential) GPS • Odometry and vehicle sensor technology (inertial sensors) 3. Sensor data analysis • Localisation • Object recognition • Motion estimation 4. Sensor data fusion • Kalman filter and condensation algorithm • Bayes filter • Democratic integration • Map creation and map representation • SLAM (Simultaneous Localisation and Mapping) 5. Application examples • Motor vehicles, service robotics • Exploration, disaster relief
4	**Frequency of offering** **04CV200101 - Fundamentals of Autonomous Mobile Systems (V)** Irregular **04CV200102 - Fundamentals of Autonomous Mobile Systems (Ü)** Irregular
5	**Language of instruction** **04CV200101 - Fundamentals of Autonomous Mobile Systems (V)** German **04CV200102 - Fundamentals of Autonomous Mobile Systems (Ü)** German
6	**Individual course requirements**
7	**Examination** Fundamentals of Autonomous Mobile Systems: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator**

	Mr Dietrich Paulus
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV200101 - Fundamentals of Autonomous Mobile Systems (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV200102 - Fundamentals of Autonomous Mobile Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** **04CV200101 - Fundamentals of Autonomous Mobile Systems (V)** S. Thrun et al., Probabilistic Robotics
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information** Examination participation requires regular and qualified attendance (maximum of 2 absences)

module 17 **04CV2002**	**Medical Image Processing 1**						6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term	
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	17.1	V	Medical Image Processing 1	04CV200201	Compulsory	2 hours per week 30 hours	60 hours	30	3
	17.2	Ü	Medical image processing 1	04CV200202	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / competences**

The course teaches the fundamentals of medical image processing in theory and practice. The theory of image formation, image enhancement and image analysis is covered, as are the medical contexts. Practical implementation in tutorials using suitable programming languages deepens understanding of the processes.

3 **Contents**

1. Medical imaging
    1. X-ray
    2. CT
    3. MRI
    4. PET
    5. DICOM
2. Fourier transformation
    1. Taylor series
    2. Fourier transformation
    3. Discrete Fourier Transformation
3. Reconstruction
    1. Filtered Backprojection
    2. Fourier slice theorem
    3. Convolution
    4. Backprojection
    5. Algebraic Reconstruction
        1. ART – Weights
        2. Kaczmarz
        3. Cimmino
    4. Preprocessing 1
    1. Point-Oriented Operations
        1. Thresholding
        2. Windowing
    2. Local Filters
        1. Average filter
        2. Median filter (…, minimum, maximum)
        3. Binomial filter (Gaussian)
        4. Sigma filter
        5. Sharpen
        6. Edge detection filter
    3. Global Filters
        1. Histogram Equalisation
    4. Convolution Theorem

5. Parametric mapping
6. Preprocessing 2
    1. Preliminaries
        1. Derivative
        2. Gradient
        3. Divergence
        4. Laplace
    2. Diffusion filter
        1. Heat Equation
        2. Perona-Malik Diffusion
        3. Anisotropic Diffusion
    3. Computation
    4. Additive Operator Splitting
    5. Thomas Algorithm
    6. Edge Detection
    7. Preprocessing 3
        1. Bilateral Filter
        2. Sigmoid filter
    3. L0 Gradient Minimisation
    4. Frangi filter
    5. Wiener filter
    6. Hole Filling
        1. Band Limit
        2. Laplace Equation
8. Image Segmentation
    1. Manual Segmentation
    2. Point-Oriented Procedures
        1. Otsu
    3. Edge-Oriented Procedures
        1. LiveWire (Dijkstra)
    4. Region-Oriented Procedures
        1. region Growing, Watershed Transform
    5. Model-Oriented Procedures
        1. Snakes
    6. Representation
9. Image Segmentation 2
    1. Cluster Analysis
    2. Graph Cut
    3. Level sets
    4. Active Shape Model
    5. Evaluation of Segmentation Results
10. Registration
    1. Transformations & Iterative Closest Point
    2. Quaternions
    3. Voxel-based Registration
    4. Non-linear Voxel-based Registration
    5. Demon-based registration
11. Quantitative Image Analysis
    1. Basic image analysis
        1. Distances, angles, areas, volumes
    2. Texture analysis
        1. Haralick
        2. Laws
        3. Power Spectrum
    3. Fractal image analysis
        1. Fractal Dimension
        2. Hausdorff Dimension

3. Box Counting Dimension

12. Classification
    1. Naïve Bayes Classifier
    2. Maximum Likelihood Estimation
    3. Expectation Maximisation
    4. Multivariate Normal Distribution
    5. Euclidean Classifier & k-Nearest Neighbours Algorithm
    6. Evaluating Classification

04CV200201 - Medical Image Processing 1 (V)

1. Fundamentals
    - Image Modalities
    - History
    - Device Types
    - DICOM and PACS
    - Basic medical terms
2. Pre-processing organised by modality
    - X-ray images
    - Camera calibration
    - Endoscopic images
    - Magnetic resonance images
    - SPECT and PET
3. Reconstruction
    - Fourier slice theorem and filtered back projection
    - Algebraic reconstruction
    - Probabilistic reconstruction methods
4. Fusion and registration
    - Maximum transformation
    - Feature-based registration
    - Interpolation methods
5. Case studies in medicine
    - Radiology
    - Internal medicine

04CV200202 - Medical Image Processing 1 (Ü)

1. Fundamentals
    - Image modalities
    - History
    - Device Types
    - DICOM and PACS
    - Basic medical terms
2. Pre-processing organised by modality
    - X-ray images
    - Camera calibration
    - Endoscopic images
    - Magnetic resonance images
    - SPECT and PET
3. Reconstruction
    - Fourier slice theorem and filtered back projection
    - Algebraic reconstruction
    - Probabilistic reconstruction methods
4. Fusion and registration
    - Maximum transformation
    - Feature-based registration
    - Interpolation methods

	5. Case studies in medicine • Radiology • Internal medicine
4	**Frequency of offering** **04CV200201 - Medical Image Processing 1 (V)** Every 3rd term **04CV200202 - Medical Image Processing 1 (tutorial)** Every 3rd term
5	**Language** **04CV200201 - Medical Image Processing 1 (L)** German **04CV200202 - Medical Image Processing 1 (Ü)** German
6	**Individual course requirements**
7	**Examination** Medical Image Processing 1 as not specified (n.a. n.a.)
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Kai Lawonn
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV200201 - Medical Image Processing 1 (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV200202 - Medical Image Processing 1 (Ü)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** **04CV200201 - Medical Image Processing 1 (V)** • H. H. Ehricke, Medical Imaging: Digital Image Analysis and Communication in Medicine, Vieweg., Wiesbaden 1997 • T. M. Lehman E. Meyer zu Bexten, Handbook of Medical Computer Sciences, Carl Hanser Verlag, Munich 2002 • J. Hornegger, D. Paulus, Medical Computer Vision, Springer, 2006
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 18 **04CV2005**	**Pattern Recognition**						6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term	
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	18.1	V	Pattern Recognition	04CV200501	Compulsory	2 hours per week 30 hours	60 hours	30	3
	18.2	Ü	Pattern Recognition	04CV200502	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Upon successful completion of the course, students will be able to fully design a pattern recognition system for a specific problem, so that its components are optimised even before development (based on theoretical expertise).

3 **Contents**

04CV200501 - Pattern Recognition (V)

The course teaches current algorithms and methods for automatic, computer-based pattern recognition. Pattern recognition is the ability to recognise regularities, repetitions, similarities or patterns in a set of data. Typical examples of the countless areas of application are speech recognition, text recognition, face recognition, or automatic waste separation based on spectrometric images. The course deliberately abstracts from the type of signal to be interpreted in order to teach general methods that can be used for images as well as audio, speech, or other types of signals. The content is divided into two categories. While the first part of the course covers supervised algorithms, the second part deals with unsupervised methods. In the supervised strategy, learning takes place on the basis of known and manually categorised training examples. The unsupervised methods recognise the regularities in the data without this prior knowledge. The following topics related to the supervised strategy are covered in the course: Bayes classifiers, linear classifiers, nonlinear classifiers, feature selection, feature generation, template matching, context-dependent classification. Selected clustering algorithms are shown for unsupervised methods: sequential algorithms, hierarchical algorithms, schemes based on function optimisation. After a historical overview of neural networks, current approaches (deep networks, convolutional networks, autoencoders, etc.) are presented and their use for feature detection and classification is discussed.

4 **Frequency of offering**

04CV200501 - Pattern Recognition (V)

only in the summer semester

04CV200502 - Pattern Recognition (Ü)

Summer semester only

5 **Language of instruction**

04CV200501 - Pattern Recognition (V)

English

	04CV200502 - Pattern Recognition (Ü) English
6	**Individual course requirements**
7	**Examination** Pattern Recognition as not specified (N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Dietrich Paulus
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV200501 - Pattern Recognition (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV200502 - Pattern Recognition (Ü)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** **04CV200501 - Pattern Recognition (V)** • H. Niemann: Classification of Patterns. Springer, 1983 • K. Fukunaga: Statistical Pattern Recognition. Academic Press, 1991 • M. Pavel: Fundamentals of Pattern Recognition. Dekker, 1993 • J. Schuermann: Pattern Classification – A Unified View of Statistical and Neural Approaches. Wiley, 1996 • R. O. Duda, P. E. Hart, D. G. Stork: Pattern Classification. Wiley, 2001 • A. R. Webb: Statistical Pattern Recognition, Second Edition, John Wiley and Sons Ltd., 2002 • C. M. Bishop: Pattern Recognition and Machine Learning. Springer, 2006 • M. Grzegorzek: Appearance-Based Statistical Object Recognition Including Colour and Context Modelling, Logos, 2007 • S. Theodoridis and K. Koutroumbas: Pattern Recognition, Fourth Edition, Academic Press, 2008
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualisation (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** **04CV200501 - Pattern Recognition (V)** PDF slides, blackboard, live demonstrations

module 19 04CV2014	Animation and simulation	6 credit points Elective module

Workload 180 hours	semester	Duration 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	19	V	Animation and simulation	04CV201401	Compulsory	2 hours per week 30 hours	60 hours	30	3
	19.2	P	Animation and simulation	04CV2014-2	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

The lecture teaches the basic algorithms and methods used in simulation and animation. The core topics are methods for interpolating positions and orientations in connection with path-time diagrams (animations) and the physical laws of kinetics and kinematics with the corresponding simulation methods. The focus is primarily on real-time methods for use in virtual worlds or computer games. The topics are explored in greater depth in an internship, and students implement their own application.

3 **Contents**

1. Introduction
   - Concept formation and examples
   - Objective: Motion control over time
   - Interpolation with Bézier and Hermite curves
2. Kinematics
   - Fundamentals
   - Distance-time control
   - Arc length table
3. Distance-time behaviour
   - Distance-time curves
     - Ease-in/ease-out
   - Viewing direction
4. Orientation
   - Degrees of freedom
   - Rotation matrices
   - Euler/cardan angles and gimbal lock
   - Angle-axis
5. Quaternions
   - Quaternions as a class
   - Advantages and disadvantages of quaternions
   - Algebra, addition and multiplication
   - Application to vectors
   - Interpolation (lerp and slerp)
6. Dynamics of mass points
   - Rotational dynamics, derivation of matrices, angular velocity with
7. quaternions
   - Newton's axioms, forces
   - ordinary differential equation (ODE)
   - Numerical integration: Euler and Runge-Kutta
8. Dynamics of rigid bodies

	• Collision handling, elastic/inelastic collision • Angular momentum and moments of inertia • Physics engine
4	**Frequency of the offer** **04CV201401 - Animation and Simulation (V)** Irregular **04CV2014-2 - Animation and Simulation (P)** Check input
5	**Language of instruction** **04CV201401 - Animation and Simulation (V)** German **04CV2014-2 - Animation and Simulation (P)** German
6	**Individual course requirements**
7	**Examination** Animation and simulation: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Stefan Müller
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201401 - Animation and Simulation (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV2014-2 - Animation and Simulation (P)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** Parent, Rick: Computer Animation - Algorithms and Techniques, Morgan Kaufman, 2002 Eberly, David. H.: Game Physics, Morgan Kaufman, 2004 Bourg, David M.: Physics for Game Developers, O'Reilly, 2001 van den Bergen, Gino.: Collision Detection in Interactive 3D Environments, Morgan Kaufman, 2004
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)

	M.Sc. Computer Visualistics (2019)
14	**Other information**

module 20 **04CV2016** module	**Photorealistic computer graphics**	6 credit points Compulsory

Workload	**semester**	**Duration**
180 hours		1 term

1

Courses				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
20	V	Photorealistic computer graphics	04CV201601	Compulsory	2 hours per week 30 hours	60 hours	30	3
20.2	Ü	Photorealistic computer graphics	04CV201602	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students are familiar with the image creation process and understand the physical interactions between light and light-matter. They are familiar with rendering equations, finite element methods (radiosity), stochastic methods (Monte Carlo ray tracing) and methods of natural-based lighting.

3 **Contents**

04CV201601 - Photorealistic Computer Graphics (V)

1. Fundamentals
   - Fundamentals of light-matter interaction
2. Radiosity
   - Analytical form factor calculation
   - Discrete form factor calculation
   - Full matrix and progressive refinement method
   - Photometric consistency
   - Tone mapping
   - Patch subdivision method (meshing)
   - Hierarchical methods and clustering
   - Dynamic environments, non-diffuse light sources and daylight
3. Monte Carlo ray tracing
   - Sampling techniques
   - Monte Carlo ray tracing, path tracing
   - Photon mapping
4. Natural lighting with high-dynamic-range environment maps

04CV201602 - Photorealistic Computer Graphics (Ü)

1. Fundamentals
   - Fundamentals of light-matter interaction
2. Radiosity
   - Analytical form factor calculation
   - Discrete form factor calculation
   - Full matrix and progressive refinement method
   - Photometric consistency
   - Tone mapping
   - Patch subdivision method (meshing)
   - Hierarchical methods and clustering
   - Dynamic environments, non-diffuse light sources and daylight
3. Monte Carlo ray tracing
   - Sampling techniques
   - Monte Carlo ray tracing, path tracing
   - Photon mapping

	4. Natural lighting with high dynamic range environment maps
4	**Frequency of the course** **04CV201601 - Photorealistic Computer Graphics (V)** Irregular **04CV201602 - Photorealistic Computer Graphics (Ü)** irregular
5	**Language of instruction** **04CV201601 - Photorealistic Computer Graphics (V)** German **04CV201602 - Photorealistic Computer Graphics (Ü)** German
6	**Individual course requirements** Content from "Matt Pharr, Greg Humphreys: Physically Based Rendering, Morgan Kaufmann 2004" and "Philp Dutre, Phillippe Bekaert, Kavita Bala: Advanced Global Illumination, B&T 2003" is suitable as a prerequisite.
7	**Examination** Photorealistic computer graphics: see https://ist.uni-koblenz.de/MoMa/
8	**Prerequisites for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Stefan Müller
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201601 - Photorealistic Computer Graphics (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201602 - Photorealistic Computer Graphics (Ü)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** **04CV201601 - Photorealistic Computer Graphics (V)** • Peter Shirley: Realistic Ray Tracing, 2nd edition, AK Peters 2003. • Henrik Wann Jensen: Realistic Image Synthesis Using Photon Mapping, AK Peters 2001. • Matt Pharr, Greg Humphreys: Physically Based Rendering, Morgan Kaufmann 2004. • Philp Dutre, Phillippe Bekaert, Kavita Bala: Advanced Global Illumination, B&T 2003 **04CV201602 - Photorealistic Computer Graphics (Ü)** • Peter Shirley: Realistic Ray Tracing, 2nd edition, AK Peters 2003. • Henrik Wann Jensen: Realistic Image Synthesis Using Photon Mapping, AK Peters 2001. • Matt Pharr, Greg Humphreys: Physically Based Rendering, Morgan Kaufmann 2004.

	• Philp Dutre, Phillippe Bekaert, Kavita Bala: Advanced Global Illumination, B&T 2003
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualisation (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 21 **04CV2017**	**Real-time Rendering**							6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	21	V	Real-time rendering	04CV201701	Compulsory	2 hours per week 30 hours	60 hours	30	3
	21.2	P	Real-time rendering	04CV201702	Compulsory	2 SWS 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students are familiar with current algorithms and methods for generating synthetic three-dimensional images in a fraction of a second. In particular, they are familiar with methods based on the capabilities of modern programmable graphics hardware. Furthermore, they can classify both macroscopic and microscopic aspects of the creation of three-dimensional virtual worlds, as well as aesthetically motivated methods.

3 **Contents**

1. Introduction
   - Concept formation and examples
2. GPU 2
   - Fundamentals of GPU programming
3. Rendering landscapes
   - ROAM
   - Chunked LOD
   - Geometry MipMaps
   - Geometry clipmaps
4. GPGPU
   - Fundamentals (Deferred Shading)
   - Basic Algorithms (Gather, Scatter, Reduce, Sort)
   - Programming (programming languages, libraries, debugging)
5. Normal mapping
   - Fundamentals
   - Tangent space
   - Bump mapping
   - Parallax mapping
   - Relief mapping
6. Non-photorealistic rendering
   - Introduction to NPR
   - Silhouettes (object space, image space, two-pass method, stylisation)
   - Shading (toon shading, Gooch shading, hatching)
7. Guest lecture: Depth and screen space-based effects
   - Insight into game development
   - Rendering acceleration strategies
   - Deferred shading
   - Mixed shading
   - Z-buffer-based effects (screen space overlays, volume fog, atmospheric scattering, SSAO)
8. Ambient occlusion
   - Fundamentals

	• Image-based methods (Screen Space Ambient Occlusion, Horizon-Based AO, Screen-Space Directional Occlusion) • Hybrid Ambient Occlusion (Fast Scene Voxelisation) 9. Guest lecture: Soft Shadows • Fundamentals • Soft shadow mapping • PCF Soft Shadows • Shadow Volumes (Stencil Shadows, Soft Shadow Volumes)
4	**Frequency of offering** **04CV201701 - Real-time Rendering (V)** Irregular **04CV201702 - Real-time rendering (P)** Irregular
5	**Language of instruction** **04CV201701 - Real-time rendering (V)** German **04CV201702 - Real-time Rendering (P)** German
6	**Individual course requirements**
7	**Examination** Real-time rendering as not specified (N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Stefan Müller
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201701 - Real-time Rendering (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201702 - Real-time Rendering (P)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** Real-Time Rendering - Third Edition (T. Akenine Möller, E. Haines, N. Hoffman)
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualisation (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 22 04CV2019	Autonomous Mobile Robots	6 credit points Elective module

Workload	semester	Duration
180 hours	3rd term (recommended)	1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	22	V	Autonomous Mobile Robots	04CV201901	Compulsory	2 hours per week 30 hours	60 hours	30	3
	22.2	Ü	Autonomous Mobile Robots	04CV201902	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 Learning outcomes / Competences

Students define the function of an autonomous mobile system. They apply established methods from statistics to problems of localisation and navigation. They make decisions on the selection of suitable methods for configuring a vision-based autonomous system.

3 Contents

The course deepens the understanding of "probabilistic robotics". Bayesian networks, Kalman filters, Markov random fields and conditional random fields are introduced to solve the SLAM problem ("Simultaneous Localisation and Mapping"). Various sensor modalities are presented and their properties are modelled. ROS is introduced as a basic software tool.

4 Frequency

04CV201901 - Autonomous Mobile Robots (V)
Every 3rd term

04CV201902 - Autonomous Mobile Robots (Ü)
Every 3rd term

5 Language of instruction

04CV201901 - Autonomous Mobile Robots (V)
German

04CV201902 - Autonomous Mobile Robots (Ü)
German

6 Individual course requirements

Attendance at the courses 'Autonomous Mobile Systems' and Image Processing 1-3 is recommended.

