

First year courses

BA Data Science & AI Year 1 Core Courses

Introduction to Data Science and Artificial Intelligence

Full course description

The course Introduction to Data Science and Artificial Intelligence offers a comprehensive overview of the core topics in Data Science and Artificial Intelligence, both from a mathematical and from a computational perspective. Particular emphasis is put on the basic classes of techniques and methods, the theoretical underpinnings of data science and computational intelligence, and some example application domains of data science and artificial intelligence. As such, the course provides an overview of many topics that are addressed in much more detail throughout the Bachelor's Data Science and Artificial Intelligence programme. Knowledge and understanding: After successful completion of the course, students will be able to recognise what real world problems require the use of data science, and approach their solution by using a data science process, namely: explore the data, model the data, and perform simulations if required. Moreover, they will exhibit knowledge in the basic concepts of artificial intelligence, such as agents, search, artificial intelligence, decision trees. Applying knowledge and understanding: Students learn to recognise applications of data science and artificial intelligence in different domains and apply the basic techniques they have learnt from both.

Prerequisites

None.

Desired Prior Knowledge: The course appears as desired prior knowledge for the courses Reasoning Techniques and Theoretical Computer Science

Recommended reading

- S. Russell and P. Norvig (2010): Artificial Intelligence, A Modern Approach. Third edition, Pearson Education, ISBN 978-0-13-207148-2.
- C.D. Manning, P. Raghavan and H. Schütze (2008) Introduction to Information Retrieval. Cambridge University Press. ISBN 0521865719

KEN1110

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

- [P. Bonizzi](#)
- [R. Cavill](#)
- [A.M. Wilbik](#)

Procedural Programming

Full course description

The course provides the basics of computer science and computer programming. After a short introduction to computer organization, the principles of programming are presented. The main topics of the course are: data types, variables, methods, parameters, decision structures, iteration, arrays, recursion and a branching application (related to the semester project). Programming skills will be acquired during practical sessions using the object-oriented programming language Java.

Prerequisites

None. It appears as part of the pre-requisites of the second semester project in year 1, both projects of year 2, the year 2 course Databases and the year 3 courses, Parallel Programming and Robotics and Embedded Systems.

The course appears as desired prior knowledge for the courses Introduction to Objects in Programming, Data Structures and Algorithms, Software Engineering, Databases and Machine Learning.

Recommended reading

H. Schildt, Java: A Beginner's Guide, Eighth Edition, ISBN: 1260440214, McGraw-Hill Education

KEN1120

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [E. Hortal Quesada](#)
- [C. Kouzinopoulos](#)

Teaching methods:

Data Science and Artificial Intelligence

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Discrete Mathematics

Full course description

In this course, we build a mathematical framework that is based on logic and reason. The main objective of the course is to make students familiar with the language of mathematics. Students will learn how to make sound arguments and to detect where and why certain arguments go wrong. For this purpose, we will discuss the basic principles of logic and, closely related, the basic types of mathematical proofs. In doing so, we will encounter numbers such as integers, natural numbers and real numbers and we shall examine what makes these numbers special. After that, we will use basic logic to discuss, among other things, the following mathematical concepts: infinity, sets, relations, functions, permutations and combinations. Our fundamental tool in all of this is plain common sense. You really do not need your toolbox of mathematical formulas learned in previous studies and neither do you need a calculator. Pen and paper are the basic instruments needed. After completing each topic, exercises will be provided to be completed in class or at home, since mathematics is mainly learned by practising repeatedly.

Prerequisites

None.

Recommended reading

None.

KEN1130

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [M. Musegaas](#)
- [O. D'Huys](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Objects in Programming

Full course description

This course is a follow-up of the course Procedural Programming (Formerly known as Introduction to Computer Science 1). It teaches object-oriented programming in Java. The main topics covered in the course are objects and classes, interfaces and polymorphism, event handling, inheritance, graphic user interfaces, exception handling, and streams.

