# Computer Science Master


*ECTS Information Package*

# Computer Science - Master

## General Description

The Computer Science/Mathematics Department 07 offers programs of study in two different areas:
- Computer Science (Bachelor and Master)
- Information Systems and Management (Bachelor and Master, in cooperation with the Business Administration Department 10)

This brochure only describes the Computer Science Master program of study. There are separate brochures for the Bachelor Degree Program, and for the programs of study in Information Systems and Management.

The following 13 laboratories with about 100 workstations are available to students:

- Laboratory for Chip Cards,
- Laboratory for Computer Anatomy,
- Laboratory for Computer Graphics and Image Processing,
- Laboratory for Autonomous Systems,
- Laboratory for Microcomputers,
- Laboratory for Computer Integrated Manufacturing,
- Laboratory for Computer Vision and Pattern Recognition,
- Laboratory for Computer Organisation,
- Laboratory for Software Development,
- Laboratory for Java,
- Laboratory for Knowledge-Based Systems, and
- Laboratory for e-Commerce.
- Laboratory for Database Systems and Information Management,

## Qualification achieved

**Master's program of study in Computer Science**
The newly designed Master program with focus on Computer Graphics and Image Processing will lead to the

**Academic degree:** Master of Science (M.Sc.)

The Master degree program was **accredited** by the ASIIN, including the qualification for higher service positions in German public service.

Concurrently to the Master program of study, students may enrol in the supplemental program „Privacy and Data Protection" ( 1 ECTS credits). Successful graduates of this supplemental program will receive a state-approved university certificate. The list of required courses and their descriptions are contained in the brochure for the Bachelor degree program.



## Admission requirements

Admission requirement for the Master degree program is a university course of study in computer science or in some other scientific or technical area, completed with at least a Bachelor's degree, and with a total grade no worse than 2.5. In certain cases (e.g. grade worse than 2.0 or other subject than computer science), applicants will also have to take an aptitude test.

**Recommendations for exchange students**

The study period at the Munich University of Applied Sciences (MUAS) can be one or more semesters in length. All courses in the Bachelor degree program are one semester in length and conclude with an examination at the end of the semester.
Note, however, that not all courses are offered in every semester. Some courses will only be offered in summer semester, others only in winter semester. In each semester, only a choice of the electives will be offered.

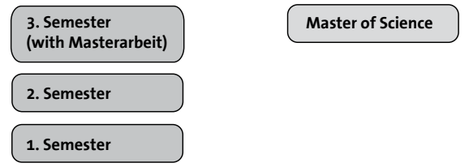
Exchange students are free to make a course selection that most complements the course requirements of their home university. When making their choice, it is irrelevant whether the chosen courses are required courses, or electives, or whether the courses are from different programs of study or take place in different semester of study. It is, however, the student's own responsibility to make sure that there are no scheduling conflicts in the student's weekly lecture schedule. Such conflicts can generally be avoided by choosing courses that all take place in the same semester of study.

Each semester, a small number of the courses will be offered in English language. However, in order to allow for a useful and flexible selection of courses, it is strongly recommended that exchange students be able to attend courses in German language.

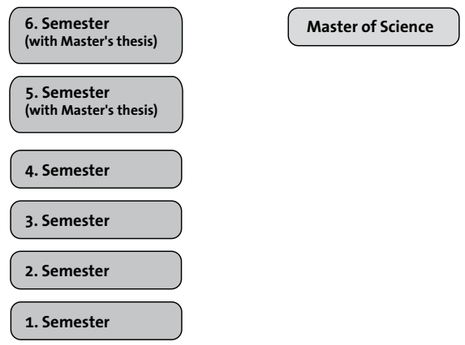
Students interested in a practical study semester in industry should apply directly with the company. However, since the department has a list of companies which are hiring students for internships, and close relations with many of them, you might want to contact the department first.

## Computer Science Master

**Master's program of study in Computer Science (full-time)**




**Master's program of study in Computer Science (part-time, 50% course load)**



**Examination regulations and grading procedures:**

In most courses, students will have to pass a written exam at the end of the semester. Others require students to also hand in practicum assignments or research project reports, or to give presentations. Most of these assignments receive a grade. Some are marked on a „pass“ or „fail“ basis.

1.0 is the highest grade and 5.0 the lowest; a grade of 4.0 means you have just passed the exam.

| | |
|---|---|
| **1,0 or 1,3** | means: very good |
| **1.7 or 2.0 or 2.3** | means: good |
| **2.7 or 3.0 or 3.3** | means: satisfactory |
| **3.7 or 4.0** | means: adequate |
| **5,0** | means: insufficient (failed) |

Students may repeat any failed exam once. A limited number of exams may be repeated twice upon applying to do so.

You will find the binding rules for exams in the current course calendar (Studienplan) as well as in the conditions of study and exam ordinance (Studien- und Prüfungsordnung).

## International Student Advisor

**Name: Prof. Dr. Christian Vogt**
**Responsible for all of the department‘s partner universities.**

## Description of the individual courses in each semester

**Abbreviations:**

DCE = Departmental Compulsory Elective
H/W = Hours per Week
CG = Course Group
CEG = Compulsory Elective from a specific course group

## Computer Science Master

This course of studies can be taken full-time in 3 semesters, or part-time (50% course load) in 6 semesters. In both cases, studies can be started either in winter or in summer semester.

Some courses can be chosen at will from the currently offered courses in the following course groups:

CG 1 Theoretical Computer Science
CG 2 Software Technology
CG 3 Scientific Computing
CG 4 General Courses
CG 5 Immersion Courses

At least one course each must be chosen from the course groups CG1, CG2, and CG4, and at least two courses must be chosen from CG3. A further (sixth) course is to be taken from any of the groups CG1 to CG4. Three courses must be chosen from the course group CG5.