7 Examination formats

Autonomous Mobile Robots as Not specified (N/A)

8 Requirements for awarding credit points

9 Significance of the final grade

6/120 of the study programme

10	**Module coordinator** Mr Dietrich Paulus
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201901 - Autonomous Mobile Robots (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201902 - Autonomous Mobile Robots (Ü)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** Probabilistic Robotics (INTELLIGENT ROBOTICS AND AUTONOMOUS AGENTS) 2005 by Sebastian Thrun, Wolfram Burgard, Dieter Fox
13	**Use in study programme** M.Sc. Computer Visualistics (2006) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 23 **04CV2025**	**Mesh Processing**						6 credit points Elective module	
Workload 180 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	23	V	Mesh processing	04CV2025	Compulsory	2 hours per week 30 hours	60 hours	30	3
	23.2	Ü	Mesh processing	04CV202502	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

The course teaches the fundamentals of geometric processing in theory and practice. The theory of differential geometry and discrete differential geometry is explored in depth in the tutorials using appropriate programming languages.

3 **Contents**

04CV2025 - Mesh Processing (V)

1. Introduction: surface representations
2. Data acquisition & surface reconstruction
3. Mesh data structures
4. Differential geometry I/II
5. Discrete differential geometry
6. Smoothing / denoising
7. Parameterisation
8. Decimation/simplification
9. Remeshing
10. Shape editing / deformation
11. Model repair

04CV202502 - Mesh Processing (Ü)

1. Introduction: surface representations
2. Data acquisition & surface reconstruction
3. Mesh data structures
4. Differential geometry I/II
5. Discrete differential geometry
6. Smoothing / denoising
7. Parameterisation
8. Decimation/simplification
9. Remeshing
10. Shape editing / deformation
11. Model repair

4 **Frequency of offer**

04CV2025 - Mesh Processing (V)

Check input

04CV202502 - Mesh Processing (Ü)

Irregular

5	**Language of instruction** **04CV2025 - Mesh Processing (V)** German **04CV202502 - Mesh Processing (Ü)** German
6	**Individual course requirements**
7	**Examination** Mesh processing not specified (N/A)
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Kai Lawonn
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV2025 - Mesh Processing (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04CV202502 - Mesh Processing (Ü)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** **04CV2025 - Mesh Processing (V)** • Mario Botsch, Mark Pauly, Christian Rössl, Stephan Bischoff, and Leif Kobbelt. Geometric modelling based on triangle meshes. In SIGGRAPH Course Notes, Boston, USA, 2006. ACM. • Mario Botsch, Mark Pauly, Leif Kobbelt, Pierre Alliez, Bruno Lévy, Stephan Bischoff, and Christian Rössl. Geometric modelling based on polygonal meshes. In SIGGRAPH Course Notes, San Diego, California, 2007. ACM. Revised course notes **04CV202502 - Mesh Processing (Ü)** • Mario Botsch, Mark Pauly, Christian Rössl, Stephan Bischoff, and Leif Kobbelt. Geometric modelling based on triangle meshes. In SIGGRAPH Course Notes, Boston, USA, 2006. ACM. • Mario Botsch, Mark Pauly, Leif Kobbelt, Pierre Alliez, Bruno Lévy, Stephan Bischoff, and Christian Rössl. Geometric modelling based on polygonal meshes. In SIGGRAPH Course Notes, San Diego, California, 2007. ACM. Revised course notes
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualisation (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 24 **04CV2103**	**Advanced Topics in Logic and Theoretical Computer Science** **Computer Sciences**						6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term	
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	24.1	V	Advanced Topics in Logic and Theoretical Computer Sciences	04CV210301	Compulsory	2 hours per week 30 hours	60 hours	30	3
	24.2	Ü	Advanced Topics in Logic and Theoretical Computer Sciences	04CV210302	Comp	2 hours per week 30 hours	60 hours	30	3
2	**Learning outcomes / Competences** Students can describe problems in the field of theoretical Computer Sciences in a formal mathematical way. They can formally prove statements about computability, satisfiability and complexity. Students can assess the practical solubility of specific problems in the field covered.								
3	**Contents** The module covers topics that go beyond the theoretical content anchored in the curriculum. These are changing topics from the areas of automata theory, formal language theory, computability and complexity theory, and logic.								
4	**Frequency** **04CV210301 - Advanced Topics in Logic and Theoretical Computer Sciences (V)** Every 3rd term **04CV210302 - Advanced Topics in Logic and Theoretical Computer Sciences (Ü)** every third term								
5	**Language of instruction** **04CV210301 - Advanced Topics in Logic and Theoretical Computer Sciences (V)** German **04CV210302 - Advanced Topics in Logic and Theoretical Computer Sciences (Ü)** German								
6	**Individual course requirements**								
7	**Examination** Advanced topics in logic and theoretical Computer Sciences: see https://ist.uni-								
8	**Requirements for the award of credit points**								
9	**Significance of the final grade** 6/120 of the study programme								

10	**Module coordinator** Mr Dietrich Paulus
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV210301 - Advanced Topics in Logic and Theoretical Computer Sciences (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV210302 - Advanced Topics in Logic and Theoretical Computer Sciences (seminar)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 25 **04CV2015**	**CV integration**							6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	25	V	CV integration	04CV201501	Compulsory	2 hours per week 30 hours	60 hours	40	3
	25.2	Ü	CV integration	04CV201502	Compulsory	2 hours per week 30 hours	60 hours	20	3

2 **Learning outcomes / Competences**

This module introduces the fundamentals and basic models of image formation from the perspective of computer graphics, image processing and computer vision, examining them holistically and comparing them with one another. The module is taught jointly by two lecturers (one from image processing and one from computer graphics).

3 **Contents**

04CV201501 - CV Integration (V)

1. Radiometric and photometric fundamentals
   - Spectra, XYZ colours and V(lambda) curve
   - Photometric radiation equivalent
   - The 5 variables and their units (I, L, Φ, ω, E)
2. Light and colour
   - Integration of photometric quantities into the RGB system
   - Photometric consistency
   - CCD properties, camera properties, high dynamic range (HDR) images
   - Tone mapping
3. Rendering equation
   - Derivation of the rendering equation
   - Differences from colorimetric models
4. Material descriptions
   - BRDF and its approximations
   - Methods for creation and measurement
   - BTF
5. Three-dimensionality
   - 3D reconstruction (computer vision)
   - 3D modelling (computer graphics)
   - Similarities and differences (using MPEG7 as an example)
   - Projection models

04CV201502 - CV integration (Ü)

1. Radiometric and photometric fundamentals
   - Spectra, XYZ colours and V(lambda) curve
   - Photometric radiation equivalent
   - The 5 variables and their units (I, L, Φ, ω, E)
2. Light and colour
   - Integration of photometric quantities into the RGB system
   - Photometric consistency
   - CCD properties, camera properties, high dynamic range (HDR) images
   - Tone mapping

	3. Rendering equation • Derivation of the rendering equation • Differences from colorimetric models 4. Material descriptions • BRDF and its approximations • Methods for creation and measurement • BTF 5. Three-dimensionality • 3D reconstruction (computer vision) • 3D modelling (computer graphics) • Similarities and differences (using MPEG7 as an example) • Projection models
4	**Frequency of the course** **04CV201501 - CV Integration (V)** only in the winter semester **04CV201502 - CV Integration (Ü)** only in the winter semester
5	**Language of instruction** **04CV201501 - CV Integration (V)** German **04CV201502 - CV Integration (Ü)** German
6	**Individual course requirements**
7	**Examination formats** CV integration as not specified (N/A)
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Stefan Müller
11	**Responsible institution** FB 4 - Computer Sciences -> Institute for Computational Visualistics **04CV201501 - CV Integration (V)** FB 4 - Computer Sciences -> Institute for Computational Visualistics **04CV201502 - CV Integration (Ü)** FB 4 - Computer Sciences -> Institute for Computational Visualistics
12	**Literature** **04CV201501 - CV Integration (V)** Matt Pharr, Greg Humphreys: Physically Based Rendering, Morgan Kaufmann 2004.

	Philp Dutre, Phillippe Bekaert, Kavita Bala: Advanced Global Illumination, B&T 2003 Marc Ebner, Colour Constancy, McGraw-Hill, 2007 (to appear) **04CV201502 - CV Integration (Ü)** Matt Pharr, Greg Humphreys: Physically Based Rendering, Morgan Kaufmann 2004. Philp Dutre, Phillippe Bekaert, Kavita Bala: Advanced Global Illumination, B&T 2003 Marc Ebner, Colour Constancy, McGraw-Hill, 2007 (to appear)
13	**Use in study programme** M.Sc. Computer Visualisation (2019)
14	**Other information**

module 26 **04CV2102**	**Visual Analytics**						6 credit points Elective module	
Workload 180 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	26	V	Visual analytics	04CV210201	Compulsory	2 hours per week 30 hours	60 hours	30	3
	26.2	Ü	Visual analytics	04CV210202	Compulsory	2 hours per week 30 hours	60 hours	30	3
2	**Learning outcomes / Competences** This lecture teaches how to analyse large amounts of high-dimensional data. Analysis techniques and interactive visualisations are discussed.								
3	**Contents** 1 Introduction 2 Clustering 3 Subspace clustering 4 Cluster analysis: validation, visualisation, outlier detection 5 Visual analysis of biclusters 6 Scatterplot-Based Visual Representations 7 Linear Dimension Reduction 8 Non-linear dimension reduction 9 Association Rules 10 Decision trees 11 Regression Models 12 Temporal Event Sequences 13 Visual Analytics in Healthcare 14 Interactive and Collaborative Visual Analytics								
4	**Frequency of offering** **04CV210201 - Visual Analytics (V)** Every third term **04CV210202 - Visual Analytics (Ü)** Every third term								
5	**Language of instruction** **04CV210201 - Visual Analytics (V)** German **04CV210202 - Visual Analytics (Ü)** German								
6	**Individual course requirements**								
7	**Examination** Visual analytics as not specified (N/A)								

8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Kai Lawonn
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV210201 - Visual Analytics (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV210202 - Visual Analytics (Ü)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 27 04IN1002	Fundamentals of Computer Networks	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	27	V	Fundamentals of computer networks	04IN100201	Compulsory	3 hours per week 45 hours	75 hours	150	4
	27.2	Ü	Fundamentals of Computer Networks	04IN100202	Comp	1 SWS 15 hours	45 hours	30	2

2 **Learning outcomes / Competences**

Students will be able to analyse and apply the principles of local and global computer communication. Transmission techniques and methods for setting up scalable networks will be understood from the perspective of the designer, user and administrator. This will provide students with a sound understanding of the essential fundamentals of computer networks.

3 **Contents**

04IN100201 - Fundamentals of Computer Networks (V)

Introduction: Basic components and terms; fundamentals of communication; addressing; minutes and layers; performance; history and present

Physical layer: frequency, spectrum and bandwidth; channel capacity; encoding and modulation; examples of transmission media

Link layer: Error detection, error correction, flow control, error control, framing

Media access control: multiplexing and multiple access; dynamic channel allocation; multiple access protocols; spread spectrum; orthogonal frequency division multiplexing

Local area networks: Repeaters and bridges; hubs and switches; virtual LANs; Ethernet case study; wireless LAN case study

Internetworking: Basic concepts; Internet routing; Limited address space

Transport layer: Simple demultiplexer (UDP); Transmission Control Protocol (TCP); TCP congestion control; TCP congestion avoidance; TCP variants

Application layer: Web and HTTP; File transfer: FTP; Electronic mail; Domain Name System (DNS)

4 **Frequency of offering**

04IN100201 - Fundamentals of Computer Networks (V)
only in the winter semester

04IN100202 - Fundamentals of Computer Networks (P)
only in the winter semester

5 **Language of instruction**

04IN100201 - Fundamentals of Computer Networks (L)

	German **04IN100202 - Fundamentals of Computer Networks (P)** German
6	**Individual course requirements**
7	**Examination** Fundamentals of Computer Networks as an exam (written - 120 minutes)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Johannes Frey
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN100201 - Fundamentals of Computer Networks (V)** Koblenz Campus **->** faculty 4 - Computer Sciences **04IN100202 - Fundamentals of Computer Networks (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN100201 - Fundamentals of Computer Networks (L)** • William Stallings, Data and Computer Communications, Ninth Edition Prentice Hall, 2011 • Larry L. Peterson and Bruce S. Davie, Computer Networks: A Systems Approach, Edition 4, Morgan Kaufman, 2007 • Andrew S. Tanenbaum, Computer Networks, Fourth Edition, Pearson Education International, 2003
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Business Informatics (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Qualified participation in the tutorials as well as the completion of the tutorial tasks. At least 50% of the points must be achieved in order to be admitted to the exam. **04IN100201 - Fundamentals of Computer Networks (V)** Tutorials with the VNUML and Opnet network simulators.

module 28 **04IN1005**	**Fundamentals of Operating Systems**						6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term	
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	28	V	Fundamentals of operating systems	04IN100501	Compulsory	3 hours per week 45 hours	75 hours	70	4
	28.2	Ü	Fundamentals of Operating Systems	04IN100502	Compulsory	1 SWS 15 hours	45 hours	35	2

2 **Learning outcomes / competencies**

Students learn about the range of tasks performed by operating systems, their design principles and key components. They become familiar with various standard procedures and learn to apply and interpret them in the field of operating systems and beyond through abstraction. A further objective is the delivery of theoretical principles and the testing of practical skills in connection with parallel and distributed programming. Students will learn which concepts of parallel and distributed programming determine the structure of operating systems. They will also understand and evaluate the significance of these concepts for application programming, particularly in connection with multi-core processors.

3 **Contents**

04IN100501 - Fundamentals of Operating Systems (V)

Introduction
Tasks, design principles, genealogy of important operating systems Parallel programming
Parallelism, concepts and methods of synchronising parallel processes, systematic approach to developing correct parallel programmes, deadlock, livelock, fairness
Components of operating systems
Process management, memory management, file management, drivers and their access to devices, characteristic algorithms and their evaluation, principles of operating system design Distributed systems
Principles of communication and synchronisation with messages, programming concepts, ordering of events, synchronisation of clocks, standard procedures for distributed programming

04IN100502 - Fundamentals of Operating Systems (Ü)

Accompaniment to the lecture Fundamentals of Operating Systems with practical tutorials, primarily using the C programming language and the Linux operating system.

4 **Frequency**

04IN100501 - Fundamentals of Operating Systems (L)
Winter semester only

04IN100502 - Fundamentals of Operating Systems (P)
only in the winter semester

5 **Language of instruction**

	04IN100501 - Fundamentals of Operating Systems (V) German **04IN100502 - Fundamentals of Operating Systems (P)** German
6	**Individual course requirements**
7	**Examination formats** Fundamentals of operating systems as not specified (N/A N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Dieter Zöbel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN100501 - Fundamentals of Operating Systems (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN100502 - Fundamentals of Operating Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN100501 - Fundamentals of Operating Systems (V)** • W. Stallings, Operating Systems - Internals and Design Principles, Prentice Hall, New Jersey, 9th edition, 2017 • D. Bovet, M. Cesati, Understanding the Linux Kernel, O'Reilly, Sebastopol, California, 2006 • P. Mandl, Basic Course in Operating Systems, Vieweg, Wiesbaden, 2008 • A. M. McHoes, I.M. Flynn, Understanding Operating Systems, Course Technology, Boston, 2009 • Th. Anderson, Michael Dahlin, Operating Systems, Recursive Books, Boston, 2011 • Ch. Braun, Compact Operating Systems, Springer-Vieweg, Berlin, 2017. **04IN100502 - Fundamentals of Operating Systems (Ü)** Identical to the information provided for the lecture Fundamentals of Operating Systems.
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** **04IN100501 - Fundamentals of Operating Systems (V)** There is a script for most of the lecture.

	04IN100502 - Fundamentals of Operating Systems (Ü) Credit points are awarded for active participation in the tutorials and passing the first or second exam.

module 29 04IN1006	Evaluation of the operational performance of systems	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	29	V	Evaluation of the operational performance of systems	04IN100601	Comp	3 hours per week 45 hours	75 hours	30	4
	29.2	Ü	Evaluation of the operational performance of systems	04IN100602	Comp	1 SWS 15 hours	45 hours	30	2

2 **Learning outcomes / competencies**

The classic subject of operational evaluation is the computer. In addition, there are a number of other application systems that provide services and whose performance is of interest. These include wired and wireless computer networks, machine production processes, automated transport systems and road vehicles. Students understand the basic mathematical methods used to evaluate service-providing systems. They are able to abstract from the real world and map essential relationships onto models. They apply calculation methods and interpret the results. They are able to assess the limits of the interpretability of the results in the respective application contexts.

3 **Contents**

04IN100601 - Evaluation of the operational performance of systems (V)

Introduction
Tasks, objectives, roles, measures Modelling
Operating system, queues, random processes, transformation Evaluation of central operating systems
Markov property and Markov chains, M/M/1 and M/G/1 systems, interpretation of performance parameters
Evaluation of distributed operating systems
Networks of operating systems, open and closed networks, interpretation of performance parameters

4 **Frequency of the course**

04IN100601 - Evaluation of the operational performance of systems (V)
Irregular

04IN100602 - Evaluation of the operational performance of systems (Ü)
Irregular

5 **Language of instruction**

04IN100601 - Evaluation of the operational performance of systems (V)
German

04IN100602 - Evaluation of the operational performance of systems (Ü)
German

6 **Individual course requirements**

7	**Examination** Assessment of the operational performance of systems: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Dieter Zöbel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN100601 - Evaluation of the Operational Performance of Systems (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN100602 - Evaluation of the Operational Performance of Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN100601 - Evaluation of the Operational Performance of Systems (V)** • P. Tran-Gia, Introduction to Performance Evaluation and Traffic Theory, Oldenbourg, 2005 • D. Zöbel, E. Balcerak, Modelling and Analysis of Computing Systems - A Tutorial, vdf-Verlag, Zurich 1999 • G. R. Dattareya; Performance Analysis of Queuing Computer Networks, CRC Press, Dallas, 2008 • R. Nelson; Probability, Stochastic Processes, and Queuing Theory, Springer-Verlag, New York, 1995
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 30 **04IN1017**	**JavaEE Web Application**						6 credit points Elective module	
Workload 180 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	30	V	JavaEE web applications	04IN101701	Compulsory	2 hours per week 30 hours	60 hours	30	3
	30.2	Ü	JavaEE web applications	04IN101702	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students are familiar with the architecture of JavaEE web applications and their main components. They can describe the architecture and are able to assign obligations and typical tasks to the different components. Students can explain the flow of information that originates from a client request. They can show how a request will be processed by the different layers of a web application and relate this to the responsibilities of the application components.

Technical terms and concepts in the JavaEE technological space are known and can be classified. Students can assign technical terms to the architectural components and use the terms consistently and correctly.

Students can develop (small) JavaEE web applications.

3 **Contents**

04IN101701 - JavaEE Web Applications (V)

Selected topics:

Differences between Java SE and Java EE Architecture
of Java EE Applications Execution environments
Deployment of applications Java EE
API overview Enterprise Java Beans
(EJB)
Persistence with Java Persistence API (JPA) Business logic:
EJB variants
User interfaces: Java Server Faces (JSF) Java EE
Containers and their Services
In the accompanying exercise/laboratory course, students will solve practical problems in small programming tasks. Topics from the lecture part are repeated and illustrated by excerpts from real applications.