Prerequisites

Desired prior knowledge: Basic Java Programming

Recommended reading

C. Horstmann (2016). Java Concepts (8th Edition). John Wiley & Sons, New York, ISBN: 978-1-1190-5645-4 C.

Horstmann (2012). Big Java Late Objects. John Wiley & Sons, New York, ISBN 978-1-1180-8788-6

KEN1220

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [T.A. Bitterman](#)
- [E.N. Smirnov](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Calculus

Full course description

The following subjects will be discussed in Calculus: limits and continuity, differential calculus, inverse and transcendental functions, mean value theorem, integral calculus, sequences and series, introduction to differential equations, introduction to multivariable calculus. In addition to the main facts and concepts, problem-solving strategies will be discussed. Both the intuition behind the concepts and their rigorous definitions will be presented along with simple examples of formal mathematical proofs.

Prerequisites

None.

Recommended reading

None.

KEN1440

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [O. D'Huys](#)
- [G.M. Schoenmakers](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Logic

Full course description

This course deals with three logical systems, namely propositional logic, first-order predicate logic and epistemic logic. The course covers notation systems, syntax and semantics, valid consequences, deduction, semantic tableaux, and proof systems.

Prerequisites

None. The course appears as a prerequisite for the course Logic for AI.

Recommended reading

None.

KEN1530

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [T.D. Rienstra](#)
- [S.J. Maubach](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Project 1-1

Full course description

Students work on a project assignment in small groups of about six students. The group composition stays the same for the whole project and is announced shortly before the project opening in period 1.1. The students are guided through the project by a fixed tutor. The project assignment is divided into three subtasks (one per period) and is strongly related to the content of the courses from period 1.1 and 1.2. In period 1.1, after receiving the assignment for the whole project at the end of week 5, the students work full-time on the project in week 6. In this week, each group meets the tutor twice. In period 1.2, the students continue working on the project, while also having to attend the courses of that period. They meet their tutor approximately once a week. In period 1.3, the students work three weeks full-time on the project and meet their tutor about twice a week.

At the beginning of period 1.2 and 1.3, the students have to hand in a planning for the current phase. At the end of each period, the students have to give a presentation and the source code, presentation and an overview of who did what need to be uploaded to Canvas. While the presentations at the end of period 1.1 and 1.2 are in front of the examiners and the tutors, the presentations at the end of period 1.3 will additionally be in front of the fellow students. In period 1.3, they furthermore have to hand in a report and attend a product and report examination.

Project 1-1 will start in period 1.1 and period 1.2. The credits for the projects will become available at the end of period 1.3.

For each period, we will give a short explanation of the various parts. Before the start of each period, the students will receive detailed information about the content, the study material, the teaching form, the schedule, and the examination method.

Prerequisites

This project has no prerequisites. This project occurs as part of the prerequisites of project 2-1.

KEN1300

Semester 1

2 Sep 2024

24 Jan 2025

[Print course description](#)

ECTS credits:

6.0

Instruction language:

English

Coordinator:

- [M. Boussé](#)

Teaching methods:

Project-Centered Learning, Work in subgroups, Presentation(s), Skills

Assessment methods:

Assignment, Presentation and paper, Participation

Linear Algebra

Full course description

This course introduces the fundamental concepts of linear algebra, and examines them from both an algebraic and a geometric point of view. First, we address what can be recognized without doubt as the most frequently occurring mathematical problem in practical applications: how to solve a system of linear equations. Then we discuss linear functions and mappings, which can be studied naturally from a geometric point of view. Vector spaces are then introduced as a common framework that brings all themes together. Next, we shift from the geometric point of view to the dynamic perspective, where the focus is on the effects of iterations (i.e., the repeated application of a linear mapping). This involves a basic theory of eigenvalues and eigenvectors, which have many applications in various branches of science as for instance in problems involving dynamics and stability, in control theory, and in optimization problems found in data science. Key concepts in the course are vectors, matrices, systems of linear equations, eigenvalues, eigenvectors, linear transformations, and orthogonality. The software package Matlab is introduced in the accompanying computer classes, where emphasis is put on the application of linear algebra to solve real world problems.