### Master Program of Studies (Full-Time)

| 1 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| IF-I-M001 | Computer Graphics | Mandatory | 4 | 5 |
| IF-I-M002 | Digital Image Processing | Mandatory | 4 | 5 |
| IF-I-M003 | Pattern Recognition 1) | Mandatory | 4 | 5 |

1) Instead of Pattern Recognition, students, who begin their studies in summer semester, attend an immersion course from CG5, which does not require IF-I-M001 up to IF-I-M003 as a prerequisite.

| 2 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 5 | Immersion Course | CEG | 4 | 5 |
| from CG 5 | Immersion Course | CEG | 4 | 5 |
| from CG 5 | Immersion Course 2) | CEG | 4 | 5 |
| from CG 5 | Immersion Course 2) | CEG | 4 | 5 |

2) Instead of the third immersion course, students, who started their studies in summer semester, attend the course IF-I-M003 Pattern Recognition.

| 3 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| IF-I-M004 | Advanced Seminar | Mandatory | | 6 |
| IF-I-M005 | Master Thesis | Mandatory | | 24 |

### Master Program of Studies (Part-Time)

| 1 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |

| 2 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |
| from CG 1-4 | Compulsory Elective from CG 1-4 | CEG | 4 | 5 |

| 3 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| IF-I-M001 | Computer Graphics | Mandatory | 4 | 5 |
| IF-I-M002 | Digital Image Processing | Mandatory | 4 | 5 |
| IF-I-M003 | Pattern Recognition 1) | Mandatory | 4 | 5 |

1) Instead of Pattern Recognition, students, who begin their studies in summer semester, attend an immersion course from CG5, which does not require IF-I-M001 up to IF-I-M003 as a prerequisite.

| 4 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| from CG 5 | Immersion Course | CEG | 4 | 5 |
| from CG 5 | Immersion Course | CEG | 4 | 5 |
| from CG 5 | Immersion Course 2) | CEG | 4 | 5 |

2) Instead of the third immersion course, students, who started their studies in summer semester, attend the course IF-I-M003 Pattern Recognition.

| 5 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| IF-I-M004 | Advanced Seminar | Mandatory | | 6 |
| IF-I-M005 | Master Thesis | Mandatory | | 9 |

| 6 Semester | | | | |
|---|---|---|---|---|
| **Course no** | **Title** | **Type** | **H/W** | **Credits** |
| IF-I-M005 | Master Thesis | Mandatory | | 15 |

| Examples of courses from the course group CG 1 „Theoretical Computer Science“ (*): | | |
|---|---|---|
| **Title** | **H/W** | **Credits** |
| Logic Calculus | 4 | 5 |
| Data Flow Analysis | 4 | 5 |
| Program Verification | 4 | 5 |
| Semantics of Programming Languages | 4 | 5 |
| Graph Theory | 4 | 5 |

| Examples of courses from the course group CG 2 „Software Technology“ (*): | | |
|---|---|---|
| **Title** | **H/W** | **Credits** |
| Knowledge Based Systems | 4 | 5 |
| Secure Systems | 4 | 5 |
| Embedded Systems | 4 | 5 |
| Graphical User Interfaces | 4 | 5 |



| Examples of courses from the course group CG 3 „Scientific Computing“ (*): | | |
|---|---|---|
| **Title** | **H/W** | **Credits** |
| Advanced Numerical Analysis | 4 | 5 |
| Stochastics | 4 | 5 |
| System Theory | 4 | 5 |
| Modelling and Simulation | 4 | 5 |
| Computational Geometry | 4 | 5 |
| Optimization | 4 | 5 |

| Examples of courses from the course group CG 4 „General Courses“ (*): | | |
|---|---|---|
| **Title** | **H/W** | **Credits** |
| Project Management and Quality Assurance | 4 | 5 |
| Social Skills | 4 | 5 |
| IT Infrastructures | 4 | 5 |
| Decision Theory | 4 | 5 |

| Examples of courses from the course group CG 5 „Immersion Courses“ (*): | | |
|---|---|---|
| **Title** | **H/W** | **Credits** |
| Realtime 3D Computer Graphics | 4 | 5 |
| 3D Modelling | 4 | 5 |
| Model Driven Image Analysis | 4 | 5 |
| Digital Copression of Still Images and Viseo | 4 | 5 |
| Medical Image Processing | 4 | 5 |
| Photogrammetric Image Processing | 4 | 5 |
| 3D Reconstruction | 4 | 5 |
| Photogrammetric Image | 4 | 5 |
| Realtime Simulation | 4 | 5 |
| Robotics | 4 | 5 |
| Image Sequence Processing and Motion Analysis | 4 | 5 |

(*) Each semester, only a selection of the courses will be offered.

## 1. Computer Graphics

*Module no.: IF-I-M001*

*Module representative: Nischwitz*

*4 H/W*

*5 ECTS-Credits*

*Offered: every semester*

**Applicability:**
Mandatory (should be taken prior to courses from subject group CG5 „Immersion Courses“, if possible)

**Objectives**
This course will cover the following topics:
Components of modern graphics hardware, interactivity and real-time demands, the fixed function rendering pipeline, geometric modelling, transformations and matrix stacks, hidden surface removal, color, transparency and color blending, anti-aliasing, fog and atmospheric effects, lighting models and shading, texture mapping (photo textures, multi-textures, projective textures, environment textures), animations, the programmable rendering pipeline (vertex and pixel shaders), ray tracing and radiosity.

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|---|---|
| **Prerequisites** | solid programming skills in C/C++, Linear Algebra, recommended: IF-I-B24 Integral Transformations |
| **Course objective** | An understanding of basic computer graphics concepts, algorithms and processes. An overview of the main branches, immersion in a particular topic in as far as advanced lectures can build on solid knowledge of the fundamentals. |
| **Recommended literature** | *A. Nischwitz, P. Haberäcker*: Masterkurs Computergrafik und Bildverarbeitung, Vieweg 2004 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | oral exam |
| **Language of instruction** | German or English |
| **Name of lecturer** | Nischwitz, M. Fischer |

## 2. Digital Image Processing

*Module no.: IF-I-M002*

*Module representative: Schnörr*

*4 H/W*

*5 ECTS-Credits*

*Offered: every semester*

**Applicability:**
Mandatory (should be taken prior to courses from subject group CG5 „Immersion Courses“, if possible)

**Objectives**
The processing of digital images by means of computers is rapidly occupying more and more application fields. This course will provide the necessary foundations and discuss the most significant branches of digital image processing:
- Data structures and image types
- Fourier transformation, digital filters
- Point transformations
- Filter design
- Geometric transformations and restorations
- Morphological binary and grey-valued image processing
- Feature extraction, e.g.
  - Hough transformation
  - Gauss and Laplace pyramids
- Segmentation
  - e.g. Scale Space filtering
- Introduction to
  - 3D image processing and
  - motion analysis (object tracking)

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|---|---|
| **Prerequisites** | mathematical skills from the Bachelor programme of studies |
| **Course objective** | the convey of fundamental concepts as well as applicable procedures, the ability to autonomously solve image processing problems. |
| **Recommended literature** | *R.C. Gonzalez, R.E. Woods:* Digital Image Processing, Addison-Wesley, 2000 . *A. Nischwitz, P. Haberäcker:* Masterkurs Computergrafik und Bildverarbeitung, Vieweg, 2004. *P. Soille:* Morphologische Bildverarbeitung, Springer-Verlag 1998. *W. Abmayr:* Einführung in die digitale Bildverarbeitung, Teubner, 1994 |
| **Method of instruction** | seminars and a practicum and exercises |
| **Examination** | term work (40%), written exam (60%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Schnörr, M. Fischer, Nischwitz |