4 **Frequency of offering**

04IN101701 - JavaEE Web Applications (V)

only in the summer semester

04IN101702 - JavaEE Web Applications (Ü)

only in the summer semester

5 **Language of instruction**

	04IN101701 - JavaEE Web Applications (V) English **04IN101702 - JavaEE Web Applications (Ü)** English
6	**Individual course requirements** Java programming skills, object-oriented concepts Software design patterns (basics) UML (class diagrams, use case diagrams, activity diagrams, state machines) Basic knowledge of XML, HTML and CSS Basic knowledge of databases: foundations of relational databases, SQL, required minimum knowledge will be presented/repeated
7	**Examination** JavaEE web applications as not specified (N/A)
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Volker Riediger
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN101701 - JavaEE Web Applications (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN101702 - JavaEE Web Applications (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN101701 - JavaEE Web Applications (V)** • M. Marinschek, M. Kurz, G. Müllan: Java Server Faces 2.0 - Fundamentals and Advanced Concepts; dpunkt 2010 • U. Rozanski: Enterprise JavaBeans 3.0 with Eclipse and JBoss; MITP 2007 • O. Ihns, D. Harbeck, S. Heldt, H. Koschek: EJB 3 Professional; dpunkt 2009 • Java EE Documentation, Oracle Corp., 2014 • Glassfish Server Documentation, Oracle Corp. 2013 • The Java EE 7 Tutorial, Oracle Corp. 2014
13	**Used in the** M.Sc. Web and Data Science **study programme** (2019) B.Sc. Computer Sciences (2019) B.Sc. Business Informatics (2019) B.Sc. Computer Visualisation (2019) B.Sc. Computer Visualistics (2019)

	M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 31 **04IN1020**	**Fundamentals of databases**	6 credit points Elective module

Workload 180 hours	**semester** N/A	**Duration** 1 term

1 **Courses**

				Compulsory/elective	**Contact hours**	**Self-study**	**Planned group size**	**LP**
31	V	Fundamentals of databases	04IN102001	Compulsory	2 hours per week 30 hours	60 hours	132	3
31.2	Ü	Fundamentals of databases	04IN102002	Compulsory	2 hours per week 30 hours	60 hours	33	3

2 **Learning outcomes / Competences**

Students understand how relational database management systems work. They can design and implement the use of such a system. Based on their knowledge of how relational database systems work, they can analyse and avoid or circumvent potential bottlenecks in the behaviour of a database management system. They are able to adopt data management methods into their own systems and apply these methods and the relational database management system in practice.

3 **Contents**

04IN102001 - Fundamentals of Databases (V)

1. Motivation & Fundamentals
2. SQL
   - Data Definition
   - Data Manipulation & Queries
3. The Relational Data Model
   - Relational Algebra
   - Tuple calculus & domain calculus
4. Data Integrity & Relational Design Theory
   - Data integrity
   - Functional dependencies
   - Normal Forms & Normalisation
5. Physical Data Organisation
   - Storage Hierarchy
   - Background storage/RAID
   - B-trees, R-trees, hashing
6. Query processing
   - Logical optimisation
   - Physical optimisation
7. Transactions & Error Handling
   - ACID
   - Change logging
   - Recovery after errors
8. Multi-user synchronisation
   - Serialisation
   - Locks, deadlocks
   - Synchronisation

4 **Frequency of offering**

04IN102001 - Fundamentals of Databases (V)

	only in the winter semester **04IN102002 - Fundamentals of Databases (Ü)** only in the winter semester
5	**Language of instruction** **04IN102001 - Fundamentals of Databases (V)** German **04IN102002 - Fundamentals of Databases (P)** German
6	**Individual course requirements** Knowledge of algorithms and data structures.
7	**Examination formats** Fundamentals of databases as an exam (written - 90 minutes)
8	**Requirements for awarding credit points** Regular and qualified attendance (maximum of 2 absences)
9	**Significance of the final grade** For secondary school teaching: 5% corresponding to the credit points (6:120) For secondary school teaching: 10% corresponding to the credit points (6:60)
10	**Module coordinator** Mr Steffen Staab
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102001 - Fundamentals of Databases (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102002 - Fundamentals of Databases (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN102001 - Fundamentals of Databases (V)** A. Kemper, A. Eickler, Database Systems - An Introduction, 5th edition, Oldenbourg Verlag, Munich 2004
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Business Informatics (2019) B.Sc. Information Management (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 32 **04IN1021**	**Web Retrieval**							6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact time**	**Self-study**	**Planned group size**	**LP**
	32.1	V	Web retrieval	04IN102101	Compulsory	2 hours per week 30 hours	60 hours	30	3
	32.2	Ü	Web Retrieval	04IN102102	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

A good understanding of tasks and challenges in information retrieval in a web setting, deep understanding of the theory of state-of-the-art retrieval models, thorough knowledge of algorithms and data structures for managing and retrieving data in an IR system, ability to design, implement and evaluate a small-scale web retrieval system.

3 **Contents**

04IN102101 - Web Retrieval (V)

The lecture will give an introduction to established retrieval models for text-based documents, models that exploit the graph structure of the WWW, the topic of evaluating the performance of retrieval systems and related tasks such as classification and clustering of web documents. The concepts communicated in the lecture will be applied in practical exercises and tutorials.

More specifically, the lecture will cover the following topics:

Information seeking behaviour on the web and user models Evaluation of retrieval systems
Boolean retrieval and essential data structures Vector space
retrieval model
Probabilistic information retrieval models Language
models
Cross-language retrieval Topic models
Web crawling
Authority ranking
Document clustering and classification Information
extraction

4 **Frequency of offering**

04IN102101 - Web Retrieval (V)

Every 3rd term

04IN102102 - Web Retrieval (Ü)

Every 3rd term

5 **Language of instruction**

04IN102101 - Web Retrieval (V)

English

	04IN102102 - Web Retrieval (Ü) English
6	**Individual course requirements** This module requires a basic understanding of algorithmics and programming as well as basic knowledge of linear algebra and stochastics.
7	**Examination formats** Web retrieval as not specified (N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Steffen Staab
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102101 - Web Retrieval (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102102 - Web Retrieval (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN102101 - Web Retrieval (V)** • R. Baeza-Yates, B. Ribeiro-Neto. Modern Information Retrieval. Addison-Wesley. • Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze. Introduction to Information Retrieval. Cambridge University Press, 2008.
13	**Use in study programme** M.Sc. Web and Data Science (2019) M.Sc. Web and Data Science (2019) B.Sc. Computer Sciences (2019) B.Sc. Business Informatics (2019) B.Sc. Computer Visualisation (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information 04IN102101 - Web Retrieval (V)** Postgres Open Source Database

module 33 **04IN1022**	**Logic for Computer Sciences**						6 credit points Elective module	
Workload 180 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	33.1	V	Logic for Computer Sciences	04IN102201	Compulsory	3 hours per week 45 hours	75 hours	140	4
	33.2	Ü	Logic for Computer Sciences	04IN102202	Comp	1 SWS 15 hours	45 hours	35	2

2 **Learning outcomes / Competences**

Students understand the fundamentals of mathematical logic with a particular focus on applications in Computer Sciences. They should:

practise mathematical working methods (training their ability to think abstractly, reasoning), recognise the expressiveness of propositional logic and predicate logic,
Gain insight into the problems of algorithmic treatment of questions in logic, understand the applications of logic in Computer Sciences,
Furthermore, students acquire basic knowledge of the concepts of logical programming.

3 **Contents**

04IN102201 - Logic for Computer Sciences (V)

1. Introduction History of

logic
Role of logic in Computer Sciences Basic proof techniques
Inductive proofs (Noether induction, structural induction)

2. Propositional logic

Syntax and semantics
Calculi:
Resolution Analytical
Tableaux

3. Predicate logic

Syntax and semantics
Calculi:
Resolution Analytical
Tableaux

4. Fundamentals of logical programming

5. Outlook: Applications and other logical systems

04IN102202 - Logic for Computer Sciences (Ü)

The tutorials for "Logic for Computer Sciences" repeat and reinforce the content from the lectures. The topic-related tutorials are presented and discussed by the students. Students receive handouts to help them solve the tutorials.

4 **Frequency of offering**

	04IN102201 - Logic for Computer Sciences (V) Summer semester only **04IN102202 - Logic for Computer Sciences (Ü)** only in the summer semester
5	**Language of instruction** **04IN102201 - Logic for Computer Sciences (V)** German **04IN102202 - Logic for Computer Sciences (P)** German
6	**Individual course requirements**
7	**Examination** Logic for Computer Sciences as not specified (N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Ms Viorica Sofronie-Stokkermans
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102201 - Logic for Computer Sciences (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102202 - Logic for Computer Sciences (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN102201 - Logic for Computer Sciences (V)** • Ulrich Furbach. Logics for Computer Scientists, https://en.wikibooks.org/wiki/Logic_for_Computer_Scientists • Uwe Schöning: Logic for Computer Sciences, Spektrum Akademischer Verlag; Edition: 5th edition, 2000. • Michael Huth and Mark Ryan: Logic in Computer Science: Modelling and reasoning about Systems, Cambridge Univ. Press 2004.
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Business Informatics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Regular qualified participation in courses and completion of exercises (max. 3 missing assignments; min. 50% of points from the area of Prolog, min. 50% of

	points in propositional logic, min. 50% of points in predicate logic) are required for admission to the exam.

module 34 04IN1023	Fundamentals of functional programming	6 credit points Elective module

Workload 180 hours	semester	Duration 1 term

1 **Courses**

				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
34.1	V	Fundamentals of functional programming	04IN102301	Compulsory	2 hours per week 30 hours	60 hours	120	3
34.2	Ü	Fundamentals of functional programming	04IN102302	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students will master the paradigm of functional programming and a corresponding programming language such as Haskell, Scheme, F# or the functional subset of Scala. Students will be able to model simple algorithmic problems and data structures functionally, using higher-order functions and type constructors such as functors, monads and monoids. Students are familiar with typical scenarios of functional programming, for example in the context of data/web or parallel programming.

3 **Contents**

04IN102301 - Fundamentals of Functional Programming (V)

1. Introduction and motivation
2. Algebraic Data Types
3. Abstract Data Types
4. Type Constructors
5. Anonymous Functions
6. Higher-order functions
7. Monoids
8. Functors
9. Monads
10. Equation-based reasoning
11. Libraries of combinators
12. Applications of functional programming

4 **Frequency of offering**

Only in the summer semester

04IN102301 - Fundamentals of functional programming (V)

Only in the summer semester

04IN102302 - Fundamentals of Functional Programming (Ü)

Only in the summer semester

5 **Language of instruction**

04IN102301 - Fundamentals of Functional Programming (V)

German

04IN102302 - Fundamentals of Functional Programming (P)

German

6	**Individual course requirements**
7	**Examination** Fundamentals of functional programming: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Ralf Lämmel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102301 - Fundamentals of Functional Programming (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102302 - Fundamentals of Functional Programming (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN102301 - Fundamentals of Functional Programming (V)** • Graham Hutton: Programming in Haskell. Cambridge University Press. 2007 • Simon Thompson: Haskell: The Craft of Functional Programming (3rd Edition). Addison-Wesley. 2011
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualisation (2019) B.Sc. Computer Visualistics (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 35 **04IN1024** module	**Theory of Programming Languages**		6 credit points Compulsory elective
Workload 180 hours	**semester**		**Duration** 1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	35.1	V	Theories of programming languages	04IN102401	Compulsory	2 hours per week 30 hours	60 hours	35	3
	35.2	Ü	Theories of Programming Languages	04IN102402	Compulsory	2 hours per week 30 hours	60 hours	35	3

2 **Learning outcomes / Competences**

Students will master the use of formal grammars and operational and denotational semantic descriptions for formalising programming languages, including important properties such as type safety. They understand fundamental calculi from the field of programming language theory, such as lambda calculus and approaches to process algebras, and in particular they can create variants of these calculi and implement them in logical or functional programmes.

3 **Contents**

1. Overview and motivation
2. Concrete and abstract syntax
3. Natural semantics
4. Structured, operational semantics
5. Semantics of imperative languages
6. Semantics of object-oriented languages
7. Semantics of functional languages
8. Type systems
9. Type safety
10. Process algebras
11. Denotational semantics
12. Programme analysis
13. Executable semantic descriptions

4 **Frequency of offering**

04IN102401 - Theories of Programming Languages (V)
Winter semester only

04IN102402 - Theories of Programming Languages (seminar)
only in the winter semester

5 **Language of instruction**

04IN102401 - Theories of Programming Languages (V)
German

04IN102402 - Theories of Programming Languages (Ü)
German

6 **Individual course requirements**

	Basic knowledge of functional and logical programming as well as computer sciences.
7	**Examination** Theory of programming languages: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Ralf Lämmel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102401 - Theories of Programming Languages (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN102402 - Theories of Programming Languages (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Benjamin C. Pierce: Types and Programming Languages. The MIT Press. 2002 Hanne Riis Nielson and Flemming Nielson: Semantics with Applications: An Appetizer. Springer. 2007. Additional literature by chapter
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 36 04IN2001	Non-classical logics	6 credit points Elective module

Workload	semester	Duration
180 hours		1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
		V	Non-classical logics	04IN200101	Compulsory	3 hours per week 45 hours	75 hours	30	4
		Ü	Non-classical logics	04IN200102	Compulsory	1 SWS 15 hours	45 hours	30	2

2 **Learning outcomes / Competences**

Students are familiar with the most important non-classical logics that are relevant in Computer Sciences. They can use these to model and analyse systems, and they have mastered deductive techniques and calculi for non-classical logics.

3 **Contents**

04IN200101 - Non-classical logics (V)

1. Introduction History of

logic
Review: classical logic

2. Many-valued logics

Final value logics: definition, examples, calculations Fuzzy logics:
definition, examples, calculations

3. Modal logics

Introduction; motivation; examples Syntax; axiom
systems; provability
Semantics (modal algebras, Kripke models) Correspondence
theory
Normal modal logics Decidability
Description logics Modal quantifier
logic Calculi for modal logics

4. Dynamic logic

Introduction; motivation; examples Syntax; axiom
systems; provability Semantics (Kripke models)
Propositional dynamic logic: completeness, decidability

5. Applications

04IN200102 - Non-classical logics (tutorial)

The tutorials on "Non-classical logics" repeat and deepen the content from the lectures. The topic-related tutorials are presented and discussed by the students.

4 **Frequency**

	04IN200101 - Non-classical logics (V) Every 3rd term **04IN200102 - Non-classical logics (Ü)** Every 3rd term
5	**Language of instruction** **04IN200101 - Non-classical logics (V)** German **04IN200102 - Non-classical logics (Ü)** German
6	**Individual course requirements** Knowledge of logic: propositional logic, predicate logic. The book by Uwe Schöning: "Logik für Informatiker" (Logic for Computer Sciences), 5th edition. Spektrum Akademischer Verlag, 2000 covers the prerequisites sufficiently.
7	**Examination formats** Non-classical logics as not specified (k.A. k.A.)
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Ms Viorica Sofronie-Stokkermans
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200101 - Non-classical Logics (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200102 - Non-classical logics (seminar)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN200101 - Non-classical Logics (V)** • Peter H. Schmitt. Non-classical logics. Lecture notes. University of Karlsruhe, 200. • S. Gottwald. A Treatise on Many-Valued Logic. Research Studies Press, 2001. • M. Fitting. Basic modal logic. In Handbook of Logic in Artificial Intelligence and Logic Programming, Vol 1: Logical Foundations. 368-448 • F. Baader, D. Calvanese, D. McGuiness, D. Nardi, and P. Patel-Schneider. The Description Logic Handbook. Cambridge University Press, 2003. • D. Harel and D. Kozen and J. Tiuryn. Dynamic logic, MIT Press, 2000 • E.A. Emerson. Temporal and modal logic. Handbook of Theoretical Computer Science, 1990.
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019)

	M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 37 04IN2002	Formal Specification and Verification	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	37.1	V	Formal specification and verification	04IN200201	Compulsory	3 hours per week 45 hours	75 hours	30	4
	37.2	Ü	Formal specification and verification	04IN200202	Comp	1 SWS 15 hours	45 hours	30	2

2 **Learning outcomes / Competences**

Students are familiar with various methods and languages for the formal specification of software and can apply them in practice. They are familiar with techniques for the deductive verification of software and understand their logical foundations. They can formally verify the correctness of programmes using appropriate tools.

3 **Contents**

04IN200201 - Formal Specification and Verification (V)

1. Fundamentals
   - Propositional logic, predicate logic
2. Specification and analysis
   - Model-based specifications
   - Algebraic specification
   - Declarative modelling
3. Verification
   - Programming logics
   - Hoare logic, dynamic logic, temporal logic
   - Model checking
   - Deductive verification; software model checking
4. Applications, examples

04IN200202 - Formal Specification and Verification (Ü)

The tutorials on "Formal Specification and Verification" repeat and reinforce the content covered in the lectures. The topic-related tutorials are presented and discussed by the students.

4 **Frequency**

04IN200201 - Formal Specification and Verification (V)

Every 3rd term

04IN200202 - Formal Specification and Verification (Ü)

Every 3rd term

5 **Language of instruction**

04IN200201 - Formal Specification and Verification (V)

German

	04IN200202 - Formal Specification and Verification (Ü) German
6	**Individual course requirements** Knowledge of logic: propositional logic, predicate logic. The content of the book by Uwe Schöning: "Logik für Informatiker" (Logic for Computer Sciences), 5th edition. Spektrum Akademischer Verlag, 2000 covers the prerequisites sufficiently.
7	**Examination formats** Formal specification and verification: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Ms Viorica Sofronie-Stokkermans
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200201 - Formal Specification and Verification (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200202 - Formal Specification and Verification (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN200201 - Formal Specification and Verification (V)** • Peter H. Schmitt. Formal Specification and Verification. Lecture notes. University of Karlsruhe, 2005. • Michael Huth, Mark Dermot Ryan: Logic in computer science - modelling and reasoning about systems Cambridge University Press 2004. • Christel Baier and Joost-Pieter Katoen. Principles of Model Checking, The MIT Press 2008. • Aaron R. Bradley and Zohar Manna. The Calculus of Computation: Decision Procedures with Applications to Verification. Springer, 2007. • Jose Bacelar Almeida, Maria Joao Frade, Jorge Sousa Pinto and Simao Melo de Sousa. Rigorous Software Development: An Introduction to Program Verification, Springer Verlag, 2011. • Zohar Manna and Amir Pnueli. Temporal Verification of Reactive Systems: Safety. Springer-Verlag, 1995.
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)

14	**Other information** Regular and qualified participation in the exercises is required in order to take the exam.

module 38 04IN2006	Automotive Systems in Automation	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	38.1	V	Automotive systems in automation	04IN200601	Compulsory	3 SWS 45 hours	75 hours	30	4
	38.2	Ü	Automotive systems in automation	04IN200602	Compulsory	1 SWS 15 hours	45 hours	30	2

2 **Learning outcomes / competences**

Students learn about the potential of transport automation and systematically explore the components that can be used to build software solutions. To this end, they gain an understanding of the fundamentals of kinematics, position and location detection, trajectory calculation, reliable trajectory tracking and integration in the form of software components. Students will be able to design automation concepts, develop them and ultimately evaluate them in terms of feasibility and usefulness.

3 **Contents**

Components, concepts of a mobile component library

04IN200601 - Automotive systems in automation (V)

1. Introduction
   - Tasks, overview of the technical status
2. Basic model of automation
   - Control loops, transfer functions, controllability, stability, autonomy models
3. Kinematics of vehicles
   - Steering mechanics, kinematic modelling, non-holonomic system properties, Lie operator, trajectory calculation using the chain method
4. Trajectory planning
   - Reference architecture for trajectory planning, smooth transition curves, curves with smooth curvature, canonical manoeuvres
5. Trajectory tracking
   - Reference architecture for trajectory tracking, target point determination, approach curves
6. Safety in autonomous driving
   - Reference architecture for safe driving, modelling of static and dynamic obstacles, envelope formation for vehicles, prevention of jamming
7. Communication and positioning
   - Methods of position and location determination, wired networks in vehicles, wireless networks for vehicles
8. Operational performance evaluation
   - Modelling for autonomous transport systems, transfer to classic methods of performance analysis and evaluation
9. Software engineering for automotive systems
   - Component architecture, interaction mechanisms for mobile components, concepts for a mobile component library

04IN200602 - Automotive Systems in Automation (Ü)

Solution of theoretical and practical questions on topics closely related to the lecture of the same name:

	- Autonomous driving and legal foundations - Autonomous driving and certification - Operational and attack security in autonomous driving - Path planning and tracking for vehicles of different kinematic types - Communication within the vehicle and between vehicles - Development of special driving manoeuvres - Performance analysis for autonomous driving applications
4	**Frequency of offering** **04IN200601 - Automotive Systems in Automation (V)** Every 3rd term **04IN200602 - Automotive Systems in Automation (Ü)** Every 3rd term
5	**Language of instruction** **04IN200601 - Automotive Systems in Automation (V)** German **04IN200602 - Automotive Systems in Automation (Ü)** German
6	**Individual course requirements**
7	**Types of examinations** Automotive systems in automation: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Dieter Zöbel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200601 - Automotive Systems in Automation (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200602 - Automotive Systems in Automation (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced at the relevant events
13	**Use in study programme** B.Sc. Computer Sciences (2019)

	B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information** Active participation in the tutorials is required in order to take the exam.

module 39 **04IN2007**	**Real-time systems**						6 credit points Elective module	
Workload 180 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	39.1	V	Real-time systems	04IN200701	Compulsory	2 hours per week 30 hours	60 hours	30	3
	39.2	Ü	Real-time systems	04IN200702	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students understand the cross-disciplinary nature of the field of real-time systems. Specifically, this means that they understand and classify the unifying characteristics of the field, such as timeliness, predictability and reliability. They apply the characteristic methods primarily from the fields of planning, synchronisation, networking and multi-core processors. They evaluate the extent to which highly abstract methods can be applied to specific application scenarios.

