

**COMPUTER SCIENCE, doctoral study programme,
third Bologna cycle,
international joint (University of St Andrews)**

Compulsory and elective course descriptions

COMPULSORY COURSES

Course name: **SEMINAR 1**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Course name: **SEMINAR 2**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Course name: **SEMINAR 3**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Course name: **SEMINAR 4**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Course name: **SEMINAR 5**
Number of ECTS credits: **9**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Course name: **INDIVIDUAL RESEARCH WORK (1ST YEAR)**

Number of ECTS credits: **31**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/report. Article/Report needs to be than presented orally to the audience.

Course name: **INDIVIDUAL RESEARCH WORK (2ND YEAR)**

Number of ECTS credits: **25**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/report. Article/Report needs to be than presented orally to the audience.

Course name: **INDIVIDUAL RESEARCH WORK (3RD YEAR)**

Number of ECTS credits: **54**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/report. Article/Report needs to be presented orally to the audience.

Course name: **INDIVIDUAL RESEARCH WORK (DOCTORAL DISSERTATION) (4TH YEAR)**

Number of ECTS credits: **54**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/report. Article/Report needs to be presented orally to the audience.

ELECTIVE COURSES

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN MATHEMATICAL METHODS IN COMPUTER SCIENCE 1**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- random graphs
- permutation groups
- hypergraphs and Boolean functions
- advanced topics in coding theory
- advanced counting techniques
- random walks on graphs
- graph decompositions
- the probabilistic method in combinatorics
- discrete Fourier analysis and applications
- connection of the above with information theory and algorithms

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN MATHEMATICAL METHODS IN COMPUTER SCIENCE 2**

Number of ECTS credits: **9**

Content:

The course covers a detailed study of contemporary and emerging cryptographic and cryptanalytic techniques and their importance in the implementation of secure computer systems. The topics might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Information theoretic vs. computational security
- Fast hash based signatures
- Elliptic curve cryptography and pairings
- Lattice based cryptography
- Malleable cryptography
- Analysis of number theoretic assumptions
- Primality testing and factorization
- Blockchain and Cryptocurrencies
- Zero-knowledge proofs and interactive protocols
- Searchable encryption
- Multi-party secure computation

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN DATA STRUCTURES AND ALGORITHMS 1**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Partial and Full persistence
- Purely functional data structures (concatenable lists)
- Deamortization and Dynamization techniques
- Sorting and Priority queues
- List order maintenance
- Interpolation search
- Deterministic hashing
- Priority queues: Binomial, Fibonacci, Skew heaps
- Finger search trees
- RAM data structures
- Least common ancestor data structures
- Succinct data structures
- Implicit data structures
- van Emde Boas data structures
- Union-(split)-find data structures

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN DATA STRUCTURES AND ALGORITHMS 2**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Taxonomy of parallelism: Flynn's classification
- Vector, SIMD, MIMD computers
- Programming of parallel computers
- Energy efficiency
- Customized architecture with specific algorithms
- Distributed computing
- Formal models and computational complexity of parallel computing
- Design in the analysis of parallel algorithms
- Linear programming
- Parallel, String, Online, Approximation, Fixed-Parameter, External-Memory, Streaming Algorithms
- Computational Geometry

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN SOFTWARE DEVELOPMENT 1**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Model Driven Development/Architecture
- Model Transformation and Code Generation
- Models at Runtime
- Software Repository Mining
- Data Analytics in Software Engineering
- Defect Prediction
- Microservices
- Natural language processing techniques
- Infrastructure as Code
- Computing Paradigms
- Cloud Standards
- Parallel systems
- Continuous Delivery and DevOps
- Software engineering and AI
- Adaptive Learning Systems

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN SOFTWARE DEVELOPMENT 2**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Light/object(s) interaction techniques
- Texture and environment mapping
- Raytracing algorithms
- Multiresolution modeling
- Physically based modeling
- Deformation modeling
- Advanced real-time rendering
- Radiosity
- Computer vision and (multi-view) geometry

- Learning based methods in computer vision
- Motion analysis and activity recognition
- The use of the above in animations, simulations and 3D user interfaces

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN COMPUTER SYSTEMS 1**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Foundations and design of sensor networks
- Performance evaluation
- Architectural developments
- Advances in allocation algorithms
- Service discovery and selection
- Scheduling optimization
- Energy related issues
- Communication with and between sensors
- Domain-specific aspects of sensor data
- Mediation solutions for data heterogeneity problems
- Failure recovery in shared systems
- Distributed transaction processing
- Information diffusion
- Security, Semantics, Protocols
- Environments for massively distributed data collection and processing
- Sensor networks and Machine Learning
- Fusion-based sensor networks

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN COMPUTER SYSTEMS 2**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Advanced machine learning techniques
- Deep learning
- Active learning
- Applications of artificial intelligence
- Agent technologies
- Large scale data mining
- Temporal pattern mining
- Social media analytics
- Statistical data analysis
- Information visualisation techniques
- Opinion Mining and Sentiment Analysis
- Statistical modeling
- Recommender systems
- Viral marketing

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN COMPUTER INTERACTIONS 1**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Theories behind HCI and their application to a number of newly emerging technologies
- Software infrastructures for the user interfaces
- Design languages & methods applied to user interface design
- Specifying & designing functionality
- User modelling and its applications to adaptive user interfaces
- Major user interface paradigms, including anthropomorphic interfaces
- Novel user interfaces
- Co-design of hardware & computer interfaces
- Social and ethical issues
- Critical & Cultural Computing
- Designing to Change Power and Authority
- User Interfaces for Built Environments

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SELECTED TOPICS IN COMPUTER INTERACTIONS 2**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- appropriate allocation of visual attributes to data variables
- the psychology of human vision and perception
- visual analytics
- interaction, rapid navigation
- Storytelling
- text visual analytics
- big data, uncertainty, network, geospatial (cartographic) visualization
- animation and time series visualization
- Input techniques, virtual viewpoint control
- multi-dimensional visualization
- visualization research methodologies
- evaluating the applicability of theories to infovis problems

Course name: **SCIENTIFIC SKILLS - DESIGN AND ANALYSIS OF PLANNED EXPERIMENTS**

Number of ECTS credits: **6**

Content:

The student will become familiar with the following topics in experimental design and analysis, with an emphasis on data capture, data preparation and statistical analysis:

- Identifying and expressing hypotheses
- Sampling, experimental units, replication
- Factors and levels
- Relationship between sample size, predictive power, and planned analysis
- Randomisation

- One-way layouts
- Matched pairs
- Fixed effects, random effects, mixed effects
- Factorial arrangement
- Blocking, latin squares, split plots, nesting
- Analysis and reporting in R
- Other topics in analytics

Course name: **SCIENTIFIC SKILLS - SCIENTIFIC WRITING AND PRESENTATION**

Number of ECTS credits: **6**

Content:

Students will review and practice key skills in scientific writing and presentation:

- Reporting scientific results
- Structuring scientific writing
- Oral presentations of scientific results
- Presenting science to non-scientific audiences
- Argument and persuasive writing
- Proposal writing
- Poster presentation
- Role of graphics and visualisation