## 3. Pattern Recognition

*Module no.: IF-I-M003*

*Module representative: Schnörr*

*4 H/W*

*5 ECTS-Credits*

*Offered: every winter semester*

**Applicability:**
Mandatory (should be taken prior to courses from subject group CG4 „Immersion Courses“, if possible)

**Objectives**
This course covers the fundamental concepts of pattern recognition used to recognise patterns in a broad range of signals. Students will learn to systematically improve and benchmark recognition results. In addition, solutions to problems in vastly different fields will be covered. Some of the topics discussed will be:
- the feature concept, examples of feature-based descriptions
- Bayes decision theory
- Supervised Learning
  - Classification
    - parametric procedures
    - non-parametric procedures
    - Support Vector Machines
  - Regression
    - linear and non-linear regression
    - Support Vector Regression
- Feature reduction approaches
- Unsupervised Learning
- Approaches to measure recognition progress
- Complexity and Generalisation

| | |
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| **Prerequisites** | recommended: Statistics (IF-I-B23) |
| **Course objective** | An understanding of the fundamental concepts in the field, ability to autonomously handle concrete types of approaches, proficiency in dealing critically with collections of ready-made libraries of solutions in a target-oriented manner. |
| **Recommended literature** | *R.O. Duda, P.E. Hart, D.G.Stork:* Pattern Classification, Wiley & Sons, 2nd. Ed., 2001. *N. Christianini, J. Shawe-Taylor:* Support Vector Machines, Cambridge University Press, 2000. *A. Nischwitz, P. Haberäcker:* Masterkurs Computergrafik und Bildverarbeitung, Vieweg, 2004 |
| **Method of instruction** | seminars and a practicum and exercises |
| **Examination** | term work (40%), written exam (60%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Schnörr, Nischwitz |

## 4. Advanced Seminar

*Module no.: IF-I-M004*

*Module representative: Nischwitz*

*4 H/W*

*6 ECTS-Credits*

*Offered: every semester*

**Applicability:**
Mandatory course

**Objectives**
independent study of a current issue in computer science - preferably in the fields of computer graphics and image processing - using scientific methods. Completion of a written term paper and a presentation thereof.

| | |
|---|---|
| **Prerequisites** | IF-I-M001 Computer Graphics, IF-I-M002 Digital Image Processing, IF-I-M003 Pattern Recognition |
| **Course objective** | competence with methodologies when working independently with the latest scientific insights as well as the ability to present those insights. |
| **Recommended literature** | Specialised literature: will be determined during the main seminar. General literature: *George D. Gopen and Judith A. Swan:* The Science of Scientific Writing, American Scientist, Nov. 1990, Volume 78, pp. 550-558. *Donald E. Knuth et al.:* Mathematical Writing, MAA Notes, The Mathematical Association of America, 1989, Number 14. |
| **Method of instruction** | independent study (with direction and supervision) |
| **Examination** | term work (60%), presentation (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Nischwitz, M. Fischer, Schnörr |

## 5. Master‘s Thesis

*Module no.: IF-I-M005*

*24 ECTS-Credits*

*Offered: The Master‘s thesis may be started at any time as long as the regulations set out in the SPO are followed.*

**Applicability:**
Mandatory component of the Master‘s programme of study

**Objectives**
independent study of a demanding problem statement from science or engineering using scientific methods. In the case of applied projects a partner from industry may participate in the execution and supervision of the work. The finished project and its results will be put together in the form of a scientific study as well as a presentation.

| | |
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| **Prerequisites** | The topic of the Master‘s thesis may only be issued once the student has achieved a final grade of „adequate“ or better in courses with at least 45 ECTS points. |
| **Course objective** | the ability to independently complete a demanding practical or theoretical assignment and present it in the form of a scientific study. |
| **Recommended literature** | *George D. Gopen and Judith A. Swan:* The Science of Scientific Writing, American Scientist, Nov. 1990, Volume 78, pp. 550-558. *Donald E. Knuth et al.:* Mathematical Writing, MAA Notes, The Mathematical Association of America, 1989, Number 14. |
| **Method of instruction** | independent study (with direction and supervision) |
| **Examination** | Master‘s thesis |
| **Language of instruction** | German or English (language of the Master‘s thesis) |
| **Name of lecturer** | Supervision and provision of topic may be done by any of the professors and instructor that are part of the Master‘s programme of study. |

## 6. Logic Calculus

*Module no.: IF-I-M100*

*Module representative: Ruckert*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Theoretical Computer Science“ from which 1-2 courses must be chosen.

**Objectives**
This course covers terminology, notions, and methods of mathematical logic with a strong focus on applications to computer science.
After a review of basic concepts (syntax, semantics, interpretation and model), the course will examine proofs as semantically correct syntactic transformations. Different types of logic systems will be studied and their most significant characteristics (correctness, completeness, decidability, complexity, strength) will be examined. A discussion of recent results, current developments, and practical applications to databases, logic programming, verification, model checking round out the course.

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|---|---|
| **Prerequisites** | none |
| **Course objective** | Students will learn to use theory and methods of mathematical logic to model the syntactic and semantic aspects of problem domains primarily taken from the field of computer science. In addition, students will acquire a firm grasp of the strengths and weaknesses, as well as the principal limitations, of formal methods. |
| **Recommended literature** | *Schöning:* Logik für Informatiker, BI-Wissenschaftsverlag.<br>*Bernhard Heinemann und Klaus Weihrauch:* Logik für Informatiker, Teubner Stuttgart 1980<br>*M.Ruckert:* Logik für Informatiker (Skriptum) |
| **Method of instruction** | seminars with exercises |
| **Examination** | written exam |
| **Language of instruction** | German or English |
| **Name of lecturer** | Ruckert |



## 7. Data Flow Analysis

*Module no.: IF-I-M101*

*Module representative: Möncke*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Theoretical Computer Science“ from which 1-2 courses must be chosen.

**Objectives**
Non-Standard interpreters, by which statements regarding the runtime of the program can be made, will be developed for a simple programming language and analysed. The basis is the theory of abstract interpretation.

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|---|---|
| **Prerequisites** | none |
| **Course objective** | an understanding of the mechanisms and insight into the practical applicability. |
| **Recommended literature** | *P. Cousot, R. Cousot :* „Systematic design of program analysis framworks “, in: Conf. Records of the 6.th Annual ACM SIGPLAN-SIGACT Symp. On Principles of Programming Languages, ACM Press, New York, 1997, pp. 269-282. |
| **Method of instruction** | lectures |
| **Examination** | written exam with practicum |
| **Language of instruction** | German or English |
| **Name of lecturer** | Schiedermeier, Möncke |

## 8. Program Verification

*Module no.: IF-I-M102*

*Module representative: Möncke*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Theoretical Computer Science“ from which 1-2 courses must be chosen.