3 **Contents**

04IN200701 - Real-time systems (V)

1. Introduction
   - Basic model of a real-time system, process model, times and clocks, application examples
2. Fundamentals of process planning
   - Modelling, cyclical planning, basic planning methods (e.g. EDF and RMS), planning according to margins, server-oriented planning methods, comparison of planning methods
3. Synchronisation and real time
   - Real-time operating systems, concepts of process synchronisation, priority inversion, minutes for priority inheritance and priority limits
4. Computer networks and real time
   - Real-time classification of computer networks, time-weighted bus protocols, time-weighted network protocols, integration into process planning
5. Further topics
   - Global and distributed planning for multi-core systems

04IN200702 - Real-time systems (Ü)

Theoretical and practical tutorials for the lecture of the same name.

4 **Frequency**

04IN200701 - Real-time systems (V)

Every 3rd term

04IN200702 - Real-time Systems (P)

Every 3rd term

5 **Language of instruction**

04IN200701 - Real-Time Systems (V)

	German **04IN200702 - Real-time Systems (Ü)** German
6	**Individual course requirements**
7	**Examination** Real-time systems as not specified (N/A N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 from the study programme
10	**Module coordinator** Mr Dieter Zöbel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200701 - Real-Time Systems (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200702 - Real-Time Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** H. Kopetz, Real-Time Systems - Design Principles for Distributed Embedded Applications, Springer, New York, 2011 G. C. Buttazzo, Hard Real-Time Computing Systems - Predictable Scheduling Algorithms and Applications, Springer, Heidelberg, 2005 D. Zöbel, Real-Time Systems – Fundamentals of Planning, Springer, Heidelberg, 2008 **04IN200701 - Real-Time Systems (V)** • H. Kopetz, Real-Time Systems - Design Principles for Distributed Embedded Applications, Springer, New York, 2011 • G. C. Buttazzo, Hard Real-Time Computing Systems – Predictable Scheduling Algorithms and Applications, Springer, Heidelberg, 2005 • D. Zöbel, Real-Time Systems - Fundamentals of Planning, Springer, Heidelberg, 2008 • G. Buttazzo; G. Lipari; L. Abeni; M. Caccamo; Soft Real-Time Systems, Springer, 2005 • S. Baruah; M. Bertogna; G. Buttazzo; Multiprocessor Scheduling for Real-Time Systems, Springer, 2014 • W. Zimmermann, R. Schmidgall: Bus Systems in Vehicle Technology, Vieweg-Teubner, 2008
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019)

	M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information**

module 40 04IN2008	Empirical Software Engineering	6 credit points Elective module

Workload 180 hours	semester	Duration 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	40.1	V	Empirical Software Engineering	04IN200801	Compulsory	2 hours per week 30 hours	60 hours	30	3
	40.2	S	Empirical Software Engineering	04IN200802	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students will master empirical methods in the context of software engineering so that they can examine scientific problems in this context by applying user studies, exploratory investigations and other forms of empirical research, and demonstrate this in a simple student project. Particular attention will be paid to empirical questions involving the use of automated software analyses.

3 **Contents**

04IN200801 - Empirical Software Engineering (V)

1. Scientific methodological approach
2. Examples of empirical studies
3. Classification of empirical studies
4. User studies
5. Controlled experiments
6. Exploratory analysis
7. Design of experiments
8. Relevant methods of software analysis
9. Planning the student project
10. Evaluation of student projects

4 **Frequency of offering**

04IN200801 - Empirical Software Engineering (V)

Every 3rd term

04IN200802 - Empirical Software Engineering (S)

Every 3rd term

5 **Language of instruction**

04IN200801 - Empirical Software Engineering (V)

German

04IN200802 - Empirical Software Engineering (S)

German

6 **Individual course requirements**

Fundamentals of software engineering and programming.

7 **Examination**

	Empirical software engineering as not specified (N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Ralf Lämmel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200801 - Empirical Software Engineering (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200802 - Empirical Software Engineering (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Web and Data Science (2019) B.Sc. Computer Sciences (2019) B.Sc. Computer Visualisation (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 41 04IN2009	Advanced Software Engineering	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	41.1	V	Advanced Software Engineering	04IN200901	Compulsory	2 hours per week 30 hours	60 hours	40	3
	41.2	Ü	Advanced Software Engineering	04IN200902	Comp	2 hours per week 30 hours	60 hours	40	3

2 **Learning outcomes / Competences**

Students will master all essential activities of software development and software maintenance. In particular, they will also be familiar with cross-functional activities and quality assurance measures. They will master the modelling of different views of the software and the underlying concepts. They will be able to conceptually classify current trends in software engineering.

3 **Contents**

I) Introduction and fundamentals

II) Software quality and security: advanced examples of software defects and vulnerabilities
- Vulnerability databases
- Meltdown & Spectre
- Buffer overflows
- Integer arithmetic vulnerabilities
- Unvalidated parameters
- Access control errors

III) Advanced software quality assurance and software security techniques
- Microsoft Security Development Lifecycle (SDL)
- Quality & Security by Design
- Quality and security principles
- Model-based security and threat analysis
- Reduction of attack surfaces and defect impact
Model-based security with UMLsec
- Code-based analysis of quality and security
- Advanced techniques of dynamic code analysis (Control flow-based, condition-based and data flow-based testing, security testing)
- Static analysis
- Software metrics

IV) Advanced techniques for constructive quality assurance
- Model-based software development
- BPMN
- Object Constraint Language
- Eclipse Modelling Framework

V) Epilogue

4 **Frequency of offering**

	04IN200901 - Advanced Software Engineering (V) only in the winter semester **04IN200902 - Advanced Software Engineering (Ü)** only in the winter semester
5	**Language of instruction** **04IN200901 - Advanced Software Engineering (V)** German **04IN200902 - Advanced Software Engineering (Ü)** German
6	**Individual course requirements** Prerequisites for participation are the successful acquisition of knowledge as taught, for example, in the Koblenz Bachelor's programme in modules 04IN1010 (Object-Oriented Programming and Modelling), 04IN1104 (Programming Techniques and Software Design) and 04IN1012 (Fundamentals of Software Engineering), for example: Programming skills in an object-oriented programming language (usually Java) and use of development environments, confidence in using basic APIs (e.g. collections) Knowledge of software architectures and orchestration of components Ability to model UML models for structure (class diagrams) and behaviour (activity diagrams, statecharts, sequence diagrams) for software design and design patterns Ability to implement models, understand the relationship between models and code Quality assurance: black box testing, white box testing
7	**Types of examination** Advanced software engineering as not specified (N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Jan Jürjens
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200901 - Advanced Software Engineering (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN200902 - Advanced Software Engineering (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced in the relevant events
13	**Use in study programme** M.Sc. Web and Data Science (2019) M.Sc. Computer Sciences (2019)

	M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information** Qualified participation in the tutorials (max. 2 absences) and completion of the tutorial tasks (max. 2 missing tasks, 50% of the points in total) are required in order to take the exam.

module 42 04IN2012	Engineering Web and Data Intensive Systems	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	42.1	V	Engineering Web and Data-intensive Systems	04IN201201	Compulsory	2 hours per week 30 hours	60 hours	60	3
	42.2	Ü	Engineering Web and Data-intensive Systems	04IN201202	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

The students understand the particularities of engineering web-based and data-intensive systems compared to classical software engineering. They have fundamental knowledge of the languages involved in web-based and data-intensive systems, and they are able to classify the most important technologies and tools used. They have deepened knowledge of software processes with respect to the area of web-based and data-intensive systems.

3 **Contents**

- Introduction
- Internet & its Security
- Documents
- Communication
- Building Quality, Security and Privacy into Web-based and Data-intensive applications
- Processes and requirements for web-based and data-intensive applications
- Architectures for Web-based and Data-intensive applications
- Client-server architectures
- Client-side technologies
- Server-side technologies
- Service-Oriented Architectures
- Specification of service orchestration with BPMN
- Execution of Service Orchestration with BPEL
- Testing Web-based and Data-intensive applications
- Industrial Applications: The Industrial Data Space
- Epilogue

04IN201201 - Engineering Web and Data-intensive Systems (V)

1. Introduction
   - web applications, requirements, characteristics and quality goals
2. World Wide Web
   - hypermedia, languages (HTML, XML), protocols and layers, application protocols, terminology, languages (HTTP)
3. Server-side Components
   - application servers, frameworks, components, languages (PHP)
4. Client-side components
   - browsers, plugins, languages (JavaScript)
5. Web development process
   - requirements, modelling, architecture, quality assurance, web security

4 **Frequency of the offer**

	04IN201201 - Engineering Web and Data-intensive Systems (V) only in the winter semester **04IN201202 - Engineering Web and Data-intensive Systems (Ü)** Every third term
5	**Language of instruction** **04IN201201 - Engineering Web and Data-intensive Systems (V)** English **04IN201202 - Engineering Web and Data-intensive Systems (Ü)** English
6	**Individual course requirements**
7	**Examination** Engineering Web and Data Intensive Systems: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Jan Jürjens
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN201201 - Engineering Web and Data-intensive Systems (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN201202 - Engineering Web and Data-intensive Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN201201 - Engineering Web and Data-intensive Systems (V)** • Emilia Mendes, Nike Mosley: Web Engineering. Springer, 2006, ISBN 978-3-540-28196-2 • Gerti Kappel, Birgit Pröll, Siegfried Reich, and Werner Retschitzegger: Web Engineering - The Discipline of Systematic Development of Web Applications. John Wiley & Sons, 2006
13	**Used in the** M.Sc. Web and Data Science **study programme** (2019) M.Sc. Web and Data Science (2019) M.Sc. Web and Data Science (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

Literature includes:

Emilia Mendes, Nike Mosley: Web Engineering. Springer, 2006, ISBN 978-3-540-28196-2

Gerti Kappel, Birgit Pröll, Siegfried Reich, and Werner Retschitzegger: Web Engineering - The Discipline of Systematic Development of Web Applications. John Wiley & Sons, 2006

Precondition for the assignment of credit points is the successful participation in the tutorials (max. 2 missed tutorials) and the successful delivery of exercise solutions (max. 2 missing exercises, altogether at least 50% of the possible points).

module 43 **04IN2014**	**Software Architecture**							6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	43.1	V	Software architecture	04IN201401	Compulsory	2 hours per week 30 hours	60 hours	30	3
	43.2	Ü	Software Architecture	04IN201402	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students understand the different perspectives on the architecture of software systems and have mastered methods for describing and evaluating them. They are familiar with the most important architectural styles and can assess architectural approaches such as component-based architectures, product lines and service-oriented architectures.

3 **Contents**

4 **Frequency**

04IN201401 - Software Architecture (V)
Irregular

04IN201402 - Software Architecture (Ü)
irregular

5 **Language of instruction**

04IN201401 - Software Architecture (V)
German

04IN201402 - Software Architecture (Ü)
German

6 **Individual course requirements**

Participants should master the essential activities involved in creating large software systems and be able to apply the languages and methods of software engineering in the various phases of software development and maintenance. They should be able to describe different views of software using UML and understand the most important process models.

7 **Examination formats**

Software architecture as not specified (n.a. n.a.)

8 **Requirements for awarding credit points**

9 **Significance of the final grade**

6/120 of the study programme

10 **Module coordinator**

	Prof. Dr. Jan Jürjens
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN201401 - Software Architecture (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN201402 - Software Architecture (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 44 04IN2016	Efficient Graph Algorithms	6 credit points Elective module

Workload 180 hours	semester	Duration 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	44.1	V	Efficient graph algorithms	04IN201601	Compulsory	4 SWS 60 hours	120 hours	30	6

2 Learning outcomes / Competences

Students will be able to model discrete situations as graphs and specify problems on graphs. They will master the use of search methods and their adaptation to specific problems. They will be familiar with the most important algorithmic approaches and will be able to evaluate their complexity.

3 Contents

1. Fundamentals (definitions, algorithmic procedures)
2. Data structures (storage of graphs, programming interface (API))
3. Directed traversal methods (search, breadth-first search, depth-first search, Kahn-Knuth method, Dijkstra method, A* method, Ford-Moore method)
4. Undirected traversal methods (undirected search, breadth-first search, depth-first search, Prim-Dijkstra method)
5. Structure-independent methods (union-find problem, Kruskal's algorithm, Warshall's algorithm, Floyd's algorithm)
6. Path tracing methods (Euler paths, Hamilton paths, backtracking, greedy methods, branch-and-bound)
7. Problem area "flows" (flow measurement, flow maximisation, Ford-Fulkerson method)
8. Problem area "Matching" (matching, Hungarian method)

4 Frequency of offering

04IN201601 - Efficient graph algorithms (V)
Irregular

5 Language of instruction

04IN201601 - Efficient Graph Algorithms (V)
German

6 Individual course requirements

Basic knowledge of algorithms and data structures

7 Examination formats

Efficient graph algorithms as not specified (N/A N/A)

8 Requirements for awarding credit points

9 Significance of the final grade

6/120 of the study programme

10 Module coordinator

	Mr Johannes Frey
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN201601 - Efficient Graph Algorithms (V)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Andreas Brandstädt. Graphs and Algorithms. B.G. Teubner, 1994. Jürgen Ebert. Efficient Graph Algorithms. Akademische Verlagsgesellschaft, 1981. Robert Sedgewick. Algorithms in Java. Addison-Wesley, 2004. Volker Turau. Algorithmic Graph Theory. Addison-Wesley, 1996.
13	**Use in study programme** M.Sc. Web and Data Science (2019) B.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 45 **04IN2019** module	**Advanced Computer Sciences: Theoretical Computer Sciences**		6 credit points Compulsory elective
Workload 180 hours	**semester**		**Duration** 1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	45.1	V	Advanced theoretical Computer Sciences	04IN201901	Comp	2 hours per week 30 hours	60 hours	40	3
	45.2	Ü	Advanced Computer Sciences: Theoretical Computer Sciences	04IN201902	Comp	2 hours per week 30 hours	60 hours	40	3

2 **Learning outcomes / Competences**

In-depth understanding of formal concepts, the provable limits of computability and complexity.

Students will learn about different concepts of computability and their connections, methods for assessing computability and decidability, how to prove undecidability, measures of complexity and complexity classes, and methods for dealing with complexity.

3 **Contents**

04IN201901 - Advanced Theoretical Computer Sciences (V)

1. Advanced Computability Register

Machines
LOOP-computable functions, while-computable functions, GOTO-computable functions Recursive functions
Primitive recursive functions, µ-recursive functions Connections:
LOOP-computable functions vs. primitive recursive functions
TM-computable functions vs. WHILE/GOTO computable functions vs. µ-recursive functions Church's thesis

2. Undecidable problems

Undecidability proofs via reduction Rice's theorem
Undecidability and formal languages

3. Complexity theory

Complexity classes
NP-complete problems PSPACE
completeness and QBF

4. Applications in Computer Sciences and logic

04IN201902 - Advanced Theoretical Computer Sciences (seminar)

	The tutorials for "Advanced Computer Sciences" repeat and deepen the content from the lectures. The topic-related tutorials are presented and discussed by the students.
4	**Frequency** **04IN201901 - Advanced Theoretical Computer Sciences (V)** only in the winter semester **04IN201902 - Advanced Theoretical Computer Sciences (Ü)** only in the winter semester
5	**Language of instruction** **04IN201901 - Advanced Theoretical Computer Sciences (V)** German **04IN201902 - Advanced Theoretical Computer Sciences (Ü)** German
6	**Individual course requirements** Knowledge of the fundamentals of theoretical Computer Sciences, such as: automata and formal languages and their interrelationships, methods for assessing computability and decidability, fundamentals of complexity theory
7	**Types of examinations** Advanced theoretical computer sciences: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Ms Viorica Sofronie-Stokkermans
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN201901 - Advanced Theoretical Computer Sciences (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN201902 - Advanced Theoretical Computer Sciences (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN201901 - Advanced Theoretical Computer Sciences (V)** • Katrin Erk, Lutz Priese, Computer Sciences, Springer Verlag, 2000 • Michael Garey, David Johnson: Computers and Intractability: A Guide to the Theory of NP-Completeness, Freeman and Co, 1991. • John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullmann. Introduction to Automata Theory, Languages, and Computation. Third edition. Addison Wesley, 2006.

13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information** Regular and qualified participation required for exam participation.

module 46 **Semantic Web** 6 credit points
04IN2023 Elective module

Workload	**semester**	**Duration**
180 hours		1 term

1 **Courses**

				Compulsory/elective	**Contact hours**	**Self-study**	**Planned group size**	**LP**
46.1	V	Semantic Web	04IN202301	Compulsory	2 hours per week 30 hours	60 hours	30	3
46.2	Ü	Semantic Web	04IN202302	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

The student should be able to design and develop semantic web applications. The student should be able to advance semantic web technologies in order to broaden and facilitate their use. The student should be able to understand the interaction of different standards, their technical implications, and the social processes that underlie various semantic web applications.

3 **Contents**

04IN202301 - Semantic Web (V)

1. Foundations
   - Problems
   - Basic approach
2. Languages
   - RDF
   - OWL
   - Rule languages
3. Ontologies
   - Applications
   - Modelling trade-offs
   - Foundational Ontologies
   - A Core Ontology for Software
4. Semantic annotation
   Re-using databases
   - Information Extraction
   - Multimedia Annotation
5. Ontology alignment
   - Information Flow
   - Learning Alignments

4 **Frequency of offering**

04IN202301 - Semantic Web (V)
Every 3rd term

04IN202302 - Semantic Web (Ü)
Every 3rd term

5 **Language of instruction**

04IN202301 - Semantic Web (V)
English

	04IN202302 - Semantic Web (Ü) English
6	**Individual course requirements** Basic knowledge of conceptual modelling. Basic knowledge of logic and data engineering recommended.
7	**Examination formats** Semantic Web as not specified (N/A N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 from the study programme
10	**Module coordinator** Mr Steffen Staab
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202301 - Semantic Web (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202302 - Semantic Web (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN202301 - Semantic Web (V)** • S. Staab, R. Studer, Handbook on Ontologies, International Handbooks on Information Systems, Springer Verlag, 2004 • S. Handschuh, S. Staab, Annotation for the Semantic Web, IOS Press, 2003 • P. Hitzler, S. Rudolph, M. Krötzsch. Foundations of Semantic Web Technologies, Chapman & Hall, 2010 • A. Dengel (ed.). Semantic Technologies. Spektrum, 2012. • J. Domingue, D. Fensel, J. Hendler (Eds) Handbook of Semantic Web Technologies, Springer 2011.
13	**Use in study programme** M.Sc. Web and Data Science (2019) M.Sc. Web and Data Science (2019) B.Sc. Computer Sciences (2019) B.Sc. Computer Visualisation (2019) B.Sc. Computer Visualisation (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information**

module 47 04IN2026	Introduction to Web Science	8 credit points Elective module

Workload 240 hours	semester	Duration 1 term

1 **Courses**

				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
47.1	V	Introduction to Web Science	04IN202601	Compulsory	4 hours per week 60 hours	120 hours	70	6
47.2	Ü	Introduction to Web Science	04IN202602	Comp	2 hours per week 30 hours	30 hours	35	2

2 **Learning outcomes / Competences**

The student should acquire an understanding of the Web as a complex socio-technical system. He should be able to relate problems and opportunities incurred in this system to the technical, social and economic foundations of the Web. He should be capable of choosing different research methods suitable for various challenges in understanding and engineering the Web.