Prerequisites

None.

Desired prior knowledge for the second year courses, Mathematical Modelling, Linear Programming.

Recommended reading

None.

KEN1410

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [M. Musegaas](#)
- [P.W.L. Dreesen](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Data Structures and Algorithms

Full course description

As a continuation of the courses Procedural Programming (formerly known as Introduction to Computer Science 1) and Objects in Programming (formerly known as Introduction to Computer Science 2), this course will treat the systematic design and application of data structures and algorithms.

Data structures such as lists, trees, graphs, and strings, the associated algorithms and their complexity will be treated. Design principles for algorithms such as recursion, divide-and-conquer and dynamic programming will be treated as well.

Prerequisites

Desired Prior Knowledge: Discrete Mathematics, Procedural Programming (formerly known as Introduction to Computer Science 1) and Objects in Programming (formerly known as Introduction to Computer Science 2). The course is desired prior knowledge for Theoretical Computer Science.

The course itself occurs as part of the pre-requisites of both projects of year 2 and the third year course Parallel Programming.

Recommended reading

Required Reading: Sedgewick and Wayne (2011) Algorithms Fourth Edition. Addison Wesley. ISBN: 978-0321573513

Recommended Reading: A Y Bhargava (2016). Grokking Algorithms: An Illustrated Guide for Programmers and Other Curious People. Manning. ISBN: 978-1617292231

KEN1420

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [F. Barile](#)
- T.H.J. Pepels

- [S.S. Kotala](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Dept. of Advanced Computing Sciences

Principles of Data Science

Full course description

Nowadays data science is at the core of modern society. We collect large amounts of data with the goal to make better decisions. We need to make sense of the data and leverage it in effective ways.

In this course, we will start with where data comes from—controlled experiments and observational studies. We will look at potential biases that can affect conclusions that we make from data. We will focus on what kind of causal statement one can draw based on data coming from experiments versus observational studies.

We will then summarize and visualize data using histograms and scatter plots. As we will see, there are some interesting recurring patterns when we summarize data. For example, the distribution of the average follows the bell shape curve. We will also consider deviations from the bell shape curve in case of outliers, and how to deal with real world and possible “unclean” data. Scatter plots will help us study the regression line and correlations.

This course will build the foundation for subsequent courses: probability and statistics, simulation and statistical analysis, and machine learning. You will learn how to convert data into tables and use them for subsequent analysis and plotting. We will focus on the principles of modern reproducible science, that is, to build analysis workflows that can easily be understood and re-run by others. We will learn how to keep track of analysis decisions and parameter choices. We will summarize all the uncertainties in an accessible way and see that this is crucial for effective decision making in the modern world.

During the labs, we will learn Python—one of the main programming languages used in data science—and how to use it to write analysis reports using literate programming—mixing code, plots, and narrative in the same document. We will analyze and visualize real datasets.

Prerequisites

Desired Prior Knowledge: Procedural Programming

Recommended reading

Study material: Statistics (fourth edition, 2007) by Freedman, Pisani, and Purves.
Additional selected material from data science textbooks and other resources.

KEN1435

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Coordinators:

- [M.C. ten Thij](#)
- [A. Wodeyar](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Computational and Cognitive Neuroscience

Full course description

The course Computational and Cognitive Neuroscience presents an overview of the core topics in cognitive and biological psychology. These topics include (human) perception, learning, memory, planning, problem solving, reasoning, language, speech, and action. Both the functional and neuroanatomical foundations of cognitive faculties are addressed. Several models of cognition and theories of brain function that are of relevance to knowledge engineering will be outlined. Several skills trainings will be given to train understanding in biological functioning of neuronal communication, and functioning of neural networks and genetic algorithms.

Prerequisites

none

Recommended reading

Sternberg, R.J. (1999). Cognitive psychology (latest edition).