**Objectives**
This course presents the various rudiments of verification including the necessary mathematical background and required mechanisms such as term reduction, mechanical proof processes, finite automatons, etc. In addition to the classic axiomatic and denotational approaches, particular attention will be paid to the so-called model checking methods.

| | |
|---|---|
| **Prerequisites** | solid mathematical skills |
| **Course objective** | an understanding of the methodology and assessment of the practical applicability. |
| **Recommended literature** | *Loeckx , Sieber :* The Foundations of Program Verification, Teubner, 1987<br>*Apt, Olderog:* Verification of Sequential and Concurrent Programs, Springer, 1997 |
| **Method of instruction** | lectures |
| **Examination** | written exam |
| **Language of instruction** | German or English |
| **Name of lecturer** | N.N. |

## 9. Semantics of Programming Languages

*Module no.: IF-I-M103*

*Module representative: Schiedermeier*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Theoretical Computer Science" from which 1-2 courses must be chosen.

**Objectives**
In this course, a series of interpreters will be designed and analysed. With this series, a fully-fledged programming language will be translated via step for step transformations into successively more primitive formalisms to become the code for a virtual machine.

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|---|---|
| **Prerequisites** | none |
| **Course objective** | a deep understanding of the basic mechanisms and concepts of programming languages. |
| **Recommended literature** | *Friedman, Wand, Haynes:* „Essentials of Programming Languages", MIT-Press, 1992 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%),<br>Practical proof of achievement (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Schiedermeier |

## 10. Graph Theory

*Module no.: IF-I-M104*

*Module representative: M. Fischer*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Theoretical Computer Science" from which 1-2 courses must be chosen.

**Objectives**
Objects and relationships between objects occur in many computer science applications. Graphs are a generalisation of these systems made up of objects and their relationships. Graph theory provides the tools to represent graphs, analyse them for particular characteristics, efficiently compare them or browse them, etc. Beginning with simple case studies the following areas will be covered:
- Classes of graphs
- Representation of graphs
- Characteristics of graphs
- Search in graphs

| | |
|---|---|
| **Prerequisites** | none |
| **Course objective** | a practical introduction to graph theory and its applications |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%),<br>Term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | M. Fischer, Kirch-Prinz |



## 11. Knowledge-Based Systems

*Module no.: IF-I-M201*

*Module representative: Köhler*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Software Technology" from which 1-2 courses must be chosen.

**Objectives**
In order to solve problems for which there are no or only very complex mathematical models, symbolic artificial intelligence techniques as well as neural networks are used. When doing so, various forms of knowledge representation, heuristic search procedures (rule-based systems, e.g. Prolog), fuzzy logic-based decision support (uncertain knowledge) and the learning ability of neural systems play an important role.

| | |
|---|---|
| **Prerequisites** | none |
| **Course objective** | theoretical principles of non-algorithmic problem-solving methods and testing of the practical applications through term work. |
| **Recommended literature** | *Lämmel, Cleve:* Künstliche Intelligenz, Hanser Verlag |
| **Method of instruction** | seminars and a term work |
| **Examination** | written exam or a colloquium (60%),<br>Term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Köhler. Streng |

## 12. Secure Systems

*Module no.: IF-I-M202*

*Module representative: Pleier*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Software Technology" from which 1-2 courses must be chosen.

**Objectives**
This course expands on topics, principles, methods and techniques used for the realisation of IT security. For example:
- Vulnerabilities, attack methods and techniques
- Protection principles, mechanisms, and procedures
- Security organisation and Security management
- Principles and techniques for implementing secure systems
- Innovative solutions and concepts
- Selected practical examples / case studies

| | |
|---|---|
| **Prerequisites** | basic knowledge of IT security issues |
| **Course objective** | immersion and expansion of knowledge based on problem statements, principles, concepts, and mechanisms for the realisation of the security of and in IT systems. |
| **Recommended literature** | one of the standard textbooks on security, e.g.:<br>*Claudia Eckert:* IT-Sicherheit. Konzepte, Verfahren, Protokolle, Oldenbourg, München, 2001 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%),<br>Term work (40%) |
| **Language of instruction** | German |
| **Name of lecturer** | Pleier |

## 13. Embedded Systems

*Module no.: IF-I-M203*

*Module representative: M. Fischer*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Software Technology" from which 1-2 courses must be chosen.

**Objectives**
Embedded systems are information technology systems integrated into a larger system. Increasingly they are taking over tasks such as control, signal processing and monitoring of a device's components. Areas of application for embedded systems are extensive: motor vehicles, airplanes, cameras, cell phones, household and entertainment devices are but some examples. This course will cover the following topics:
• Models and architectures for embedded systems
• Design methodology (e.g. state machines, data flow graphs)
• Overview of hardware technologies (section criteria): VLSI chips, field programmable gate arrays (FPGAs), system-on-a-chip, microcontrollers, embedded PCs, ...
• Software technologies (hardware-level programming, real-time systems)

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| **Prerequisites** | basic knowledge of digital and computer engineering, programming skills |
| **Course objective** | knowledge of the hardware and software implementation characteristics of embedded systems, with a focus on software implementation. |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%),<br>Term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | M. Fischer, Kirch-Prinz, Böttcher |

## 14. Graphical User Interfaces (GUI)

*Module no.: IF-I-M204*

*Module representative: N.N.*

*4 H/W*

*5 ECTS-Credits*

*Offered: alternating irregularily with other courses from subject group M2*

**Applicability:**
This course belongs to the subject group „Software Technology" from which 1-2 courses must be chosen.

**Objectives**
Some of the topics covered:
• Ergonomics:
  - ergonomic guidelines
  - interface design principles
• Three-tier application architecture
• UML interface patterns, such as observer, model-view controller, command processor
• The most important GUI standards:
  - Microsoft class libraries (e.g. .NET)
  - Java AWT and JFC (Swing)
  - Qt and the signal-slot mechanism
  - GTK libraries and callback mechanism
• Real-world application examples

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| **Prerequisites** | recommended: knowledge of UML, Java, software patterns, software engineering |
| **Course objective** | A user-friendly graphical interface (GUI) is an integral part of any modern application. When developing such an interface particular demands arise in the fields of software ergonomics and design patterns. The objective is to understand and be able to classify the most important GUI standards as well as their structural similarities and differences. Students will also be able to design and create simple GUIs. |
| **Recommended literature** | Pattern-Oriented Software Architecture Vol. 1: A System of Patterns; *Frank Buschmann et. al.*, John Wiley & Sons, 1997 |
| **Method of instruction** | seminars and a practicum and exercises |
| **Examination** | written exam (60%),<br>Term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | N N |



## 15. Advanced Numerical Analysis

*Module no.: IF-I-M300*

*Module representative: Eich-Soellner*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Scientific Computing" from which 2-3 courses must be chosen