04IN202601 - Introduction to Web Science (V)

3 **Contents**

04IN202601 - Introduction to Web Science (V)

- History of the Web
  - Pre-Web: Memex, Hypertext, Internet, Usenet, FTP, Gopher
  - Web 1.0, Web 2.0, Web 3.0
  - Social and economic growth
- Web Science and Web Science Methodologies
  - Descriptive, prescriptive, normative scientific methods:
    - What are descriptions and models of the Web?
    - What are the prerequisites for specific objectives (e.g. no government by a single institution)?
  - Quantitative analytical and predictive methods
  - Simulation
- Web architecture and major applications
  - HTTP, HTML, Internet, web server, browser, transactions
  - User-generated content, blogs, wikis, folksonomies, social networks
  - Semantic Web summary: XML, RDF, OWL, microformats, microdata
  - Web security
- Web Government
  - Institutions: W3C, IETF, ICANN
  - Government: Privacy laws, Copyright laws
  - Principles and attacks: net neutrality, censorship
- Web content
  - Media and standards
  - Language and cultural diversity
  - Generative models
  - Rhetorical models on the web
  - Web annotations (tagging, metadata, rich snippets)
- Web and user behaviour/HCI
  - Navigation behaviour
  - Search behaviour
  - Recommendations
- Web and social behaviour

	• Web reflecting social behaviour • Web affecting social behaviour • Web structure • Link structure, small world • Social network sites • Blogosphere • Web analysis • Web measurements (size, performance, etc.) • Crawlers • Search engines • Web archiving • Web economics • Advertisement, including cross-site advertisements and search • Auctioning in search and online auctions
4	**Frequency of the course** **04IN202601 - Introduction to Web Science (V)** only in the winter semester **04IN202602 - Introduction to Web Science (Ü)** only in the winter semester
5	**Language of instruction** **04IN202601 - Introduction to Web Science (V)** English **04IN202602 - Introduction to Web Science (Ü)** English
6	**Individual course requirements** Basic understanding of computer science as taught in a type-2 bachelor programme. Expected knowledge will include basic capabilities of programming in a language such as Java or C, algorithmic understanding, knowledge about basic data structures and basic internet networking. **04IN202601 - Introduction to Web Science (V)** Basic understanding of computer science as taught in a type-2 bachelor programme. Expected knowledge will include basic capabilities of programming in a language such as Java or C, algorithmic understanding, knowledge of basic data structures and basic internet networking.
7	**Examination formats** Introduction to Web Science as not specified (N/A N/A)
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 8/120 of the study programme
10	**Module coordinator** Mr Steffen Staab
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science

	04IN202601 - Introduction to Web Science (V) FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202602 - Introduction to Web Science (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN202601 - Introduction to Web Science (V)** Brügger, Niels (2010). Web History. Peter Lang. Tim Berners-Lee and Mark Fischetti, Weaving the Web, 1999. Lawrence Lessig and Jonathan Zittrain. The Future of the Internet - And How to Stop It. Yale University Press, 2008/2009 Tim Berners-Lee, Wendy Hall, James A. Hendler, Kieron O'Hara, Nigel Shadbolt, Daniel J. Weitzner. A Framework for Web Science. Foundations and Trends in Web Science, Now Publishers, 1(1), 2006; DOI: 10.1561/1800000001.
13	**Used in the following study programmes** M.Sc. Web and Data Science (2019) B.Sc. Business Informatics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 48 04IN2027	Network Theory and Dynamic Systems	6 credit points Elective module

Workload 180 hours	semester	Duration 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	48.1	V	Network Theory and Dynamic Systems	04IN202701	Compulsory	2 hours per week 30 hours	60 hours	60	3
	48.2	Ü	Network Theory and Dynamic Systems	04IN202702	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

The student should become able to understand the structure and dynamics of network models and how to apply them to structures of artefacts and human behaviours on the World Wide Web.

3 **Contents**

04IN202701 - Network Theory and Dynamic Systems (V)

I. Graph Theory and Social Networks

a. Paths
b. Core network measures
c. Strong and weak ties
d. Homophily and link prediction
e. Taxonomy of network types

II. Game theory

a. Definition of a game
b. Best responses and Nash equilibrium
c. Mixed strategies
d. Pareto and Social Optimality
e. Modelling network traffic using game theory
f. Tragedy of the commons

III. Information Networks and the World Wide Web

a. Structure of the Web
b. Link analysis
c. Sponsored search markets

IV. Network dynamics: Population models

a. Information cascades
b. Economy with/without network effects
c. Stability, instability and tipping points
d. Power laws and rich-get-richer phenomena
e. Long tail

V. Network dynamics: Structural models

a. Diffusion
b. Small world

	c. Epidemics d. Group decision making e. Different voting schemes
4	**Frequency of the offer** **04IN202701 - Network Theory and Dynamic Systems (V)** Summer semester only **04IN202702 - Network Theory and Dynamic Systems (Ü)** only in the summer semester
5	**Language of instruction** **04IN202701 - Network Theory and Dynamic Systems (V)** English **04IN202702 - Network Theory and Dynamic Systems (Ü)** English
6	**Individual course requirements** Basic knowledge of linear algebra as well as data structures and algorithms.
7	**Examination** Network Theory and Dynamic Systems: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Steffen Staab
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202701 - Network Theory and Dynamic Systems (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202702 - Network Theory and Dynamic Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN202701 - Network Theory and Dynamic Systems (V)** • David Easley and Jon Kleinberg: Networks, Crowds, and Markets - Reasoning About a Highly Connected World, Cambridge University Press 2010
13	**Used in the following study programmes** M.Sc. Web and Data Science (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)

	M.Sc. E-Government (2019)
14	**Other information**

module 49 **04IN2028**	**Machine Learning**							6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	49.1	V	Machine learning	04IN202801	Compulsory	2 hours per week 30 hours	60 hours	120	3
	49.2	Ü	Machine learning	04IN202802	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Machine learning is devoted to automated learning from input data. It suggests explanation models and estimates their parameters for understanding and predicting future system behaviour. Machine learning serves as a formal backbone for many methods and models in computer science.

3 **Contents**

04IN202801 - Machine Learning (V)

The lecture addresses master's students in computer science, computer visualistics, information management, business informatics and web science who want to extend and structure their knowledge in machine learning. Lecture topics include linear discriminators, kernel-based methods, Bayesian methods, as well as common applications in computer science problems. Special attention is paid to modern, state-of-the-art methods and approaches that are currently widely used in different fields of computer science.

4 **Frequency of offering**

04IN202801 - Machine Learning (V)
Every 3rd term

04IN202802 - Machine Learning (Ü)
only in the winter semester

5 **Language of instruction**

04IN202801 - Machine Learning (V)
English

04IN202802 - Machine Learning (Ü)
English

6 **Individual course requirements**

Basic knowledge of linear algebra, stochastics, data structures and algorithms.

7 **Examination**

Machine learning as not specified (N/A)

8 **Requirements for the awarding of credit points**

9 **Significance of the final grade**

	6/120 of the study programme
10	**Module coordinator** Mr Steffen Staab
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202801 - Machine Learning (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202802 - Machine Learning (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN202801 - Machine Learning (V)** • Bishop: Pattern Recognition and Machine Learning • Duda, Hart, Stork: Pattern Classification • Manning, Schütze: Foundations of Statistical Natural Language Processing
13	**Used in the following study programmes** M.Sc. Web and Data Science (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information** Students must participate actively in the lectures and tutorials

module 50 **04IN2029**	**Artificial Intelligence**						6 credit points Elective module	
Workload 180 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	50.1	V	Artificial intelligence	04IN202901	Compulsory	2 SWS 30 hours	60 hours	70	3
	50.2	Ü	Artificial Intelligence	04IN202902	Compulsory	2 hours per week 30 hours	60 hours	35	3

2 **Learning outcomes / Competences**

Students gain a basic understanding of the symbolic approach to artificial intelligence, including symbolic search, logic, and knowledge representation. Moreover, students gain experience in practical programming with Prolog.

3 **Contents**

04IN202901 - Artificial Intelligence (V)

The lecture provides an overview of the symbolic approach to artificial intelligence with a focus on logic, symbolic search, and knowledge representation methods.

1. Introduction
2. Classical logics and Prolog
    1. Classical logics
    2. Prolog
3. Search and automatic planning
    1. Uniformed search
    2. Informed search
    3. Situation calculus and STRIPS
4. Knowledge representation and reasoning
    1. Default logic
    2. Answer set programming
    3. Formal argumentation
    4. Belief revision (optional)
5. Agents and multi-agent systems
    1. Agent models
    2. Multi-agent logics (optional)
6. Summary and conclusion

4 **Frequency of the offer**

04IN202901 - Artificial Intelligence (V)
Summer semester only

04IN202902 - Artificial Intelligence (Ü)
only in the summer semester

5 **Language of instruction**

04IN202901 - Artificial Intelligence (V)

	English **04IN202902 - Artificial Intelligence (Ü)** English
6	**Individual course requirements** Foundational knowledge of logic, formal methods, and algorithms is expected.
7	**Examination** Artificial intelligence as not specified (n.a. n.a.)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Matthias Thimm
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202901 - Artificial Intelligence (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN202902 - Artificial Intelligence (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Stuart Russell, Peter Norvig. Artificial Intelligence: A Modern Approach. Third Edition, Prentice Hall, 2010 Christoph Beierle, Gabriele Kern-Isberner. Methods of Knowledge-Based Systems. Fourth Edition, Vieweg +Teubner, 2008 Ronald Brachman, Hector Levesque. Knowledge Representation and Reasoning. First Edition, Morgan Kaufmann Series, 2004 Gerhard Weiss (editor). Multiagent Systems. Second Edition, MIT Press, 2013
13	**Used in the following study programmes** M.Sc. Web and Data Science (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information**

module 51 04IN2031	Automated Reasoning and Knowledge Representation	6 credit points Elective module
Workload 180 hours	**semester** N/A	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	51.1	V	Automated Reasoning and Knowledge Representation	04IN203101	Compulsory	2 hours per week 30 hours	60 hours	30	3
		Ü	Automated Reasoning and Knowledge Representation	04IN203102	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students will understand the structure and functioning of knowledge representation and reasoning systems. In particular, they will learn to distinguish between different classes of systems and proof procedures. They will also practise using the systems in a practical context and examine simple applications from various areas of Computer Sciences.

3 **Contents**

04IN203101 - Automated Reasoning and Knowledge Representation (V)

1. Supplements to logic (equality and arithmetic)
2. Modal logics
3. Description logic
4. Dynamic logic
5. Applications and systems

4 **Frequency of offering**

Only in the summer semester

04IN203101 - Automated Reasoning and Knowledge Representation (V)

Summer semester only

04IN203102 - Automated Reasoning and Knowledge Representation (Ü)

only in the summer semester

5 **Language of instruction**

04IN203101 - Automated Reasoning and Knowledge Representation (V)

German

04IN203102 - Automated Reasoning and Knowledge Representation (Ü)

German

6 **Individual course requirements**

7 **Examination**

Automated Reasoning and Knowledge Representation: see https://ist.uni-koblenz.de/MoMa/

8 **Requirements for the award of credit points**

9 **Significance of the final grade**

6/120 of the study programme

10	**Module coordinator** Mr Ulrich Furbach
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203101 - Automated Reasoning and Knowledge Representation (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203102 - Automated Reasoning and Knowledge Representation (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN203101 - Automated Reasoning and Knowledge Representation (V)** • Robinson, Voronkov, Handbook of Automated Reasoning, North Holland 2001
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 52 04IN2032 module	**Fundamentals of Embedded Systems**							6 credit points Compulsory elective
Workload 180 hours			**semester** 3rd term (recommended)				**Duration** 1 term	
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	52.1	V	Fundamentals of Embedded Systems	04IN203201	Compulsory	3 SWS 45 hours	75 hours	30	4
	52.2	S	Fundamentals of Embedded Systems	04IN203202	Compulsory	1 SWS 15 hours	45 hours	30	2

2 **Learning outcomes / Competences**

After attending the course, students will be able to understand simple embedded systems in terms of their hardware and software structure. Students will learn to recognise which relevant areas of technological competence need to be combined and applied in order to design a functioning embedded system. In particular, basic modelling methods and techniques will be applied and evaluated. Students will recognise that embedded systems must fulfil safety-related functions and that their risks must be systematically assessed. The course enables students to gain a scientific understanding of this subject area.

3 **Contents**

04IN203201 - Fundamentals of Embedded Systems (V)

1. Introduction
   - Motivation, definitions, delimitation, application examples
2. Fundamentals of Embedded Systems
   - Control engineering, Kalman filters, Petri nets, transformations, fuzzy logic
3. Hardware of Embedded Systems
   - Processors and interfaces, energy-efficient operation, sensors and actuators, bus systems
4. Embedded systems software
   - Software architecture, software engineering, model-based software development, fundamentals of process planning (planning by deadlines, planning by monotonic rates)
5. Further topics
   - Safety standards, risk analysis, wireless sensor networks, cyber-physical systems

4 **Frequency**

04IN203201 - Fundamentals of Embedded Systems (V)

Every 3rd term

04IN203202 - Fundamentals of Embedded Systems (S)

Every 3rd term

5 **Language of instruction**

04IN203201 - Fundamentals of Embedded Systems (V)

German

04IN203202 - Fundamentals of Embedded Systems (S)

German

6	**Individual course requirements** Basic knowledge of operating systems
7	**Examination formats** Fundamentals of embedded systems: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Dieter Zöbel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203201 - Fundamentals of Embedded Systems (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203202 - Fundamentals of Embedded Systems (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Marwedel, Peter: Embedded Systems, Springer Verlag 2007 Berns, Karsten, Schürmann, Bernd, Trapp, Mario: System Fundamentals and Development of Embedded Software, Springer Verlag 2010
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 53 04IN2033	Decision-making process for verification	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	53.1	V	Decision-making process for verification	04IN203301	Comp	2 hours per week 30 hours	60 hours	30	3
	53.2	Ü	Decision-making process for verification	04IN203302	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students learn theories that are important in Computer Sciences (e.g. theories of data structures) and decision procedures for satisfiability in such theories. They can apply these decision procedures and understand how they can be used in programme verification.

3 **Contents**

04IN203301 - Decision-making procedures for verification (V)

1. Introduction; motivation
2. Review: Logic
   - Propositional logic; DPLL
   - Predicate logic; Resolution; Resolution as a decision procedure
3. Logical theories; decision procedures:
   - Equality;
   - Real and rational numbers, integers
4. Combinations of theories; combinations of decision procedures
5. SMT: DPLL(T)
6. Applications:
   - Decision procedures for lists and fields
   - Verification

04IN203302 - Decision Procedures for Verification (Ü)

The tutorials on "Decision procedures for verification" repeat and consolidate the content from the lectures. The topic-related tutorials are presented and discussed by the students.

4 **Frequency**

04IN203301 - Decision-making procedures for verification (V)

Every 3rd term

04IN203302 - Decision-making procedures for verification (Ü)

Every 3rd term

5 **Language**

04IN203301 - Decision-making Processes for Verification (V)

German

	04IN203302 - Decision-making procedures for verification (Ü) German
6	**Individual course requirements** Knowledge of logic: propositional logic, predicate logic. The book Uwe Schöning: "Logik für Informatiker" (Logic for Computer Sciences), 5th edition, Spektrum Akademischer Verlag, 2000, is suitable as a basis for prior knowledge.
7	**Examination** Decision-making process for verification: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Ms Viorica Sofronie-Stokkermans
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203301 - Decision-making procedures for verification (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203302 - Decision-making procedures for verification (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN203301 - Decision Procedures for Verification (V)** • Melvin Fitting: First-Order Logic and Automated Theorem Proving. Springer-Verlag, New York, 1996. • Uwe Schöning: Logic for Computer Scientists. Spektrum Akademischer Verlag, 2000 • A. Bradley and Z. Manna: The Calculus of Computation. Decision Procedures with Applications to Verification. Springer 2007. • Daniel Kroening and Ofer Strichman: Decision Procedures An Algorithmic Point of View, Springer 2008.
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualisation (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Regular and qualified participation in lectures is required in order to take the exam.

module 54 **04IN2035**	**Wireless Communication**	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	54.1	V	Wireless communication	04IN203501	Compulsory	2 hours per week 30 hours	90 hours	30	4
	54.2	Ü	Wireless Communication	04IN203502	Compulsory	2 hours per week 30 hours	30 hours	30	2

2 **Learning outcomes / Competences**

Students will acquire the fundamentals of wireless communication. They will be able to evaluate wireless systems analytically or through simulation. In addition, they will acquire the knowledge of the extent to which certain forms of wireless communication can be used for given applications and where the limits of wireless communication lie. Last but not least, they will be able to assess the potential of wireless communication for exciting new applications.

3 **Contents**

04IN203501 - Wireless Communication (V)

1. Introduction: Motivation and terminology; history of wireless communication; simplified reference model
2. Technical fundamentals: Electromagnetic waves; frequencies and regulations; antennas; signals; signal propagation; multiplexing; modulation; spread spectrum techniques; coding
3. Media access control: Motivation for special MAC procedures; Multiple access through spatial multiplexing (SDMA); Multiple access through frequency multiplexing (FDMA); Multiple access through time multiplexing (TDMA); Code division multiple access (CDMA)
4. Sensor networks: Example applications; Sensor hardware and network architecture; Challenges and methods; MAC layer case study IEEE 802.15.4; Energy-efficient MAC layers; WSN programming
5. Cellular networks: Cell geometry; Frequency reuse; Common system functions; Propagation models; Traffic engineering; Example GSM; Example UMTS
6. Infrastructure-less networks: Network structure and problems investigated; Topology-based routing protocols; Geographical routing protocols
7. TCP in the context of wireless communication

4 **Frequency of offering**

04IN203501 - Wireless Communication (V)

Every 3rd term

04IN203502 - Wireless Communication (Ü)

Every 3rd term

5 **Language of instruction**

04IN203501 - Wireless Communication (V)

English

04IN203502 - Wireless Communication (Ü)

English

6	**Individual course requirements** Knowledge of the layer model for communication systems and general standard procedures for bit transmission, connection security, media access control, network layer and transport layer.
7	**Examination formats** Wireless communication not specified (N/A)
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Johannes Frey
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203501 - Wireless Communication (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203502 - Wireless Communication (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN203501 - Wireless Communication (V)** • Jochen Schiller, Mobile Communication, 2nd edition, Addison Wesley, 2003 • Mischa Schwartz, Mobile Wireless Communications, Cambridge University Press, 2005 • Theodore Rappaport, Wireless Communications, Principles and Practice, Second Edition, Prentice Hall, 2002 • William Stallings, Wireless Communications & Networks, 2nd edition, Prentice Hall, 2005 • Holger Karl and Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, Wiley, 2005
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 55 04IN2037	Software Language Engineering	6 credit points Elective module

Workload 180 hours	semester	Duration 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	55.1	V	Software Language Engineering	04IN203701	Compulsory	2 hours per week 30 hours	60 hours	30	3
	55.2	S	Software Language Engineering	04IN203702	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students will master simple techniques and scenarios of language design and language implementation in terms of integrating compiler construction and special language development. In doing so, students will use declarative methods and engineering methods.

3 **Contents**

1. Overview and motivation
2. Lexical analysis
3. Syntactic analysis
4. Semantic analysis
5. Embedding of languages
6. Attributed grammars
7. Programme analysis
8. Programme transformation
9. Programme generation
10. Special languages
11. Grammar-based methods
12. Software re-/reverse engineering
13. Model-driven engineering

4 **Frequency of offer**

04IN203701 - Software Language Engineering (V)
Every 3rd term

04IN203702 - Software Language Engineering (S)
Every 3rd term

5 **Language of instruction**

04IN203701 - Software Language Engineering (V)
German

04IN203702 - Software Language Engineering (S)
German

6 **Individual course requirements**

Basic knowledge of declarative programming and formal languages.