Fort Worth: Harcourt Brace.

Kalat, J.W. (2007) 9th edition Biological psychology. Pacific Grove, California; London: Brooks Cole.

Gazzaniga, M. (2009). Cognitive Neuroscience (third edition).

KEN1210

Period 5

31 Mar 2025

23 May 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [M. Capalbo](#)
- [A.F. Roebroek](#)

Data Science and Artificial Intelligence

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Software Engineering

Full course description

This course introduces students to software design and project management concepts. Students get introduced to multiple techniques they require to work on medium and large-scale projects in professional business and research environments. Students learn how to produce professional, reliable, and cost-efficient software that can be developed in a team, reused, maintained, further evolved, and that is tested professionally. Covered concepts include requirement engineering, project planning, risk management, software evaluation and testing, software engineering processes, design principles, software architectures, design patterns and principles, API development, code review, version control, specifications, debugging, refactoring, and abstract data types.

Prerequisites

Desired prior knowledge: Procedural Programming (formerly known as Introduction to Computer Science 1), Objects in Programming (formerly known as Introduction to Computer Science 2) and Data Structures and Algorithms.

Recommended reading

- Goldman and Miller, MIT 6.031: Software Construction: <http://web.mit.edu/6.031/>
- Martin, Clean Code: A Handbook of Agile Software Craftsmanship (2008)

KEN1520

Period 5

31 Mar 2025

23 May 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- T.H.J. Pepels
- B. Küppers
- [A.D. de Freitas Sousa](#)
- [Y.C. Semerci](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Numerical Methods

Full course description

Numerical methods are techniques for solving problems from continuous mathematics (calculus and linear algebra) with the aid of a digital computer. In this course, we will cover the fundamental concepts of numerical mathematics, including the floating-point representation of real numbers, truncation and round-off errors, iterative methods and convergence. We will study the simplest and most important methods for core problems of continuous mathematics, namely the solution of algebraic equations and differential equations, interpolating data by polynomials, numerically estimating derivatives and integrals, approximating functions by polynomials and trigonometric series, solving systems of linear algebraic equations and computing eigenvalues. There will be a strong practical component, with students being expected to write their own numerical code and test the performance and suitability of different methods on various problems.

Prerequisites

Desired prior knowledge: calculus, linear algebra

Recommended reading

Recommended literature: J.D. Faires & R. Burden, "Numerical Methods", International 4th Edition, Cengage, 2012; ISBN: 978-0-495-38569-1.

Additional literature: C.F. Gerald & P.O. Wheatley, "Applied Numerical Analysis", Seventh Edition, Pearson, 2003; ISBN: 0-321-13304-8. T. Siau & A.M. Bayen, "An Introduction to Matlab Programming and Numerical Methods for Engineers", Academic Press, 2015; ISBN 978-0-12-520228-3.

KEN1540

Period 5

31 Mar 2025

23 May 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [P.J. Collins](#)
- [M. Boussé](#)
- [B. Sakçak](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Project 1-2

Full course description

Students work on a project assignment in small groups of about six students. The group composition stays the same for the whole project and is announced before the project opening in period 1.4. The students are guided through the project by a fixed tutor. The project assignment is divided into three subtasks (one per period) and is strongly related to the content of the courses from period 1.4 and 1.5. In period 1.4, after receiving the assignment for the whole project at the end of week 5, the students work full-time on the project in week 6. In this week, each group meets the tutor twice. In period 1.5, the students continue working on the project, while also having to attend the courses of that period. They meet their tutor approximately once a week. In period 1.6, the students work three weeks full-time on the project and meet their tutor twice a week.

At the beginning of period 1.5 and 1.6, the students have to hand in a planning for the current phase. At the end of each period, the students have to give a presentation and the source code, presentation and an overview of who did what need to be uploaded to Canvas. While the presentations at the end of period 1.4 and 1.5 are in front of the examiners and the tutors, the presentations at the end of period 1.6 will additionally be in front of the fellow students. In period 1.6, they furthermore have to hand in a report and attend a product and report examination.