**Objectives**
a) immersion in the following areas:
Linear systems of equation (sparse matrix methods, methods exploting the structure of the underlying problem)
- nonlinear systems of equation: pathfollowing methods,
- interpolation and approximation (in particular splines);
- numerical solution of differential equations with a focus on differential-algebraic equations and boundary value problems
- Fast Fourier transformation

b) treatment of topics such as:
- eigenvalue problems
- parameter identification
- optimisation
- wavelets
- partial differential equations

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| **Prerequisites** | basic knowledge of numerical analysis such as that gained for example from „Numerical Analysis" in the Computer Science Bachelor programme of studies |
| **Course objective** | Learning and understanding the construction prin ciples of numerical methods, Learning and applying the underlying theory, Ability to select, further develop, design from scratch and implement algorithms for specific problem statements |
| **Recommended literature** | for example: *M. Heath:* „Introduction to Scientific Computing", *E. Eich-Soellner, C. Führer:* „Numerical Methods in Multibody Dynamics", *J. Stoer/(Bulirsch):* „Numerische Mathematik I,II", *C. Überhuber:* „Computer-Numerik 1,2", *M. Hanke-Bourgeois:* „Grudlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens" |
| **Method of instruction** | seminars and a practicum |
| **Examination** | oral exam |
| **Language of instruction** | German or English |
| **Name of lecturer** | Eich-Soellner, Plöchinger |

## 16. Stochastics

*Module no.: IF-I-M301*

*Module representative: Gruber*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Scientific Computing" from which 2-3 courses must be chosen

**Objectives**
Introduction to stochastic basic terminology such as probability measure, random variable, and probability distribution by the theory of Lp-spaces. A measure-theoretical approach to limit theorems such as the laws of large numbers or the central limit theorem. Introduction to martingales and conditional expectations.

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| **Prerequisites** | Probability Theory and Statistics Stochastics (e.g. IF-I-B23), Integral Transformations (e.g. IF-I-B24), Recommended: knowledge of measure theory |
| **Course objective** | an understanding of probability theory from an abstract measure-theoretical point of view |
| **Recommended literature** | *Bauer, H.*: Wahrscheinlichkeitstheorie, 5. Aufl., de Gruyter, 2002 |
| **Method of instruction** | seminars and exercises |
| **Examination** | written exam |
| **Language of instruction** | German or English |
| **Name of lecturer** | Gruber,, Recknagel, Zielke |

## 17. System Theory

*Module no.: IF-I-M302*

*Module representative: Nischwitz*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Scientific Computing" from which 2-3 courses must be chosen

**Objectives**
System classes and spectral transformations, one- and multidimensional delta functions, one- and multidimensional Fourier and Laplace transformations, spectral transformation laws, sampling theorem and projection of multidimensional signals, z-transformation, examples of system theory applications: solving linear differential and difference equations, image processing, control theory.

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| **Prerequisites** | highly recommended: Integral Transformations (IF-I-B24) |
| **Course objective** | an understanding of one- and multidimensional methods of systems theory. Knowledge of the most important areas of application. |
| **Recommended literature** | *H. Marko:* Systemtheorie. Methoden und Anwendungen für ein- und mehrdimensionale Systeme, Springer 2001<br>*R. Bamler:* Mehrdimensionale lineare Systeme, Springer 1989 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Nischwitz, Schnörr, Zielke |



## 18. Modelling and Simulation

*Module no.: IF-I-M303*

*Module representative: Eich-Soellner*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Scientific Computing" from which 2-3 courses must be chosen

**Objectives**
Simulation is the imitation of real or imagined processes, typically using a computer. In order to simulate one needs a model of the system to be simulated. The most significant quantitative characteristics of a system are researched and improved upon prior to its actual implementation through simulation. In order to develop a simulation system, experts from a variety of fields must pool their knowledge and be ready and able to become acquainted with other areas of expertise.

This course provides knowledge of the various work processes and programming elements that are typically part of such a system: modeling, user interfaces, numerical methods, graphic representation of results.

In the accompanying practicum, students will simulate using existing simulation environments as well as programme elements of such a system themselves.

- Problem statement of modeling and simulation
- Modeling concepts
- Continuous modeling: processes for obtaining systems equations in various areas of application (e.g. mechanics, electrical circuits, chemistry, biology, traf fic, economy)
- Methods for continuous simulation (numeric processes for solving occurring equations)
- Discrete models (decision models, sequence problems, occurrences)
- Methods for discrete simulations (Petri nets, cellular automata, scheduling, ...)
- Simulation systems / simulators (presentation of various systems, learning their use)
- Hardware-in-the-loop simulation
- Validating a model via implementation of a simulation system

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| **Prerequisites** | basic knowledge of numeric mathematics as gained for example from the „Numerical Analysis" course in the Computer Science Bachelor programme of studies; programming skills |
| **Course objective** | • Knowledge of the methodical foundations of sys tems modeling and simulation from a variety of fields<br>• Knowledge of the most important components, work processes and use of a simulation system<br>• Development of software components for a simula tion system<br>• Ability to understand and use simulation languages and systems |
| **Recommended literature** | *e.g.: Werner Krabs:* „Mathematische Modellierung: Eine Einführung in die Problematik"<br>*Hartmut Bossel:* „Modellbildung und Simulation"<br>*F. Cellier:* „Continuous System Modeling"<br>*B. Zeigler, H. Praehofer, T.G. Kim:* „Theory of Modeling and Simulation"<br>*B. Page:* „Diskrete Simulation"<br>*N. Gershenfeld* : "Mathematical Modeling" |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Eich-Soellner, Nischwitz, Plöchinger |

## 19. Computational Geometry

*Module no.: IF-I-M304*

*Module representative: M. Fischer*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Scientific Computing" from which 2-3 courses must be chosen

**Objectives**
Computational geometry addresses efficient algorithms and data structures used for geometric problems involving objects such as points, lines, polygons, etc. on planes and higher dimensional spaces. A variety of applications are found for example in robotics, computer-aided design, computer graphics or Geo Information Systems (GIS).