7 **Examination**

	Software Language Engineering: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Ralf Lämmel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203701 - Software Language Engineering (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN203702 - Software Language Engineering (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** • Conference Proceedings Software Language Engineering. Springer. • Conference proceedings Generative and Transformational Techniques in Software Engineering. Springer. • Chapter-by-chapter specialised literature
13	**Use in study programme** M.Sc. Web and Data Science (2019) B.Sc. Computer Sciences (2019) B.Sc. Computer Visualisation (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 56 **04IN2042**	**Computational Social Science**							6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	56.1	V	Computational Social Science	04IN204201	Comp	2 hours per week 30 hours	60 hours	30	3
	56.2	S	Computational Social Science	04IN204202	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

In this course, students learn about opportunities and challenges when using digital trace data and computational methods to study social phenomena. More specifically, students learn how to

- design and work on a computational social science research project
- collect and combine social data
- critically reflect on measurement and representation errors
- select, test, apply and provisionally evaluate methods from the field of computer science in order to answer social science questions.

04IN204201 - Computational Social Science (V)

3 **Contents**

04IN204201 - Computational Social Science (V)

The lecture introduces students to the research area of computational social science.

The students will be trained to select, test, apply, and provisionally evaluate methods from the field of computer science in order to answer social science questions.

A basic understanding of the possible application of data mining methods will be developed for this purpose, as well as an understanding of the significance and possibilities of the operationalisation of issues and problems established in the social sciences.

The content of the module includes the following areas:

- Introduction to Social Science Questions and Computational Methods
- Data collection methods
- Text mining methods
- Communication Science Theories
- Social Network Analysis
- Social Network Theories
- Auditing Socio-technical Systems

04IN204202 - Computational Social Science (S)

Students will learn how to design and set up a computational social science project and work on small research problems in groups.

4 **Frequency**

04IN204201 - Computational Social Science (V)
Every 3rd term

04IN204202 - Computational Social Science (S)
Every 3rd term

5 **Language of instruction**

04IN204201 - Computational Social Science (V)
English

04IN204202 - Computational Social Science (S)
English

6 **Individual course requirements**

Programming skills in Python or R

7 **Examination formats**

Computational Social Science as not specified (N/A N/A)

8 **Requirements for awarding credit points**

9 **Significance of the final grade**

6/120 of the study programme

10 **Module coordinator**

Ms Claudia Wagner

11 **Responsible institution**

FB 4 - Computer Sciences **->** Institute for Computer Science

04IN204201 - Computational Social Science (V)
FB 4 - Computer Sciences **->** Institute for Computer Science

04IN204202 - Computational Social Science (S)
FB 4 - Computer Sciences **->** Institute for Computer Science

12 **Literature**

04IN204201 - Computational Social Science (V)

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- Puschmann, C. & Burgess, J. (2013). The politics of Twitter data. In K. Weller, A. Bruns, J. Burgess, M. Mahrt, & C. Puschmann (Eds.), Twitter and Society (pp. 43–54). New York, NY: Peter Lang Publishing.
- Rogers, R. (2013b). Digital methods. Cambridge, MA: The MIT Press.
- Rogers, R. (2013a). Debanalising Twitter: The transformation of an object of study. In H. Davis, H. Halpin, A. Pentland, M. Bernstein, & L. Adamic (Eds.), Websci 2013: Proceedings of the 5th annual ACM Web Science Conference (pp. 356–365). New York, NY: ACM. doi:10.1145/2464464.2464511.
- Ruths, D. & Pfeffer, J. (2014). Social media for large studies of behaviour. Science, 346(6213), 1063–1064. doi:10.1126/science.346.6213.1063.

13	**Used in the study programmes** M.Sc. Web and Data Science (2019) M.Sc. Web and Data Science (2019) M.Sc. Business Informatics (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information** Regular qualified participation in the courses (max. 2 absences) as well as the successful completion of the individual exercises and the course project are required for exam participation. **04IN204201 - Computational Social Science (V)** Slides, web page.

module 57 04IN2043	Introduction to Data Science	6 credit points Elective module

Workload 180 hours	semester	Duration 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	57.1	V	Introduction to Data Science	04IN204301	Compulsory	2 hours per week 30 hours	60 hours	60	3
	57.2	S	Introduction to Data Science	04IN204302	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

A good understanding of tasks and challenges in data analysis. The student should be able to understand the statistical foundations of data analysis and be able to apply them in big data settings. For this purpose, students should become familiar with the theoretical foundations of data engineering and large-scale data analysis and data analysis platforms.

3 **Contents**

04IN204301 - Introduction to Data Science (V)

Data science describes a set of methods for handling data-intensive problems. The topic connects several disciplines such as physics, biology, social sciences and economics. It uses elaborate computer science paradigms and requires a background in statistics.

More specifically, the lecture will cover the following topics:

Topics:

1. Data science: history and background, paradigm shift from statistics to programming
2. Problem scenarios will mostly deal with open data, such as found on the web and open statistical data
3. Background in statistics
   - Details of computing statistics and determining the quality of a probabilistic model. In particular, we will look at distributions commonly used for modelling:
   - Uniform distribution
   - Normal distribution
   - Exponential distribution
   - Power law distribution
   - Poisson distribution
   - Log normal distribution

   And we will look at quality measures such as:
   - Students' t-test (valid only for normal distributions)
   - Chi-square
   - ANOVA
   - Kulback-Leibler and Jensen-Shannon
   - Kolmogorov-Smirnov
4. Hypothesis-driven research
   - Hypothesis testing
   - Statistical fallacies
   - Applications
5. Programming paradigms
   - Relational and NoSQL database management systems
   - Parallel task processing: Gridgain

	- MapReduce (Hadoop/Spark) - Graph paradigms (GraphLab, neo4j, RDF databases) 6. Visualisation 7. Simple machine learning on large-scale data 8. Example application domain: text - n-grams - p-grams - generalised n-grams (gappy n-grams) 9. Privacy **04IN204302 - Introduction to Data Science (S)** The contents of the lecture are practised in depth. Students solve data science problems partly with pen and paper and partly programmatically.
4	**Frequency** **04IN204301 - Introduction to Data Science (V)** Winter semester only **04IN204302 - Introduction to Data Science (S)** only in the winter semester
5	**Language of instruction** **04IN204301 - Introduction to Data Science (V)** English **04IN204302 - Introduction to Data Science (S)** English
6	**Individual course requirements** This module requires a basic understanding of algorithmics and programming as well as basic knowledge of linear algebra and statistics.
7	**Examination formats** Introduction to Data Science: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Ms Claudia Wagner
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204301 - Introduction to Data Science (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204302 - Introduction to Data Science (S)**

	FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN204301 - Introduction to Data Science (V)** 1. Anand Rajaraman, Jeffrey Ullman, Jure Leskovec, Mining of Massive Datasets, Cambridge University Press (free download) 2. Jeffrey Stanton, Introduction to Data Science 3. Think Stats Probability and Statistics for Programmers by Downey 4. Dive into Python (FREE) or Python Data Science Handbook by VanderPlas 5. Storytelling With Data: A Data Visualisation Guide for Business Professionals by Nussbaumer Knaflic
13	**Used in the** M.Sc. Web and Data Science **study programme** (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Regular qualified participation in courses (max. 2 absences) and completion of exercises (max. 2 missing assignments) are required to take the exam. **04IN204301 - Introduction to Data Science (V)** Octave, R

module 58 **04IN2044**	**Local network structures**						6 credit points Elective module	
Workload 180 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	58.1	V	Local network structures	04IN204401	Compulsory	2 hours per week 30 hours	60 hours	30	3
	58.2	Ü	Local network structures	04IN204402	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

- Knowledge of mathematically manageable models for wireless multihop networks
- Knowledge of local data communication methods for wireless multi-hop networks
- Knowledge of locally manageable graph constructs that enable local data communication
- Ability to formally address graph-theoretical and algorithmic problems in the context of wireless multi-hop networks
- Ability to assess the applicability of theoretical concepts in the context of wireless multi-hop networks

3 **Contents**

04IN204402 - Local Network Structures (Ü)

1. Network types: sensor networks, ad hoc networks, sensor-actuator networks, robot networks
2. Definition of local network structures
3. Discussion of local and reactive network algorithms
4. Topology control: Independent sets, dominating sets, Planar graphs, Spanners; Degree-restricted graphs; Sensor coverage
5. Unicast: Hop count metric-based method, energy metric-based method; reactive unicast; routing in hexagon graph with double range property
6. Multicast: Methods based on hop count and energy metrics
7. Graph models and limitations of the models

4 **Frequency of offering**

04IN204401 - Local Network Structures (V)

Every 3rd term

04IN204402 - Local Network Structures (Ü)

Every 3rd term

5 **Language of instruction**

04IN204401 - Local Network Structures (V)

German

04IN204402 - Local Network Structures (Ü)

German

6 **Individual course requirements**

7 **Examination**

	Local network structures as no information available (n/a)
8	**Requirements for awarding credit points**
9	**Importance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Johannes Frey
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204401 - Local Network Structures (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204402 - Local Network Structures (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information** • Slides • Board notes

module 59 **04IN2045**	**Mining software repositories**						6 credit points Elective module	
Workload 180 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	59.1	V	Mining Software Repositories	04IN204501	Compulsory	2 hours per week 30 hours	60 hours	30	3
	59.2	S	Mining Software Repositories	04IN204502	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

The field of "Mining Software Repositories" (MSR) deals with the analysis of data available in software repositories in order to obtain scientific and practically useful information about software systems and software development. The course provides students with a basic understanding of MSR. Students gain a good overview of typical and current problems
and corresponding solutions in the field of MSR. Finally, students will also be able to plan, carry out and present their own research questions in the field of MSR in terms of the basic phases of extraction, synthesis and analysis in a combined scientific and engineering manner.

3 **Contents**

I. Overview and motivation
II. Exemplary studies on MSR
III. Relevant data and sources
IV. Data extraction and modelling
V. Simple synthesis
VI. Synthesis using information retrieval
VII. Synthesis using data mining
VIII. Analysis
IX. Relation to empirical software engineering
IX. Relation to software reverse and re-engineering
X. Planning of student projects
XI. Evaluation of student projects

4 **Frequency of the course**

04IN204501 - Mining Software Repositories (V)
Every 3rd term

04IN204502 - Mining Software Repositories (S)
Every third term

5 **Language of instruction**

04IN204501 - Mining Software Repositories (V)
English

04IN204502 - Mining Software Repositories (S)
English

6	**Individual course requirements** • Skills and knowledge in software engineering • Competencies in statistics, data mining and information retrieval are recommended
7	**Examination formats** Mining Software Repositories as not specified (N/A N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Ralf Lämmel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204501 - Mining Software Repositories (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204502 - Mining Software Repositories (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** - Proceedings of the conference "Mining Software Repositories" - Further conference volumes from the field of software engineering - Selected specialist literature (journal and conference articles)
13	**Use in study programmes** M.Sc. Web and Data Science (2019) B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 60 **04IN2047**	**Process Mining**							6 credit points Elective module	
Workload 180 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	60.1	V	Process mining	04IN204701	Compulsory	2 hours per week 30 hours	60 hours	30	3
	60.2	S	Process Mining	04IN204702	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Participants will receive a basic introduction into business process modelling using Petri nets as needed for the foundation of the Process Mining techniques considered in this course. They will learn the central techniques in process mining and will learn about some existing applications in practice. They will thus be put in a position to be able to apply these techniques in practice independently.

3 **Contents**

4 **Frequency**

04IN204701 - Process Mining (V)
Irregular

04IN204702 - Process Mining (S)
Irregular

5 **Language of instruction**

04IN204701 - Process Mining (V)
German

04IN204702 - Process Mining (S)
German

6 **Individual course requirements**

Knowledge of the fundamentals of computer science

7 **Examination**

Process mining as no information (N/A)

8 **Requirements for awarding credit points**

9 **Significance of the final grade**

6/120 of the study programme

10 **Module coordinator**

Prof. Dr. Jan Jürjens

11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204701 - Process Mining (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204702 - Process Mining (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced in the relevant courses
13	**Used in study programmes** M.Sc. Web and Data Science (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information**

module 61 04IN2048	Probabilistic functional programming	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	61.1	V	Probabilistic functional programming	04IN204801	Compulsory	2 hours per week 30 hours	60 hours	30	3
	61.2	Ü	Probabilistic functional programming	04IN204802	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

In this module, students will acquire a detailed understanding of how to functionally programme with probabilities, knowledge about inference methods for parametric and non-parametric statistics. They will acquire detailed knowledge of the programming language Church.

3 **Contents**

04IN204801 - Probabilistic functional programming (V)

The programming language Church is a functional language built on the language Scheme with the capability to represent stochastic variables. Thus, it allows for a high-level view of common probabilistic reasoning methods. In the lecture we will pursue the following topics:

1. Functional Programming with Scheme: Functions, lists, let, lambda abstraction, application, recursion
2. Functional Programming with Scheme: Tail recursion, closures
3. Generative models
4. Conditioning
5. Patterns of inference
6. Models for sequences of operations
7. Inference about inference
8. Algorithms for inference
9. Hierarchical models
10. Occam's Razor
11. Mixture models
12. Non-parametric models

Probabilistic scheme available at http://probmods.org

4 **Frequency of the course**

04IN204801 - Probabilistic functional programming (V)
Every 3rd term

04IN204802 - Probabilistic functional programming (Ü)
Every 3rd term

5 **Language of instruction**

04IN204801 - Probabilistic functional programming (V)

English

	04IN204802 - Probabilistic functional programming (Ü) English
6	**Individual course requirements** This module requires a basic understanding of algorithmics and programming as well as basic knowledge of probability theory.
7	**Examination** Probabilistic Functional Programming: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 from the study programme
10	**Module coordinator** Mr Steffen Staab
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204801 - Probabilistic functional programming (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN204802 - Probabilistic functional programming (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN204801 - Probabilistic functional programming (V)** 1. Abelson, Sussman: Structure and Interpretation of Computer Programs, MIT Press, http://groups.csail.mit.edu/mac/classes/6.001/abelson-sussman-lectures/ 2. N. D. Goodman and J. B. Tenenbaum (electronic). Probabilistic Models of Cognition. Retrieved 20 June 2016 fromhttp://probmods.org 3. Wood, F., van de Meent, J. W., & Mansinghka, V. (2014). A New Approach to Probabilistic Programming Inference. In Proceedings of the 17th International conference on Artificial Intelligence and Statistics (1024-1032). BIB PDF http://www.robots.ox.ac.uk/~fwood/anglican/ 4. Michael Izbicki. HLearn: A Machine Learning Library for Haskell. Retrieved 20 June 2016.
13	**Use in study programmes** M.Sc. Web and Data Science (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualisation (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information**

module 63 **04IN2103**	**Performance Evaluation of Wireless Networks**						6 credit points Elective module		
Workload 180 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	63.1	V	Performance evaluation of wireless networks	04IN210301	Comp	2 SWS 30 hours	90 hours		4
	63.2	S	Performance evaluation of wireless networks	04IN210302	Compulsory	2 SWS 30 hours	30 hours	30	2

2 **Learning outcomes / Competences**

In this lecture, students learn the necessary fundamentals for analysing wireless communication systems. In addition, tutorials train students to work with mathematical computer-aided tools and perform analyses.

3 **Contents**

This course introduces mathematical tools for analysing wireless networks.

04IN210301 - Performance Evaluation of Wireless Networks (V)

- Introduction and motivation
- Excerpts from measure and probability theory
- Modelling components for wireless communication
- Stochastic transformations and example applications
- Excerpts from integration theory for calculating point processes
- Point processes for modelling wireless networks

4 **Frequency of the course**

04IN210301 - Performance Evaluation of Wireless Networks (V)
Every 3rd term

04IN210302 - Performance Evaluation of Wireless Networks (S)
Every 3rd term

5 **Language of instruction**

04IN210301 - Performance Evaluation of Wireless Networks (V)
German

04IN210302 - Performance Evaluation of Wireless Networks (S)
German

6 **Individual course requirements**

Interest in mathematics. The necessary mathematical foundations will be covered in the lecture.

7 **Examination**

Performance evaluation of wireless networks: see https://ist.uni-koblenz.de/MoMa/

8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Johannes Frey
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN210301 - Performance Evaluation of Wireless Networks (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN210302 - Performance Evaluation of Wireless Networks (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN210301 - Performance Evaluation of Wireless Networks (V)** Lecture notes
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 64 **04IN2106**	**Mobile Systems Engineering**		6 credit points Elective module
Workload 180 hours	**semester**		**Duration** 1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	64.1	V	Mobile Systems Engineering	04IN210601	Compulsory	2 hours per week 30 hours	60 hours	30	3
	64.2	S	Mobile Systems Engineering	04IN210602	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / competences**

Computer and communication systems are becoming increasingly compact, powerful and versatile. Accordingly, the mobile use of such devices is penetrating almost all areas of life and changing them sustainably. This includes devices whose mobility is externally determined, such as smartphones and navigation systems, as well as devices whose mobility is self-determined, such as driverless transport systems and autonomous service robots. Both topics, those with externally determined mobility and those with self-determined mobility, are the subject of the Mobile Systems Engineering (MSE) specialisation.

The Mobile Systems Engineering lecture series provides a broad introduction to the subject area of mobile systems. The lectures by various lecturers are intended to raise central and peripheral questions about mobile applications and present known approaches to solutions. In the tutorial, practical skills in two subject areas are taught using examples:

Robot control with ROS (Robot Operating System) Software development
for smartphones

3 **Contents**

As this is a lecture series with external and internal lecturers, the content cannot be specified in detail. However, the topics are likely to cover the fields of sensor and signal technology, positioning technology, radio technology, image processing, artificial intelligence, functional safety, attack safety, vehicle kinematics and software technology for embedded systems, as well as others.

4 **Frequency of offering**

04IN210601 - Mobile Systems Engineering (V)
Every 3rd term

04IN210602 - Mobile Systems Engineering (S)
Every 3rd term

5 **Language of instruction**

04IN210601 - Mobile Systems Engineering (V)
German

04IN210602 - Mobile Systems Engineering (S)
German

6 **Individual course requirements**

7	**Examination formats** Mobile Systems Engineering as not specified (N/A N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Dieter Zöbel
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN210601 - Mobile Systems Engineering (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN210602 - Mobile Systems Engineering (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** • J. Hertzberg, K. Lingemann, A. Nüchter - Mobile Robots, Springer Verlag, 2012 • M. Quigley, B. Gerkey, W. D. Smart – Programming Robots with ROS, O'Reilly, 2011 • R. Ye – Embedded Programming with Android, John Wiley, 2016 • G. Klancar, A. Zdesar, S. Blazic, I. Skrjanc – Wheeled Mobile Robotics, Kindle eBook, 2017 • Ch. Hobbs - Embedded Software Development for Safety-Critical Systems, CRC-Book, 2016
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information**

module 65 04IN2112	Advanced Secure Software Engineering	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	65.1	V	Advanced Secure Software Engineering	04IN211201	Comp	2 SWS 30 hours	60 hours	30	3
	65.2	S	Advanced Secure Software Engineering	04IN211202	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Participants gain in-depth insight into selected current topics in IT security. The focus is on in-depth conceptual knowledge of IT security and basic practical knowledge of dealing with IT security in the context of software development and deployment.