Project 1-2 will start in period 1.4 and period 1.5. The credits for the projects will become available at the end of period 1.6.

For each period, we will give a short explanation of the various parts. Before the start of each period, the students will receive detailed information about the content, the study material, the teaching form, the schedule, and the examination method.

Prerequisites

In order to participate in this project the student has to have passed two out of four courses from the set: Discrete Mathematics, Calculus, Procedural Programming and Objects in Programming.

Recommended reading

None.

KEN1600

Semester 2

27 Jan 2025

20 Jun 2025

[Print course description](#)

ECTS credits:

6.0

Instruction language:

English

Coordinator:

- [O. D'Huys](#)

Data Science and Artificial Intelligence

Teaching methods:

Project-Centered Learning, Work in subgroups, Presentation(s), Skills

Assessment methods:

Assignment, Presentation and paper, Participation

Second year courses

If the student has obtained at least 45 credits in the first year courses, they may register for the second year courses.

Second year students **choose one out of the two** electives courses during period 4.

BA Data Science & AI Year 2 Core Courses

Databases

Full course description

This course will cover data modelling, the concepts and theory of the relational data model, and the widely used programming language SQL. These concepts will be applied in case studies.

Prerequisites

Desired Prior Knowledge: Procedural Programming (formerly known as Introduction to Computer Science 1) and Objects in Programming (formerly known as Introduction to Computer Science 2).

Recommended reading

Ramakrishnan, R. and Gehrke, G. 2002. Database Management Systems (3 ed.). McGraw-Hill, Inc., New York, NY, USA.

KEN2110

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [A.R.K. Sai](#)
- T.H.J. Pepels

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Probability and Statistics

Full course description

This course is a first introduction to probability and statistics. We will start by learning how to count and define a notion of probability. We will then move on to the concept of conditional probability, random variables and their distributions, expectation, continuous random variables, moments, joint distributions, and inequalities and limit theorems. This will provide us with the necessary language to study central topics of importance in statistics, such as the difference between a population and a sample, confidence intervals, parameter estimation, and hypothesis testing.

Prerequisites

None.

Desired prior knowledge: Discrete Mathematics and Calculus

Recommended reading

None.

KEN2130

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [C.J. Seiler](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Graph Theory

Full course description

A graph is simply a collection of points, some of which are joined by lines. This deceptively simple structure is one of the cornerstones of both theoretical and applied computer science. A great many problems that arise in the real world can be modeled as graph problems. Several classical examples include the problem of finding the shortest route between two cities, of maximizing flow in a network of pipelines, or of finding an optimal pairing between producers and consumers. In this course we will look at both the algorithmic/applied side of graph theory and its more

abstract mathematical foundations, because the latter is often important for understanding the former. We will cover topics such as paths, tours, trees, matchings, flows and colorings.

Prerequisites

Desired Prior Knowledge: Discrete Mathematics; Data Structures and Algorithms

Recommended reading

None.

KEN2220

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Coordinator:

- [M. Mihalak](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assessment

Reasoning Techniques

Full course description

Central in this course is how, based on available data, new knowledge and information can be obtained using reasoning processes. The course will be supported by tutorials, in which the acquired techniques can be put into practice by using Prolog. The following four techniques are discussed:

(1) Reasoning using logic: syntax, semantics, and inference in first-order logic, situation calculus, forward and backward reasoning, completeness, logic programming with Prolog.

(2) Problem solving using search: problem types, blind-search methods, informed-search methods, comparison of search methods, games as search problems, minimax, alpha-beta pruning, Monte Carlo Tree Search, chance games, constraint satisfaction problems.

(3) Planning: planning in situation calculus, representation of states, goals and operators, state space and plan space, algorithms for classic planning.

(4) Reasoning with uncertainty: uncertainty and probability theory, conditional probability, the Rule of Bayes, semantics of belief networks, exact and approximate inference in belief networks.