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| **Prerequisites** | knowledge of algorithms and data structures |
| **Course objective** | This course provides a practical introduction to computational geometry. With a view to applications, the following areas will be discussed:<br>• "Winged edge" data structure<br>• Plane sweep algorithms<br>• Delaunay triangulation<br>• Voronoi diagrams<br>• Convex hulls |
| **Recommended literature** | *M. de Berg, et al.:* „Computational Geometry - Algorithms and Applications", Springer, 1997.<br>*Joseph O' Rourke:* „Computational Geometry in C", Cambridge University Press, 1993 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | M. Fischer, Nischwitz |

## 20. Optimization

*Module no.: IF-I-M305*

*Module representative: Plöchinger*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Scientific Computing" from which 2-3 courses must be chosen

**Objectives**
Some of the following processes for solving unconstrained, constrained, linear, quadratic and nonlinear optimisation problems:
- Simplex method
- Processes for quadratic optimisation problems
- Quasi Newton method
- Trust region method
- Inner point method
- SQP method
- Projection and sectional methods
- Lagrange and penalty methods

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| **Prerequisites** | Linear Algebra, Analysis and Numerical Analysis |
| **Course objective** | This course provides insight into the theory and practice of the basic methods of optimisation. Students will learn how to solve optimisation problems in a variety of areas with these methods. |
| **Recommended literature** | *Nocedal, Wright:* Numerical Optimization. Springer<br>*Geiger,Kanzow:* Numerische Verfahren zur Lösung unrestringierter Optimierungsaufgaben. Springer<br>*Geiger,Kanzow:* Theorie und Numerik restringierter Optimierungsaufgaben. Springer |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Eich-Soellner, Plöchinger |



## 21. IT Infrastructures

*Module no.: IF-I-M400*

*Module representative: Heigert*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „General Courses" from which 1-2 courses must be chosen.

**Objectives**
- Modern IT infrastructure technologies and important aspects of selection and assessment: networks, systems, computer centres, databases, security, etc.
- Planning, operation and organisation of complex IT infrastructures as well as the business assessment of IT infrastructure decisions
- Building and use of support infrastructures for information processing systems

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| **Prerequisites** | • Basic knowledge of data communications<br>• Basic knowledge of database systems<br>• Programming skills |
| **Course objective** | Obtain an understanding of planning, organisation and operation of complex information and communication infrastructures as required for the management of IT departments in large companies. |
| **Recommended literature** | *Hegering, Abeck, Neumair:* Integriertes Management vernetzter Systeme, dpunkt-Verlag, 1999<br>*IT Service Management* - Pocket Guide, OGC, UK, 2001<br>*Keen, Digrius:* Making Technology Investments Profitable, John Wiley, 2003. *Krcmar:* Informationsmanagement, Springer, 2003. *Limoncelli, Hogan:* The Practice of System and Network Administration, Addison-Wesley, 2002<br>*Microsoft Operations Framework* - MOF Pocket Guide, 2002<br>*Murphy:* Achieving Business Value from IT, John Wiley 2002<br>*Van Bon et al:* IT Service Management – eine Einführung, van Haren Publishing, 2002 |
| **Method of instruction** | seminars and exercises |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Heigert, Mandl |

## 22. Social Skills

*Module no.: IF-I-M401*

*Module representative: Lindermeier*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „General Courses" from which 1-2 courses must be chosen.

**Objectives**
- Principles: different aspects of social skills (personality traits, active behaviour, passive tolerance); business demands.
- Conceptual exercises: students will learn about different soft skills (e.g. values, personality, team leadership and team building, dealing with conflict, ability to criticise, communication, work processes).

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| **Prerequisites** | • Basic knowledge in the areas of facilitating, presenting, creativity, work processes, and decision-making theory is desirable<br>• Basic knowledge of information systems and manage ment |
| **Course objective** | Strengthening the student's personally abilities and encouraging the acquisition of key qualifications that go beyond technical knowledge. |
| **Recommended literature** | *Covey, S. R.:* Die sieben Wege zur Effektivität, Heyne Business, München, *Seiwert L. J., Gay F.:* Das 1 x 1 der Persönlichkeit, Gabal, Offenbach. *Pell A.:* The complete idiots Guide to team building, alpha books, West. *Robbins S. P.:* Organisation der Unternehmung, Pearson Education, München, 2001<br>*DeMarco T., Lister T.:* Wien wartet auf dich, Hanser, München |
| **Method of instruction** | practicum |
| **Examination** | verbal colloquium, presentation |
| **Language of instruction** | German |
| **Name of lecturer** | Lindermeier |

## 23. Project Management and Quality Assurance

*Module no.: IF-I-M402*

*Module representative: Lindermeier*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
- Project management: principles; project definition, planning, development and implementation; project organisation and controlling; project environment.
- Quality assurance: principles, product quality, process quality, methods, quality policy

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| **Prerequisites** | • Basic knowledge in the areas project management and software qualitiy engineering<br>• Basic knowledge of information systems and manage ment is desirable |
| **Course objective** | An understanding of the project- and quality-specific aspects of selected areas in information systems and management. This may include the procurement, implementation, development and maintenance of information processing systems in the business environment. |
| **Recommended literature** | *Balzert H.:* Lehrbuch der Software-Technik, Band 2, Spektrum, Heidelberg. *Kerzner H.:* Projektmanagement Fallstudien, mitp, Bonn. *Süß G., Ehrl-Gruber B.:* Praxishandbuch Projektmanagement, WEKA, Augsburg. *Myers G. J.:* Methodisches Testen von Progammen, Oldenbourg, München. *Riedemann E. H.:* Testmethoden für sequentielle und nebenläufige Software-Systeme, Teubner, Stuttgart. *Wallmüller E.:* Software-Qualitätsmanagement in der Praxis, Hanser, München |
| **Method of instruction** | seminars with exercises |
| **Examination** | written exam |
| **Language of instruction** | German |
| **Name of lecturer** | Lindermeier |

## 24. Decision Theory

*Module no.: IF-I-M404*

*Module representative: Peters*

*4 H/W*

*5 ECTS-Credits*

**Objectives**
- Normative and descriptive decision models
- Decision Making with complete/incomplete information
- Multi criteria and objective decisions making
- Rational decision-making, bounded rationality
- DSS - Decision Support Systems
- Games theory
- Case studies in decision theory

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|---|---|
| **Prerequisites** | • Business Mathematics I and II<br>• Statistics and Operations Research<br>• Intermediate Business Administration and Economics |
| **Course objective** | ability to recognise, assess and optimise one's own decision-making. Knowledge of the well established decision methods, |
| **Recommended literature** | *Eisenführ, F.; Weber, M.:* Rationales Entscheiden. 4. Auflage, Springer, Berlin, 2003. *Meixner O.; Haas, R.:* Computergestützte Entscheidungsfindung. Expert Choice und AHP - innovative Werkzeuge zur Lösung komplexer Probleme, Redline Wirtschaft, Frankfurt, 2002. *Laux, H.:* Entscheidungstheorie. Springer, Berlin, 2002 |
| **Method of instruction** | seminars with practical exercises |
| **Examination** | written exam |
| **Language of instruction** | German |
| **Name of lecturer** | Peters |



## 25. Real-Time 3D Computer Graphics

*Module no.: IF-I-M500*

*Module representative: Nischwitz*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
The following topics will be covered:
Hardware architectures for real-time 3D computer graphics, hard and soft real-time demands, scene graphs, cull algorithms, level of detail (switch, fade, morph), billboards (perspective-dependent vs. -independent, impostors, sprites), multi-processor systems, multi-pipeline systems, multi-channel applications, performance measurement, pipeline optimization, programmable vertex and pixel shaders, real-time phong shading, environment mapping, bump mapping, shadow mapping, animations, real-time image processing and general purpose computing on programmable graphics hardware.