3 **Contents**

Chapter 1: Introduction and motivation: In-depth topics in IT security Chapter 2: Security engineering

- IT security throughout the software life cycle: Microsoft Security Development Lifecycle (SDL)
- Security by design
- Security principles
- Vulnerability databases – Which software/hardware has which gaps?
- Attack surface reduction
- Threat analysis
- Model-based security with UMLsec

Chapter 3: IT security in a practical context: attacks and how to defend against them

- Meltdown & Spectre
- Buffer overflows
- Integer arithmetic vulnerabilities
- Canonisation problems, insecure use of cryptography
- Security testing

Chapter 4: Common vulnerabilities in web applications (including measures and best practices)

1. Unvalidated parameters
   (a) Command injection (especially SQL injection)
   (b) Cross-site scripting vulnerabilities
2. Insecure access control
   (a) Errors in account and session management
   (b) Errors in access control
   (c) Security-related misconfiguration
3. Other vulnerabilities in the software
   (a) Insecure direct object references
   (b) Untested redirects
   (c) Insecure error handling
   (d) Use of insecure components

	(e) Insecure use of cryptography 4. Weaknesses in security management (a) Inadequate logging (b) Insecure remote maintenance (c) Insecure web server configuration Chapter 5: Security design of web applications and web application security tools e.g. WebShields, web scanners Chapter 6: IT security vs. governance, risk and compliance (GRC) The new EU General Data Protection Regulation (GDPR)
4	**Frequency of offering** **04IN211201 – Advanced Secure Software Engineering (V)** Irregular **04IN211202 - Advanced Secure Software Engineering (S)** Irregular
5	**Language of instruction** **04IN211201 - Advanced Secure Software Engineering (V)** German **04IN211202 - Advanced Secure Software Engineering (S)** German
6	**Individual course requirements** Prerequisites for participation are the successful acquisition of knowledge as taught, for example, in modules 04IN1010 (Object-Oriented Programming and Modelling) and 04IN1104 (Programming Techniques and Software Design), such as: • Programming skills in an object-oriented programming language (usually Java) and use of development environments • Confidence in the use of basic APIs (e.g. collections) • Knowledge of algorithms and data structures • Ability to model UML models for structure (class diagrams) and behaviour (activity diagrams, statecharts, sequence diagrams) for software design and design patterns • Ability to implement simple models, understand the relationship between models and code • Fundamentals of testing and verification
7	**Examination formats** Advanced Secure Software Engineering: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Jan Jürjens
11	**Responsible institution**

	FB 4 - Computer Sciences **->** Institute for Computer Science **04IN211201 - Advanced Secure Software Engineering (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN211202 - Advanced Secure Software Engineering (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN211201 - Advanced Secure Software Engineering (V)** • John Viega, Gary McGraw: Building Secure Software: How to Avoid Security Problems the Right Way, Addison-Wesley 2001 • The Open Web Application Security Project (OWASP): OWASP Top 10 2013: The 10 Most Common Web Application Security Risks, 2013 • J. Jürjens: Secure Systems Development with UML, Springer 2005
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Qualified participation in the tutorials or the successful presentation of a seminar paper are required for exam participation.

module 66 04IN2113	Advanced Smart Data Analytics	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	66.1	V	Advanced Smart Data Analytics	04IN211301	Comp	2 hours per week 30 hours	60 hours	30	3
	66.2	S	Advanced Smart Data Analytics	04IN211302	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / competences**

Digitalisation is the central social, economic and technological development. On the one hand, it is a consequence of a number of developments and, on the other hand, it is an 'enabler' of these developments. Usage models based on the sharing of resources are increasingly flourishing.

The most important success factor in meeting these requirements for products and services is the necessary data (from customers as well as products and services). The ability to manage data as an economic asset and offer "smart" services on this basis is therefore a competitive factor for companies, which is increasingly becoming an existential prerequisite.

Participants will gain an in-depth understanding of current topics, techniques and developments in the field of advanced data analytics in companies.

3 **Contents**

Chapter 1: Introduction and motivation: Advanced data analytics: Big data with artificial intelligence Chapter 2: Review: Data mining basics/overview
Chapter 3: Review: Process modelling and analysis Chapter 4: In-depth: Business
process mining Advanced techniques and concepts
Chapter 5: In-depth: Data exchange platforms
Industrial Data Space: Advanced Techniques and Concepts
Blockchains: Securing Data-Based Transactions: Advanced Techniques and Concepts
Chapter 6: In-depth: Governance – Risk – Compliance in Data Analysis Relevant Laws and Regulations
Chapter 7: In-depth: Digital insurance industry: Quo Vadis? In-depth discussion

4 **Frequency of offering**

04IN211301 – Advanced Smart Data Analytics (V)

Irregular

04IN211302 - Advanced Smart Data Analytics (S)

Irregular

5 **Language of instruction**

04IN211301 - Advanced Smart Data Analytics (V)

German

	04IN211302 - Advanced Smart Data Analytics (S) German
6	**Individual course requirements** Prerequisites for participation are the successful acquisition of knowledge as taught, for example, in modules 04IN1010 (Object-Oriented Programming and Modelling) and 04IN1104 (Programming Techniques and Software Design), such as: • Programming skills in an object-oriented programming language (usually Java) and use of development environments • Confidence in the use of basic APIs (e.g. collections) • Knowledge of algorithms and data structures • Ability to model UML models for structure (class diagrams) and behaviour (activity diagrams, statecharts, sequence diagrams) for software design and design patterns • Ability to implement simple models, understand the relationship between models and code • Fundamentals of testing and verification
7	**Examination formats** Advanced Smart Data Analytics: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Jan Jürjens
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN211301 - Advanced Smart Data Analytics (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN211302 - Advanced Smart Data Analytics (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Qualified participation in the tutorials or the successful presentation of a seminar paper is required for exam participation.

module 67 **04IN2116**	**Advanced Topics in Web-based and Data-intensive Software and its Security**		6 credit points Elective module
Workload 180 hours	**semester**		**Duration** 1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	67.1	V	Advanced Topics in Web-based and Data-intensive Software and its Security	04IN21161	Compulsory	2 hours per week 30 hours	60 hours	30	3
	67.2	S	Advanced Topics in Web-based and Data-intensive Software and its Security	04IN211602	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

The goal is for the participants to become deeply familiar with advanced topics in web-based and data-intensive software and its security.

3 **Contents**

The module concerns Advanced Topics in Web-based and Data-intensive Software and its Security, including current research topics such as:

- Engineering Responsible Information Systems
- Security, Privacy, Transparency and Fairness of algorithms for Smart Data Analytics
- Secure Software Engineering, including Model-based Security Engineering
- Current developments in industry, such as the Industrial Data Space, Blockchains, etc.

4 **Frequency of offering**

04IN21161 - Advanced Topics in Web-based and Data-intensive Software and its Security (V)

Check input

04IN211602 - Advanced Topics in Web-based and Data-intensive Software and its Security (S)

Irregular

5 **Language of instruction**

04IN21161 - Advanced Topics in Web-based and Data-intensive Software and its Security (V)

German

04IN211602 - Advanced Topics in Web-based and Data-intensive Software and its Security (S)

German

6 **Individual course requirements**

Prerequisite for participation is the successful participation in lectures comparable to the following lectures in the Koblenz Bachelor studies, in particular the modules 04IN1010 (Object-Oriented Programming and Modelling), 04IN1104 (Programming Techniques and Software Design) and 04IN1012 (Foundations of Software Engineering), including the following topics:

- Solid ability to programme in an object-oriented programming language (e.g. Java) and use of software development environments, good knowledge in the use of relevant APIs (e.g. Collections)
- Knowledge of software architectures and orchestration of components

	• Ability to create UML models including class diagrams, activity diagrams, statecharts, sequence diagrams for software design and design patterns • Ability to implement models in code and to understand the relationship between models and code • Quality assurance: black box and white box testing
7	**Examination formats** Requirements engineering and management: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Jan Jürjens
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN21161 - Advanced Topics in Web-based and Data-intensive Software and its Security (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN211602 - Advanced Topics in Web-based and Data-intensive Software and its Security (S)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019)
14	**Other information** Successful participation in the tutorials (max. 2 missed tutorials) and the successful delivery of exercise solutions (max. 2 missing exercises, altogether at least 50% of the possible points). Alternatively, successful seminar presentation.

module 68 04IN2115	Random Communication Networks	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	68.1	V	Random communication networks	04IN211501	Comp	2 hours per week 30 hours	60 hours	30	3
	68.2	Ü	Random communication networks	04IN211502	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Students can clearly explain fundamental concepts and essential laws governing randomly generated networks. They can decide on the appropriate descriptive model for exemplary problem areas of randomly networked systems. They can derive global properties of randomly generated networks for canonical questions based on descriptive models and applicable laws using appropriate computer-aided mathematical tools.

3 **Contents**

04IN211501 - Random Communication Networks (V)

- Point process models
- Calculating with point processes
- Characterisation of Interference
- Marked point processes
- Palm theory
- Random geometric graphs
- Bond and site percolation
- Continuous percolation
- Connectivity and coverage

04IN211502 - Random Communication Networks (Ü)

Using example problems accompanying the lectures, students deepen their competence in model selection and determining the properties of randomly networking systems. Teamwork competence for technical problems is promoted through collaborative and interactive problem solving guided by the lecturer using the web-based cloud computing platform CoCoalc. CoCalc provides access to various open-source mathematical tools. Students will be able to transfer the principles of symbolic and numerical problem solving to other contexts and quickly familiarise themselves with other symbolic mathematical computing environments (e.g. Mathematica or SymPy).

4 **Frequency of offering**

04IN211501 - Random Communication Networks (V)

Every 3rd term

04IN211502 - Random Communication Networks (Ü)

Every 3rd term

5 **Language of instruction**

	04IN211501 - Random Communication Networks (V) German **04IN211502 - Random Communication Networks (Ü)** German
6	**Individual course requirements**
7	**Examination** Random communication networks as no information available (n/a)
8	**Requirements for the awarding of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Johannes Frey
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN211501 - Random Communication Networks (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN211502 - Random Communication Networks (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** **04IN211501 - Random Communication Networks (V)** Lecture notes with integrated tutorials and exam questions.
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 69 04WI1011	Computer Supported Cooperative Work	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	69.1	V	Computer Supported Cooperative Work	04WI101101	Comp	2 hours per week 30 hours	60 hours	30	3
	69.2	Ü	Computer Supported Cooperative Work	04WI101102	Compulsory	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Upon successful completion of the course, a competent student will be able to explain and provide examples of:

1. the functionality and business applications of current technologies and tools to support collaborative work
2. the risks and benefits arising from the use of collaborative technologies in organisations
3. the ways an organisation can use collaborative technologies to support communication, coordination, cooperation and content management
4. the information management and business processes associated with the use of collaborative technologies

3 **Contents**

04WI101101 - Computer Supported Cooperative Work (V)

The lecture provides an introduction to the theories and frameworks relevant to the study of CSCW, an overview of the business issues and challenges organisations face when orchestrating CSCW, and an up-to-date analysis and critique of current technologies, tools, and methods for supporting collaborative work.

1. Introduction to Computer Supported Cooperative Work (CSCW)
2. Designing the Collaborative Workplace: "Understanding Users and Use"
3. Communication: "The Nature of Online Interaction"
4. Cooperation and Collaboration: "Supporting Distributed Work"
5. Collaboration: "Enterprise 2.0 and Knowledge Sharing"
6. Coordination: "Facilitating and Automating Joint Work"
7. Content Combination and Content Management
8. Compliance: "Legal and Risk Issues"
9. Contribution and Change: "Deriving Benefits and Managing Adoption"
10. Social Collaboration Analytics: "Understanding and Improving Use"
11. Topic Integration and Course Review

4 **Frequency of offering**

04WI101101 - Computer Supported Cooperative Work (V)

Winter semester only

04WI101102 - Computer Supported Cooperative Work (Ü)

only in the winter semester

5 **Language of instruction**

04WI101101 - Computer Supported Cooperative Work (V)

	German **04WI101102 - Computer Supported Cooperative Work (Ü)** German
6	**Individual course requirements**
7	**Examination formats** Computer Supported Cooperative Work: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr. Petra Schubert
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI101101 - Computer Supported Cooperative Work (V)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI101102 - Computer Supported Cooperative Work (Ü)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach
12	**Literature** **04WI101101 - Computer Supported Cooperative Work (V)** • Williams, S.P. (2011): The 8C Model for Collaborative Technologies, in: Schubert, Petra; Koch, Michael (eds.), Competitive Factor Business Software, pp. 11-21, Munich: Hanser, 2011. • Koch, Michael; Richter, Alexander (2007): Enterprise 2.0: Planning, Introduction and Successful Use of Social Software in Companies, Munich, Vienna: Oldenbourg, 2007.
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Business Informatics (2019) B.Sc. Information Management (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 70 04WI1013	Fundamentals of IT Security	6 credit points Elective module

Workload	semester	Duration
180 hours	1st term (recommended)	1 term

1 **Courses**

				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
70.1	V	Fundamentals of IT Security	04WI101301	Compulsory	2 hours per week 30 hours	60 hours	180	3
70.2	Ü	Fundamentals of IT Security	04WI101302	Compulsory	2 hours per week 30 hours	60 hours	36	3

2 **Learning outcomes / Competences**

Students have knowledge of (lecture) and practical experience in dealing with (tutorial) the fundamental risks of information technology (IT). They are familiar with methods for analysing the security of computers, networks and information and communication applications in networks. They are able to carry out security analyses of simple applications themselves. They are familiar with basic security mechanisms and understand their mathematical principles. They can install and execute simple security mechanisms, for example securing WLANs against unauthorised intruders.

3 **Contents**

04WI101301 - Fundamentals of IT Security (V)

Particular emphasis is placed on modern cryptography and its applications on the Internet.

- Threats and security requirements
- Trust mechanisms
- Mathematical and informational fundamentals of cryptography
- Practical applications of cryptography
- Selected symmetric and asymmetric cryptographic algorithms (DES, AES, one-time pad, RSA, ElGamal, DSA)
- Digital signatures, variants and attacker models
- Public key infrastructures and PGP
- Network security mechanisms (IPSec, SSL, S/MIME, XML, web services)
- Authentication protocols (Kerberos, X.509, etc.)
- Malware: viruses, worms and Trojan horses

04WI101302 - Fundamentals of IT Security (Ü)

Tutorials based on the lecture content.

4 **Frequency**

Only in the winter semester

04WI101301 - Fundamentals of IT Security (L)

Only in the winter semester

04WI101302 - Fundamentals of IT Security (Ü)

Only in the winter semester

5 **Language of instruction**

	04WI101301 - Fundamentals of IT Security (V) German **04WI101302 - Fundamentals of IT Security (Ü)** German
6	**Individual course requirements**
7	**Examination** Fundamentals of IT security as an exam (written - 90 minutes)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr Andreas Mauthe
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI101301 - Fundamentals of IT Security (V)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI101302 - Fundamentals of IT Security (Ü)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach
12	**Literature** • B. Schneier, Beyond Fear: Thinking Sensibly about Security in an Uncertain World, Copernicus Books, 2003 • B. Schneier, Applied Cryptography. Protocols, Algorithms, and Source Code in C., 2nd Ed., Wiley & Sons, Chichester 1996 • C. Eckert, IT Security. Concepts, Procedures, Minutes, Study Edition, Oldenbourg Verlag, Munich 2012 • BSI – Federal Office for Information Security, IT Baseline Protection Manual – Standard Security Measures, Oct 2010, http://www.bsi.de/gshb/deutsch/ [checked 2012] • BSI literature on electronic signatures, https://www.bsi.bund.de/ContentBSI/Themen/ElektrSignatur/esiggrundlagen.html [checked 2012] • W. Diffie, M. E. Hellman, New Directions in Cryptography, IEEE Transactions on Information Theory, Vol. IT-22, 644-654, 1976 **04WI101301 - Fundamentals of IT Security (V)** • B. Schneier, Beyond Fear: Thinking Sensibly about Security in an Uncertain World, Copernicus Books, 2003 • B. Schneier, Applied Cryptography. Protocols, Algorithms, and Source Code in C., 2nd Ed., Wiley & Sons, Chichester 1996 • C. Eckert, IT Security. Concepts, Procedures, Minutes, Study Edition, Oldenbourg Verlag, Munich 2012 • BSI – Federal Office for Information Security, IT Baseline Protection Manual – Standard Security Measures, Oct 2010, http://www.bsi.de/gshb/deutsch/ [checked 2012] • BSI literature on electronic signatures, https://www.bsi.bund.de/ContentBSI/Themen/ElektrSignatur/esiggrundlagen.html [checked 2012]

	• W. Diffie, M. E. Hellman, New Directions in Cryptography, IEEE Transactions on Information Theory, Vol. IT-22, 644-654, 1976
13	**Use in study programme** B.Sc. Computer Sciences (2019) B.Sc. Business Informatics (2019) B.Sc. Information Management (2019) B.Sc. Computer Visualistics (2019) B.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Prerequisite for exam participation: regular and qualified participation in the tutorials (maximum of 2 absences).

module 71 04WI2017	Special Topics in Information Systems	6 credit points Elective module

Workload 180 hours	semester	Duration 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	71.1	V	Special Topics in Information Systems	04WI201701	Comp	2 hours per week 30 hours	60 hours	30	3
	71.2	Ü	Special Topics in Information Systems	04WI201702	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

Depending on topics.

3 **Contents**

04WI201701 - Special Topics in Information Systems (V)

Special topics in Information Systems with varying foci. This course will be offered by guest lecturers / guest professors who are only temporarily staying in Koblenz. It can also be used as a staging area for new topics / new ideas for course content. The course will thus offer students the opportunity to profit from new inputs / new ideas or visiting experts in the field.

4 **Frequency**

04WI201701 - Special Topics in Information Systems (V)
Every 3rd term

04WI201702 - Special Topics in Information Systems (Ü)
Every 3rd term

5 **Language of instruction**

04WI201701 - Special Topics in Information Systems (V)
German

04WI201702 - Special Topics in Information Systems (Ü)
German

6 **Individual course requirements**

Basic knowledge of business administration, in particular organisational forms and business processes, as well as the fundamentals of information systems.

7 **Examination formats**

Special Topics in Information Systems: see https://ist.uni-koblenz.de/MoMa/

8 **Requirements for the award of credit points**

9 **Significance of the final grade**

6/120 of the study programme

10	**Module coordinator** Prof. Dr. Petra Schubert
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI201701 - Special Topics in Information Systems (V)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI201702 - Special Topics in Information Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach
12	**Literature** **04WI201701 - Special Topics in Information Systems (V)** Varying literature depending on topic.
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information**

module 72 04WI2102	Risk Management in Distributed Systems	6 credit points Elective module
Workload 180 hours	**semester** 1st term (recommended)	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	72.1	V	Risk Management in Distributed Systems	04WI210201	Comp	2 SWS 30 hours	60 hours	40	3
	72.2	Ü	Risk Management in Distributed Systems	04WI210202	Comp	2 SWS 30 hours	60 hours	40	3

2 **Learning outcomes / Competences**

This module takes a comprehensive look at IT security aspects, how they reflect on the risk exposure of IT systems and organisations, and how these risks can be managed technically, organisationally, and through appropriate processes and procedures. There will be an in-depth explanation of risk analysis and management methods, including how risks can be quantified, how risk assessment reflects on risk management processes, and what the relevant risk management standards are. Furthermore, roles and responsibilities for risk management within an organisational context will be discussed. In addition, there will be a detailed study of threats (e.g. cyber kill chains) and threat models. Subsequently, cyber security and technical aspects to reduce risks, protect systems and services, and to detect and mitigate against threats will be studied. This ranges from a detailed study of relevant technical protection methods and strategies (e.g. relevant cryptographic methods, authentication & access control, communication security, security in clouds, etc.). There will also be a discussion of advanced protection mechanisms and systems (e.g. firewalls, intrusion detection systems), enhanced by a detailed study of anomaly detection mitigation methods. Finally, there will be an introduction to penetration testing.

At the end of this module, students should:

- be proficient in risk analysis and management, i.e.
  - know the theory behind risk management and risk analysis
  - be familiar with relevant standards
  - be able to perform risk analysis and recommend appropriate risk management processes
- know in-depth methods for threat and risk identification, protection and detection, i.e.
  - understand the theory behind attack models, cyber kill chains, etc. and be able to apply this within risk analysis
  - understand in-depth protection methods and their background (e.g. advanced cryptography, access control, network protection, etc.)
  - have a detailed understanding of protection mechanisms and systems and their theoretical background (such as IDS and anomaly detection and the mathematical and computational concepts they are based on)
- be familiar with concepts and methods for testing systems and their resilience, i.e.
  - know the process of exploring system vulnerabilities
  - be familiar with penetration testing tools, how they work and the theory and technology they are based on.