Prerequisites

Desired Prior Knowledge: Introduction to Data Science and Knowledge Engineering, Logic.

Recommended reading

Required literature:

- Russell, S. and Norvig, P., Artificial Intelligence: A Modern Approach, 4th edition. Pearson, 2020.
- Bratko, I. (2012). Prolog: Programming for Artificial Intelligence, 4th edition. Addison-Wesley.

KEN2230

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [M.H.M. Winands](#)
- [T.D. Rienstra](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Machine Learning

Full course description

Machine learning is a major frontier field of artificial intelligence. It deals with developing computer systems that autonomously analyse data and automatically improve their performance with experience. This course presents basic and state-of-the-art techniques of machine learning. Presented techniques for automatic data classification, data clustering, data prediction, and learning include Decision Trees, Bayesian Learning, Linear and Logistic Regression, Recommender Systems, Artificial Neural Networks, Support Vector Machines, Instance-based Learning, Rule Induction, Clustering, and Reinforcement Learning. Lectures and practical assignments emphasize the practical use of the presented techniques and prepare students for developing real-world machine-learning applications.

Prerequisites

Desired prior knowledge: Introduction to Computer Science 1, Calculus, Linear Algebra, Logic, Probability and Statistics.

Recommended reading

- T. Mitchell (1997). Machine Learning, McGraw-Hill, ISBN-13: 978-0071154673.
- H. Blockeel, Machine Learning and Inductive Inference (course text), Uitgeverij ACCO, 2012.

Data Science and Artificial Intelligence

- I.H. Witten and E. Frank (2011). Data Mining: Practical Machine Learning Tools and Techniques (Third Edition), Morgan Kaufmann, January 2011, ISBN-13: 978-0123748560.

KEN2240

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [E.N. Smirnov](#)
- [E. Hortal Quesada](#)
- T.H. Dick

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Simulation and Statistical Analysis

Full course description

Mathematical simulation is concerned with studying processes and systems. Uncertainty can be an important factor and has to be modelled properly. After modelling a complex system, various scenarios can be simulated, using Monte Carlo simulation, to gain insight. The results need to be properly interpreted and uncertainty has to be reduced. The modelling, implementation, analysis and technical aspects will be discussed as an introduction in this field. Emphasis will be on discrete event simulation and the statistical analysis of the output of simulation studies, where topics are: modelling, Poisson processes, random number generators, selecting and testing input distributions, generating random variates, statistical analysis of experiments, comparing experimental results and variance reduction. Practical exercises will be used to place the techniques in context.

Prerequisites

Desired Prior Knowledge: Knowledge: Probability & Statistics, Calculus, Matlab, and Java.

Recommended reading

Object-Oriented Computer Simulation of discrete-event systems - Jerzy Tyszer, Design and Analysis of Experiments - Douglas C. Montgomery, Introduction to Probability Models - Sheldon M. Ross.

KEN2530

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [J.M.H. Karel](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Project 2-1

Full course description

Students work on a project assignment in small groups of about six students. The group composition stays the same for the whole project and is announced at the beginning of period 2.1. The students are guided through the project by a fixed tutor. The project assignment is divided into three subtasks (one per period) and is strongly related to the content of the courses from period 2.1 and 2.2. In periods 2.1 and 2.2, the students work on the project, while also having to attend the courses of these periods. They meet their tutor approximately once a week. In period 2.3, the students work three weeks full-time on the project and meet their tutor twice a week.

At the beginning of each period, the students have to hand in a planning for the current phase. At the end of each period, the students have to give a presentation and the source code, presentation and an overview of who did what need to be uploaded to Canvas. While the presentations at the end of period 2.1 and 2.2 are in front of the examiners and the tutors, the presentations at the end of period 2.3 will additionally be in front of the fellow students. In period 2.3, they furthermore have to hand in a report and attend a product and report examination.

Project 2-1 will start in period 2.1 and period 2.2 with weekly meetings. The credits for the projects will become available at the end of period 2.3.