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| **Prerequisites** | highly recommended: IF-I-M001 Computer Graphics |
| **Course objective** | And understanding of the basic concepts, algorithms and processes of real-time 3D computer graphics |
| **Recommended literature** | *A. Nischwitz, P. Haberäcker:* Masterkurs Computergrafik und Bildverarbeitung, Vieweg 2004. *T. Akenine-Möller, E. Haines:* Real-Time Rendering, A K Peters 2002 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Nischwitz, M. Fischer |

## 26. 3D Modelling

*Module no.: IF-I-M501*

*Module representative: Nischwitz*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
The following topics will be covered:
Modelling geometric objects, parameter curves, Bézier curves, splines, parametric surfaces, polygonal meshes, tessellation and triangulation, construction of triangular meshes, consolidation and simplification of polygonal meshes (level-of-detail), procedural and fractal modeling, physically based modeling, efficient 3D scene modeling for real-time rendering (consideration of special data structures of the rendering APIs).

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| **Prerequisites** | highly recommended: IF-I-M001 Computer Graphics |
| **Course objective** | And understanding of the basic concepts, algorithms and processes of real-time 3D computer graphics |
| **Recommended literature** | *A. Nischwitz, P. Haberäcker:* Masterkurs Computergrafik und Bildverarbeitung, Vieweg 2004. *M. Bender, M. Brill:* Computergrafik, Hanser 2003. *T. Akenine-Möller, E. Haines:* Real-Time Rendering, A K Peters 2002. *D.H. Eberly:* Game Physics, Morgan Kaufmann 2004. |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Nischwitz, M. Fischer |

## 27. Model-Driven Image Analysis

*Module no.: IF-I-M502*

*Module representative: Schnörr*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
Examples of selected topics:
- Moving objects: Kalman filter
- Shape, such as
  - Hough transformation
  - Statistical „shape knowledge" required for segmentation tasks
  - Hidden Markov Model (HMM)
- Colour: colour models for various object views
- 3D
  - 3D edge model and invariants
  - level set methods
- Texture: Gabor filters, orientation pyramids

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| **Prerequisites** | recommended: Digital Image Processing (IF-I-M002)<br>Helpful: 3D Reconstruction (IF-I-M506)<br>Image Sequence Processing and Motion Analysis (IF-I-M510)<br>Mathematical skills: Geometry, Linear Algebra, Differential Calculus in Rn |
| **Course objective** | Recognition performance by computer vision can be greatly increased if model concepts can be suitably formulated and considered right from the beginning. Particular analysis approaches in image processing will be introduced which are based on the modelling knowledge of various information channels: shape, colour, motion, 3D-information and texture. These procedures find many applications such as object tracking, surveillance tasks, information registration and retrieval. |
| **Recommended literature** | *D.A. Forsyth, J. Ponce:* Computer Vision: A Modern Approach, Prentice Hall, 2003. *J. Osher, R.P. Fedkiw*: Level Set Methods and Dynamic Implicit Surfaces, Springer Verlag 2002 |
| **Method of instruction** | seminars and a practicum and exercises |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German |
| **Name of lecturer** | Schnörr |

## 28. Digital Compression of Still Images and Video

*Module no.: IF-I-M503*

*Module representative: Nischwitz*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
This course will cover various image compression techniques, first as applied to single images and then successive frames. The elimination of redundant and/or irrelevant graphic data will be discussed. Important aspects include: sub-sampling and quantisation, entropy coding, decorrelation, run length coding, quad trees, fractal image compression, wavelets, intra- and inter-frame prediction, motion compensation. Individual discussions will examine the following still image and video coding standards: JPEG, H.261, H.263, MPEG-1, -2, -4.

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| **Prerequisites** | highly recommended: Digital Image Processing (IF-I-M002) |
| **Course objective** | An understanding of basic image compression methods. Knowledge of the most important image and video standards. |
| **Recommended literature** | *A. Nischwitz, P. Haberäcker:* Masterkurs Computergrafik und Bildverarbeitung, Vieweg 2004<br>*Clarke R.:* Digital Compression of Still Images and Video, Academic Press 1995 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Nischwitz, Schnörr |



## 29. Medical Image Processing

*Module no.: IF-I-M504*

*Module representative: Abmayr*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
The processing of medical images with the use of a computer has become indispensable to diagnosis and therapy. This course introduces the student to the required principles and covers essential areas such as:
- Image-producing processes and systems
- Strategies for processing medical images
- Transformations of medical images
- Filters for medical images
- Morphological operations
- Segmentation of medical images
- Feature extraction and feature analysis
- Classification principles
- Analysis and synthesis of medical images
- Typical medical question in the areas of
  - dermatology
  - cytology and histology
  - computer tomography

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| **Prerequisites** | basic knowledge of computer graphics and image processing |
| **Course objective** | The objective is to convey the most important concepts and to instil an ability to independently complete medical image processing tasks |
| **Recommended literature** | *H. Handels:* Medizinische Bildverarbeitung, Teubner Verlage, 2000. *Bildverarbeitung für die Medizin:* Grundlagen, Modelle, Methoden, Anwendungen, Prentice Hall, 1998. *W. Abmayr:* Einführung in die digitale Bildverarbeitung,Teubner, 1994 |
| **Method of instruction** | seminars and a practicum and exercises |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Abmayr, N.N. |

## 30. Photogrammetric Image Processing

*Module no.: IF-I-M505*

*Module representative: Krzystek*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
Principles and methods of digital photogrammetry:
- Sensor systems and image capture
- Digital (aerial) cameras
- Remote sensing
- Spatial transformations
- Image pyramids
- Digital image processing
- Photogrammetric stereo workstations
- Automatic generation of digital terrain models
- Digital rectification
- Digital orthophotos
- Resampling
- Mosaiking

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| **Prerequisites** | solid programming skills in C/C++ or Java |
| **Course objective** | Knowledge of the sensor technology as well as the methods and algorithms underlying digital photogrammetry. Ability to apply the methods and algorithms to an object-oriented programming language. |
| **Recommended literature** | *Th. Luhmann:* Nahbereichsphotogrammetrie, Wichmann 2004. *T. Schenk:* Digital Photogrammetry, TerraScience 1999 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Krzystek |