3 **Contents**

04WI210201 - Risk Management in Distributed Systems (V)

This module takes a comprehensive look at IT security aspects, how they reflect on the risk exposure of IT systems and organisations, and how these risks can be managed technically, organisationally, and through appropriate processes and procedures. There will be an in-depth explanation of risk analysis and management methods, including how risks can be quantified, how risk assessment reflects on

	risk management processes and what the relevant risk management standards are. Furthermore, roles and Responsibilities for risk management within an organisational context will be discussed. Furthermore, there will be a detailed study of threats (e.g. cyber kill chains) and threat models. Subsequently, cyber security and technical aspects to reduce risks, protect systems and services, and to detect and mitigate against threats will be studied. This ranges from a detailed study of relevant technical protection methods and strategies (e.g. relevant cryptographic methods, authentication & access control, communication security, security in clouds, etc.). There will also be a discussion of advanced protection mechanisms and systems (e.g. firewalls, intrusion detection systems), enhanced by a detailed study of anomaly detection mitigation methods. Finally, there will be an introduction to penetration testing. The course is divided into three parts: 1. Risk Identification and Risk Management - What is risk - Risk cycle and risk definitions - Risk and responsibilities within an organisational context - Governance corporate standards and business management aspects - Risk models and standards - Frameworks, directives and standards - Business continuity and disaster recovery - Risk identification process and contingency planning 2. Protection, detection and mitigation - Online security, authentication and cryptography – background, theory and application - Authentication and access control (multifactor, biometrics, smart chip, etc.) - Protection, detection and mitigation - Online security, authentication and cryptography – background, theory and application - Authentication and access control (multifactor, biometrics, smart chip, etc.) - Advanced Encryption Standard (AES), private-key cryptosystems; - Elliptic curve cryptosystem (ECC), digital signature standard (DSS), hashing, emerging SHA-3 standard - Communication and system security - Network security, protocols and secure communication system concepts - System and cloud security and resilience (including cloud and service resilience architecture) - Protection mechanisms and systems - Firewalls and IDS - Anomaly detection – background, theory and algorithms - Support Vector Machines, Bayesian Networks, Density-based techniques, etc. 3. Case studies and penetration testing - Security-relevant systems - E.g. online banking, web databases, industrial control systems, etc. - Penetration testing - Security testing Management and methodology - System-based security testing (including techniques and tools) - Legal aspects of penetration testing
4	**Frequency of offering** Only in the summer semester **04WI210201 - Risk Management in Distributed Systems (V)** Only in the summer semester **04WI210202 - Risk Management in Distributed Systems (Ü)** Only in the summer semester
5	**Language of instruction** **04WI210201 - Risk Management in Distributed Systems (V)**

	English **04WI210202 - Risk Management in Distributed Systems (Ü)** English
6	**Individual course requirements**
7	**Examination** Risk Management in Distributed Systems: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr Andreas Mauthe
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI210201 - Risk Management in Distributed Systems (V)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI210202 - Risk Management in Distributed Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information**

module 73 04WI2103	Security in Computer Networks and Mobile Systems	6 credit points Elective module
Workload 180 hours	**semester**	**Duration** 1 term

1	Courses				Compulsory/elective	Contact hours	Self-study	Planned group size	LP
	73.1	V	Security in computer networks and mobile systems	04WI210301	Comp	2 SWS 30 hours	60 hours	30	3
	73.2	Ü	Security in computer networks and mobile systems	04WI210302	Comp	2 hours per week 30 hours	60 hours	30	3

2 **Learning outcomes / Competences**

This module takes a comprehensive look at IT security in communication and distributed and mobile systems, where security issues occur within the communication subsystem, what the specific threats are, how they can be detected, mitigated against and prevented. There will be an in-depth discussion of the different networks, their security features, threat vectors, and involved systems. This includes a summary of relevant communication standards and their security features and how the provisions reflect on the communication process. Furthermore, mobile networks and the specific security-related issues within the context of mobile communications (including the physical layer, protocols and application level) will be covered. Subsequently, cyber security issues in the relevant application landscape will be discussed, such as Internet of Things (IoT) environments, cloud systems, distributed (industrial and other) control systems, and mobile applications (including mobile and social media applications).

At the end of this module, students should:

- be provisioned in communication network security issues, i.e.
  - know how communication networks and protocols work, and what the security issues are;
  - be familiar with relevant standards and security features;
  - be able to assess the security risk within the communication systems and related (distributed) applications;
- know in-depth methods for identifying, analysing and detecting communication threats and distributed system security issues, i.e.
  - understand the theory behind communication threat analysis and different anomaly detection methods;
  - understand in-depth protection and mitigation methods and their background;
  - have detailed knowledge of the mechanisms, systems and theoretical background for the protection of communication infrastructures (such as firewalls, IDS and IPS, etc.);
- be familiar with the communication security application context, i.e.
  - be familiar with common application areas (e.g. IoT, clouds, mobile applications, etc.);
  - be familiar with some selected application areas.

3 **Contents**

To achieve the learning outcomes, the module is structured into three main parts covering relevant aspects of communication security and related areas. The three parts are:

1. Network principles and security issues
   - Introduction to fixed networks, protocols, etc.
     - Security-centric network review
     - Security-relevant network concepts
       - Security issues, vulnerabilities, etc.
     - Network security provisions
       - Frameworks, protocols and standards for network security
       - Emerging network and communication security threats

- Recent vulnerabilities, threads, thread agents, etc.

2. Mobile communication security and application areas
   - Principles of mobile communication
     - Mobile communication technology, protocols and standards
   - Mobile communication security issues
     - Mobile security landscape
       - Interception, eavesdropping and other issues
   - Security provisions in mobile systems
     - Background, theory and technology for mobile phone protection (e.g. authentication, encryption, etc.)
   - Mobile communication application areas and security
     - Sensor network, Internet of Things (IoT), etc.
     - Emergency communication standards
     - Social media security and application
3. Case studies in mobile communication areas
   - Social media and cloud security
     - Impact of mobile and social media infrastructures on data security and privacy
   - Smart environments
     - Smart homes, smart cities, etc.
   - Resilient communication environments in emergency scenarios
     - Emergency communication plans
     - Research activities in resilient emergency environments

4	**Frequency of offering** **04WI210301 - Security in computer networks and mobile systems (V)** Every 3rd term **04WI210302 - Security in Computer Networks and Mobile Systems (Ü)** Every 3rd term
5	**Language of instruction** **04WI210301 - Security in Computer Networks and Mobile Systems (V)** German **04WI210302 - Security in Computer Networks and Mobile Systems (Ü)** German
6	**Individual course requirements** The module requires knowledge of communication networks.
7	**Examination** Security in computer networks and mobile systems: see https://ist.uni-koblenz.de/MoMa/
8	**Requirements for the award of credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Prof. Dr Andreas Mauthe
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach

	04WI210301 - Security in Computer Networks and Mobile Systems (V) FB 4 - Computer Sciences **->** Institute for Information Systems Reseach **04WI210302 - Security in Computer Networks and Mobile Systems (Ü)** FB 4 - Computer Sciences **->** Institute for Information Systems Reseach
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Business Informatics (2019) M.Sc. Computer Visualistics (2019) M.Sc. Computer Visualistics (2019) M.Sc. E-Government (2019) M.Sc. Information Management (2019)
14	**Other information**

module 74 **04CV2004**	**Image Processing 3**						5 credit points Elective module	
Workload 150 hours			**semester**			**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	74.1	V	Image processing 3	04CV200401	Compulsory	2 hours per week 30 hours	60 hours	50	3
	74.2	Ü	Image processing 3	04CV200402	Compulsory	1 SWS 15 hours	45 hours	25	2

2 **Learning outcomes / competences**

Advanced concepts in the field of image processing are presented in the course and put into practice in the tutorials. The focus is on 3D reconstruction and image sequence processing.

3 **Contents**

04CV200401 - Image Processing 3 (V)

1. Fundamentals
   - 3D sensors (depth camera)
   - Stereo
   - Homogeneous coordinates (revision, extension)
   - Parameter estimation
   - Fair parameterisation
   - Surface reconstruction
2. Camera calibration
   - Linear methods
   - Tsai/Lenz
   - Bundle compensation
   - Sensor characteristics
3. Tracking
   - Point tracking
   - Sensor fusion
   - Resolution hierarchies and scale space
4. Reconstruction
   - Disparity maps from stereo image processing
   - Trifocal tensor
   - Factorisation methods
   - Light fields
5. Object recognition
   - Model comparison
   - Neural networks

04CV200402 - Image Processing 3 (Ü)

1. Fundamentals
   - 3D sensors (depth camera)
   - Stereo
   - Homogeneous coordinates (revision, extension)
   - Parameter estimation
   - Fair parameterisation
   - Surface reconstruction

	2. Camera calibration • Linear methods • Tsai/Lenz • Bundle compensation • Sensor characteristics 3. Tracking • Point tracking • Sensor fusion • Resolution hierarchies and scale space 4. Reconstruction • Disparity maps from stereo image processing • Trifocal tensor • Factorisation methods • Light fields
4	**Frequency of offering** Only in the summer semester **04CV200401 - Image Processing 3 (V)** Only in the summer semester **04CV200402 - Image Processing 3 (Ü)** Only in the summer semester
5	**Language of instruction** **04CV200401 - Image Processing 3 (V)** German **04CV200402 - Image Processing 3 (L)** German
6	**Individual course requirements**
7	**Examination** Image processing 3 as no information (N/A N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 5/120 of the study programme
10	**Module coordinator** Mr Dietrich Paulus
11	**Responsible institution** FB 4 - Computer Sciences -> Institute for Computational Visualistics **04CV200401 - Image Processing 3 (V)** FB 4 - Computer Sciences -> Institute for Computational Visualistics **04CV200402 - Image Processing 3 (Ü)** FB 4 - Computer Sciences -> Institute for Computational Visualistics
12	**Literature**

	04CV200401 - Image Processing 3 (V) E. Trucco, A. Verri, Introduction to Computer Vision O. Faugeras, Computer Vision Hartley & Zisserman, Multi View Image Geometry **04CV200402 - Image Processing 3 (P)** E. Trucco, A. Verri, Introduction to Computer Vision O. Faugeras, Computer Vision Hartley & Zisserman, Multi View Image Geometry
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information 04CV200401 - Image** **Processing 3 (V)** Videos, PDF lecture notes, live demonstrations **04CV200402 - Image Processing 3 (Ü)** Videos, PDF lecture notes, live demonstrations

module 75 **04CV2013**	**Computer Graphics 3**						5 credit points Elective module		
Workload 150 hours			**semester**				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	75.1	V	Computer graphics 3	04CV201301	Compulsory	2 hours per week 30 hours	60 hours	40	3
	75.2	Ü	Computer graphics 3	04CV201302	Compulsory	1 SWS 15 hours	45 hours	20	2

2 **Learning outcomes / competences**

The course teaches advanced concepts in the field of computer graphics, with a particular focus on geometric data processing and scientific and technical visualisation. The tutorials provide practical application of the methods.

3 **Contents**

04CV201301 - Computer Graphics 3 (V)

1. Points and lines
   - Delaunay triangulation
   - Voronoi diagrams
2. Topological data structures
   - Winged edge
   - Half edge
3. Splines
   - Polynomials
   - Calculation of arc length
   - Lagrange polynomials
4. B-splines and NURBS
   - Knot vectors and support
   - Periodic and open B-splines
   - Matrix representation and conversion
   - NURBS and conic sections
5. Free-form surfaces
   - Parametric surfaces (Bézier, B-spline and NURBS)
   - Tangential plane and normal
   - Matrix representation and partial derivatives
   - Trim curves
6. Fundamentals of scientific and technical visualisation
   - Visualisation pipeline
   - Data structures and transfer function
   - Marching squares and marching cubes
7. Volume rendering
   - Direct vs. indirect rendering
   - Splatting, shear warp
   - Texture-based rendering
   - Raycasting

04CV201302 - Computer Graphics 3 (Ü)

1. Points and lines
   - Delaunay triangulation

- Voronoi diagrams

2. Topological data structures
   - Winged edge
   - Half edge
3. Splines
   - Polynomials
   - Calculation of arc length
   - Lagrange polynomials
4. B-splines and NURBS
   - Knot vectors and support
   - Periodic and open B-splines
   - Matrix representation and conversion
   - NURBS and conic sections
5. Free-form surfaces
   - Parametric surfaces (Bézier, B-spline and NURBS)
   - Tangential plane and normal
   - Matrix representation and partial derivatives
   - Trim curves
6. Fundamentals of scientific and technical visualisation
   - Visualisation pipeline
   - Data structures and transfer function
   - Marching squares and marching cubes
7. Volume rendering
   - Direct vs. indirect rendering
   - Splatting, shear warp
   - Texture-based rendering
   - Raycasting

4	**Frequency of offering** Only in the summer semester **04CV201301 - Computer Graphics 3 (V)** Summer semester only **04CV201302 - Computer Graphics 3 (P)** Summer semester only
5	**Language of instruction** **04CV201301 - Computer Graphics 3 (V)** German **04CV201302 - Computer Graphics 3 (Ü)** German
6	**Individual course requirements**
7	**Examination** Computer Graphics 3 as not specified (N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 5/120 of the study programme

10	**Module coordinator** Prof. Dr. Stefan Müller
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201301 - Computer Graphics 3 (V)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics **04CV201302 - Computer Graphics 3 (Ü)** FB 4 - Computer Sciences **->** Institute for Computational Visualistics
12	**Literature** **04CV201301 - Computer Graphics 3 (V)** D. Rogers, An Introduction to NURBS A. Watt, 3D Computer Graphics, 3rd Edition **04CV201302 - Computer Graphics 3 (Ü)** D. Rogers, An Introduction to NURBS A. Watt, 3D Computer Graphics, 3rd Edition
13	**Use in study programme** M.Sc. Computer Sciences (2019) M.Sc. Computer Visualistics (2019)
14	**Other information**

module 76 04IN2102 module	**Big Data**	6 credit points Compulsory

Workload	**semester**	**Duration**
180 hours	1st term (recommended)	1 term

1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
	76.1	V	Big Data	04IN210201	Compulsory	2 hours per week 30 hours	60 hours	30	3
	76.2	Ü	Big Data	04IN210202	Compulsory	2 hours per week 30 hours	60 hours	60	3

2 **Learning outcomes / Competences**

Students acquire the competency to formalise big data problems. They can develop their own big data structures. They use homomorphisms and higher-order functions to distribute big data analytic tasks. They understand the interaction between data distributions, algorithms and basic hardware configurations. They know several big data analytics algorithms and are able to re-design existing algorithms for large scale analytics.

3 **Contents**

1. Algorithm engineering for big data
   - External sorting
2. Big data programming paradigms:
   - map-reduce
   - signal-collect
   - RDD abstractions
3. Big data platforms (examples):
   - Batch processing (Spark)
   - Stream processing (Flink)
   - Data storage
     - Row store (Hbase)
     - Column store (Cassandra)
     - File system (HDFS)
       - Graph store (Giraph)
   - Machine learning (Mahout)
4. Big data analytics:
   - Distributed computation of statistical properties (mean, variance, etc.)
   - Distributed linear regression
   - Generalisation:
5. Cross-cutting topics
   - New hardware (e.g. GPUs, InfinityBand)
   - load balancing
   - Fault tolerance

4 **Frequency of offering**

Only in the summer semester

04IN210201 - Big Data (V)

Only in the summer semester

04IN210202 - Big Data (Ü)

Only in the summer semester

5	**Language of instruction** **04IN210201 - Big Data (V)** English **04IN210202 - Big Data (Ü)** English
6	**Individual course requirements** Basic knowledge of algorithms and data structures as well as database management systems. Experience with programming in Java/Scala/Python.
7	**Examination formats** Big Data as not specified (N/A N/A)
8	**Requirements for awarding credit points**
9	**Significance of the final grade** 6/120 of the study programme
10	**Module coordinator** Mr Steffen Staab
11	**Responsible institution** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN210201 - Big Data (V)** FB 4 - Computer Sciences **->** Institute for Computer Science **04IN210202 - Big Data (Ü)** FB 4 - Computer Sciences **->** Institute for Computer Science
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme** M.Sc. Web Science (2012) B.Sc. Computer Visualisation (2012) M.Sc. Computer Visualistics (2012) M.Sc. Computer Sciences (2012) B.Sc. Computer Sciences (2012) M.Sc. Mathematical Modelling of Complex Systems (20142) M.Sc. Business Informatics (2017) M.Sc. E-Government (2017) M.Sc. Mathematical Modelling of Complex Systems (20184) M.Sc. Web and Data Science (2019) M.Sc. Computer Sciences (2019) M.Sc. Computer Visualisation (2019) M.Sc. Computer Visualistics (2019)
14	**Other information** Regular and qualified attendance (maximum of 2 absences) required.

final thesis

MAT-MBV		**Master's thesis**							30 credit points Compulsory module
Workload 900 hours			**semester** 4th term (recommended)				**Duration** 1 term		
1	**Courses**				**Compulsory/elective**	**Contact hours**	**Self-study**	**Planned group size**	**LP**
		A	Master's thesis	03XX2590	Compulsory	0 hours per week 0 hours	810 hours	1	27
		A	Final oral exam	03XX2599	Compulsory	0 hours per week 0 hours	90 hours	1	3

2 **Learning outcomes / Competences**

03XX2590 - Master's thesis (A)

The Master's programme concludes with the Master's thesis.
The Master's thesis can be completed in all fields of computational science, mathematics and physics, as well as in industry or external research institutes nationally or internationally, if a professor is responsible for providing support.
The master's student must work on a scientific topic under supervision within a given time frame. The thesis must document the results in writing in an adequate form with regard to the subject and be presented in the final examination as a basis for discussion.
The candidate must be able to achieve research results under supervision but largely independently, detect, solve and critically assess problems and classify them on the basis of the given knowledge.
The results must be documented in written form (27 LP) and this work must be defended in an oral examination (3 LP). The examination is conducted by the supporting professor and a second auditor.

03XX2599 - Final oral examination (A)

The results of the Master's thesis must be documented in written form (27 LP) and this work must be defended in an oral examination (3 LP). The examination is conducted by the supervising professor and a second examiner.

3 **Contents**

03XX2590 - Master's thesis (A)

- Largely independent work on a research question under professional guidance
- Mastering the basic techniques of scientific work and publication

03XX2599 - Final oral exam (A)

The content of the final exam is the topic of the Master's thesis. The candidate has the opportunity to present his/her work within the given time.

4 **Frequency of offering**

Every term

03XX2590 - Master's thesis (A)

Every term

	03XX2599 - Final oral exam (A) Every term
5	**Language of instruction** **03XX2590 - Master's thesis (A)** English **03XX2599 - Final oral exam (A)** English
6	**Individual course requirements 03XX2590 -** **Master's thesis (A)** In accordance with Section 13 (5), admission to the Master's thesis is granted to those who 1. has earned at least 60 credit points and 2. has agreed on a preliminary topic for a Master's thesis with a supervisor. **03XX2599 - Final oral examination (A)** Competences from module 03XX2590
7	**Examination formats** Master's thesis as Master's thesis in accordance with § 13 of the examination regulations. (written - 24 weeks) Final oral exam as Oral final examination in accordance with § 14 of the examination regulations. (oral – 30–60 min.)
8	**Requirements for the award of credit points 03XX2590 - Master's thesis (A)** Passing the master's thesis in accordance with § 13 of the examination regulations for the bachelor's programme "Mathematical Modelling, Simulation and Optimisation" and the Master's programme "Mathematical Modelling, Simulation and Optimisation" at the University of Koblenz-Landau. **03XX2599 - Final oral exam (A)** Passing the final oral examination in accordance with § 14 of the examination regulations for the Bachelor's programme "Mathematical Modelling, Simulation and Optimisation" and the Master's programme "Mathematical Modelling, Simulation and Optimisation" at the University of Koblenz-Landau.
9	**Significance of the final grade** 30/120 of the study programme
10	**Module coordinator** Prof. Dr. Thomas Götz

11	**Responsible institution** FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute **03XX2590 - Master's thesis (A)** Koblenz Campus **->** faculty 4 - Computer Sciences FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics **03XX2599 - Final oral examination (A)** Koblenz Campus **->** faculty 4 - Computer Sciences FB 3 - Mathematics / Natural Sciences **->** Mathematics Institute FB 3 - Mathematics / Natural Sciences **->** Institute of Integrated Natural Sciences **->** Physics
12	**Literature** Will be announced in the relevant courses
13	**Use in study programme**
14	**Other information**