Prerequisites

Students must have passed Project 1-1. Furthermore, the student has to have passed at least two out of the following three courses: Procedural Programming, Objects in Programming, and Data Structures and Algorithms. The student furthermore needs to be registered for or has already completed at least three courses of the programme in year 2, semester 1. This project is a prerequisite for Project 3-1.

Recommended reading

None.

Data Science and Artificial Intelligence

KEN2300

Semester 1

2 Sep 2024

24 Jan 2025

[Print course description](#)

ECTS credits:

6.0

Instruction language:

English

Coordinator:

- [O. D'Huys](#)

Teaching methods:

Project-Centered Learning, Work in subgroups, Presentations, Skills

Assessment methods:

Written exam, Presentation and paper, Participation

Human Computer Interaction & Affective Computing

Full course description

Human -Computer Interaction (HCI) is the study of interaction between people (users) and computers. It is often regarded as the intersection of computer science, behavioural sciences, design and several other fields of study. Interaction between users and computers occurs at the user interface, which includes both software and hardware; for example, characters or objects displayed on a personal computer's monitor and input received from users via hardware peripherals such as keyboard, mouse and web cameras. This course also covers Affective Computing, a new branch of HCI that places emphasis on user emotions and personality. Affective Computing attempts to bring emotions into intelligent interfaces that interact with humans and see how they can have a positive and constructive impact in human-machine interactions.

Prerequisites

Desired Prior Knowledge: Machine Learning, Probabilities and Statistics.

Recommended reading

- Shneiderman B, Plaisant C, Cohen M, Jacobs S, Elmqvist N, Diakopoulos N. (2016) Designing the user interface: strategies for effective human-computer interaction. Pearson, ISBN: 978-0134380384
- Calvo RA, D'Mello S, Gratch JM, Kappas A, (2015). The Oxford handbook of affective computing. Oxford University Press, ISBN: 978-0199942237
- Coursera video lectures of Scott Klemmer and accompanying slides.

KEN2410

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

Data Science and Artificial Intelligence

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [K. Zarkogianni](#)
- [Y.C. Semerci](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Mathematical Modelling

Full course description

Mathematical modelling is of great importance for solving practical problems by casting them into a form suitable for the use of mathematical techniques. In this course, a number of basic topics are discussed. First, attention is paid to a framework for mathematical modelling. Then we focus on some widely used model classes from engineering, in particular on the class of linear time-invariant dynamical models. These are described by linear difference equations (in discrete time) or linear differential equations (in continuous time). Alternative model descriptions that are discussed are transfer functions (in the frequency domain) obtained with the z-transform and the Laplace transform respectively; and state-space models, which may or may not involve canonical forms. Some further topics receiving attention are the concepts of stability, sinusoidal fidelity, Bode diagrams, the interconnection of subsystems, and the technique of pole placement by means of state feedback.

The subject matter is clarified through exercises and examples involving practical applications. Also, relevant functionality in Matlab is introduced, which offers a powerful instrument for analysing linear dynamic models.

Prerequisites

Desired Prior knowledge: Linear Algebra, Calculus, Matlab.

Recommended reading

Richard J. Vaccaro, Digital Control: A State-Space Approach, McGraw-Hill, 1995, ISBN 0-07-066781-0.

KEN2430

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

- [J.M.H. Karel](#)
- [R.L.M. Peeters](#)

Philosophy & Artificial Intelligence

Full course description

One of the characteristics of scientific knowledge is the translation of natural phenomena into quantitative or mathematical data – the book of nature, Galileo wrote, is written in the language of mathematics. Over the course of the twentieth and twenty-first century, this desire to understand the world through the logic of mathematics has been extended beyond the natural world to include such things as human consciousness, learning, and intelligence. Indeed, the foundation of what is called ‘artificial intelligence’ is the pursuit of replicating human consciousness and intelligence through mathematical models and formulas. In this course we will examine these issues from a philosophical perspective, beginning with a basic overview of the philosophy of science with an emphasis on quantification and then moving on to study philosophical issues that have developed out of the pursuit of artificial intelligence. We will begin with classic thinkers in the field like Alan Turing, Hubert Dreyfus, and Joseph Weizenbaum and continue through to contemporary philosophical studies of cutting edge attempts to develop types of machine learning that aim to mimic human forms of learning.