## 31. 3D-Reconstruction

*Module no.: IF-I-M506*

*Module representative: Schnörr*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
Some of the topics covered:
- Classification, areas of application, and examples
- Euclidean movements (object and camera motion, transformation of coordinates)
- Projective geometry (perspectivistic projection, representation and estimation of image primitives)
- Projective transformations and invariance (transformation groups, reconstruction of affine and metric image characteristics)
- Projection and cameras (special cameras, self-calibration)
- Epipolar geometry and geometry of multiple views
- Estimation of transformations and correspondences (camera matrix, calibration, com pensation for distortions)

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| **Prerequisites** | recommended: Digital Image Processing (IF-I-M002), Mathematical skills: Geometry, Linear Algebra, Differential Calculus in Rn |
| **Course objective** | 3D information plays a very important role in Computer Vision. This course provides an overview of approaches used for the extraction of 3D information from multiple views of the same scene. Only then can the structure of a real-world scene be really understood by computer-assisted methods. These procedures find many applications such as 3D quality control in manufacturing. |
| **Recommended literature** | *R. Hartley, A. Zisserman:* Multiple View Geometry in Computer Vision, Cambridge Univ. Press, 2000<br>*D. A. Forsyth, J. Ponce:* Computer Vision: A Modern Approach, Prentice Hall, 2003 |
| **Method of instruction** | seminars and a practicum and exercises |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German |
| **Name of lecturer** | Schnörr |

## 32. Photogrammetric Image Processing

*Module no.: IF-I-M507*

*Module representative: Kammerer*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
Selected methods used for processing raster data from geographic information systems
- Radar:
  SAR and InSAR principles, Data capture and data processing, Special filter pro cesses for radar data, Geo-coding, Relief-specific radiometric corrections, Mosaic-building, DGM derivation from radar data, Classification algorithms for radar data
- Raster-based geographic information systems, Difference between vector and raster GIS, GIS analysis of raster data,
  Knowledge-based classification
  Input of rules
  Specification and verification of hypotheses
  Compilation and use of raster applications with ERDAS modellers

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| **Prerequisites** | Image processing principles |
| **Course objective** | An understanding of the basic principles and algorithms and processes of real-time computer graphics. The ability to apply the principles and algorithms to efficient software. |
| **Recommended literature** | *A. Nischwitz, P. Haberäcker:* Masterkurs Computergrafik und Bildverarbeitung, Vieweg 2004. *ERDAS Field Guide* |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | Kammerer |



## 33. Real-Time Simulation

*Module no.: IF-I-M508*

*Module representative: M. Fischer*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
In many areas of engineering (particularly in the fields of automotives and aeronautics) increasingly complex mechatronic systems are being developed. Examples from the automotive industry include assistant systems such as steer-by-wire, brake-by-wire, automatically backing into a parking space, etc. The increasing complexity of these systems more and more requires the use of simulation techniques during development. The transition from pure computer simulation to the real system is seamless due to the use of hardware-in-the-loop simulation processes. This course will focus on the following areas:
- Principles of real-time simulation
- Hardware-in-the-loop simulation
- Simulation tools for real-time simulation (e.g. Matlab SIMULINK)
- Real-time bus systems (field and processor busses such as VME, MIL, FireWire, SERCOS)
- Use of real-time processors
- Information technology integration of hardware components
- Efficient design, execution and analysis of real-time simulations

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| **Prerequisites** | Model-Building and Simulation course and if necessary Embedded Systems course |
| **Course objective** | Within the engineering fields, real-time simulation is a strongly interdisciplinary field rapidly gaining in significance. This course provides students with a wide-ranging overview of the required tools and processes needed to develop and implement efficient real-time systems. Student will also be able to execute meaningful and reality-based real-time simulations. |
| **Method of instruction** | seminars and exercises |
| **Examination** | written exam |
| **Language of instruction** | German |
| **Name of lecturer** | M. Fischer, N.N. |

## 34. Robotics

*Module no.: IF-I-M509*

*Module representative: M. Fischer*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
Until recently, robots were used primarily in factory settings. Today, we find robots present in more and more environments in which humans are found or as extensions of ourselves in environments that are hard for us to reach or dangerous. Some examples include robots in medicine; humanoid robots or intelligent toy robots in the entertainment industry; robots in space repairing satellites or exploring unknown planets; mobile service robots, which guide us through museums or serve us in households of the future; or as auxiliary systems in vehicles intelligently facilitating us when breaking, steering or parking.

This course will cover the following areas: principles of robotics (principles of kinematics, forward and inverse kinematics, robot steering components, programming of robots); simulation systems in robotics; components of intelligent robots (telerobotics, sensor-guided robots, path planning, grasping, environment modelling).

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| **Prerequisites** | This course assumes mathematical skills that are equivalent to those acquired by the preliminary exam of an engineering programme of studies |
| **Course objective** | Within the engineering fields, real-time simulation is a strongly interdisciplinary field rapidly gaining in significance. This course provides students with a wide-ranging overview of the required tools and processes needed to develop and implement efficient real-time systems. Student will also be able to execute meaningful and reality-based real-time simulations. |
| **Method of instruction** | seminars and exercises |
| **Examination** | written exam (60%), Term work (40%) |
| **Language of instruction** | German or English |
| **Name of lecturer** | M. Fischer |

## 35. Image Sequence Processing and Motion Analysis

*Module no.: IF-I-M510*

*Module representative: Schnörr*

*4 H/W*

*5 ECTS-Credits*

*Offered: at irregular intervals on a rotating basis with other courses in the same subject group*

**Applicability:**
This course belongs to the subject group „Immersion Courses" from which 3 courses must be chosen.

**Objectives**
Some of the topics covered:

- Structure and motion
  - modelling: scene and imaging process
  - 3D-reconstruction of geometric objects
  - motion vector fields
- Signal processing and the correspondence problem
  - correspondence of image features
  - aperture problems, optical flow
  - frequency domain: velocity-selecting filters
  - non-local models and motion segmentation
  - optical flow: structure matrix and variation
- Tracking procedures:
  - point matching, cross correlation, window-based search
  - difference image procedure
  - Kalman filter and motion model
  - PDM (point distribution model)
  - active contours / level-set methods
  - HMM (Hidden Markov models)

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| **Prerequisites** | recommended: Digital Image Processing (IF-I-M002) Mathematical skills: Geometry, Differential Calculus in Rn, Differential Equations |
| **Course objective** | Besides e.g. colour, shape and texture, motion is a significant information channel contributing to the recognition of objects by image processing approaches. The analysis of moving objects plays an important role in many applications. The objective of this course is to provide the necessary principles, most significant approaches as well as practical methods. |
| **Recommended literature** | *A. Blake, M. Isard:* Active Contours, Springer-Verlag, 1998, *B.S. Yaakov, T.E. Fortmann:* Tracking and Data Association, Academic Press, 1988 |
| **Method of instruction** | seminars and a practicum |
| **Examination** | written exam (60%), term work (40%) |
| **Language of instruction** | German |
| **Name of lecturer** | Schnörr |