Prerequisites

None.

Recommended reading

None

KEN2120

Period 5

31 Mar 2025

23 May 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [R. Gianni](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Linear Programming

Full course description

A linear program is very different to, say, a Java program. It simply consists of a linear objective function (of potentially very many variables) and a set of linear inequalities. The goal is to find values of the variables, which maximize or minimize the objective function, subject to all the inequalities being satisfied. Linear programs - even very large linear programs - can be solved extremely quickly, in both theory and practice. The model is also expressive enough to capture a large number of real-world problems. These two factors explain the fundamental role of linear programming in operations research, computer science, economics, management and many other fields. The course consists of an in-depth study of the simplex algorithm (a standard algorithm for solving linear programs), duality theory, and sensitivity analysis. Examples from practice illustrate the power of the model and teach the student the skill of modelling. Practical aspects of linear programming (e.g. use of software packages for solving linear programs, and integration with languages such as Java) are also considered.

Prerequisites

Desired Prior Knowledge: Linear Algebra.

Recommended reading

students are beforehand encouraged to refresh their knowledge of: (unique) solutions of systems of linear equations, matrix inversion, and matrix rank.

KEN2520

Period 5

31 Mar 2025

23 May 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [S.M. Kelk](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Natural Language Processing

Full course description

ChatGPT can answer almost any question you have. Siri can tell me when I need an umbrella. But how do they work? Over the past few years, Natural Language Processing (NLP) was revolutionized by statistical, probabilistic and machine learning methods. NLP addresses fundamental questions at the intersection of human language and machine learning. How can computers acquire, understand and produce language? How can computational methods give us insight into observed human language phenomena? How to make sense of the vast amounts of information available online in free, unstructured form? In this course students will learn how computers can learn useful text/language representations and how different tasks (language modelling, text classification, information extraction, sequence labeling, etc.) can be used for solving different complex problems (spelling correction, spam detection, search engine design, opinion analysis, summarization, question-answering, etc.). Open NLP problems (such as evaluation or interactive dialogue systems) and the effect of deep learning on NLP will be discussed.

Prerequisites

None.

Desired Prior Knowledge: Procedural Programming (formerly known as Introduction to Computer Science 1) and Objects in Programming (formerly known as Introduction to Computer Science 2), Probability and Statistics, Machine Learning

Recommended reading

- 1) Daniel Jurafsky and James H. Martin. "Speech and language processing an introduction to natural language processing, computational linguistics, and speech." Pearson, London, 2000
- 2) Chris Manning and Hinrich Schütze, Foundations of Statistical Natural Language Processing, MIT Press. Cambridge, MA. 1999

KEN2570

Period 5

31 Mar 2025

23 May 2025

[Print course description](#)

ECTS credits:

4.0

Coordinators:

- [J. Spanakis](#)
- [G. Spanakis](#)
- [G. Spanakis](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Project 2-2

Full course description

Students work on a project assignment in small groups of about six students. The group composition stays the same for the whole project and is announced at the beginning of period 2.4. The students are guided through the project by a fixed tutor. The project assignment is divided into three subtasks (one per period) and is strongly related to the content of the courses from period 2.4 and 2.5. In periods 2.4 and 2.5, the students work on the project, while also having to attend the courses of these periods. They meet their tutor approximately once a week. In period 2.6, the students work three weeks full-time on the project and meet their tutor twice a week.

At the beginning of each period, the students have to hand in a planning for the current phase. At the end of each period, the students have to give a presentation and the source code, presentation and an overview of who did what need to be uploaded to Canvas. While the presentations at the end of period 2.4 and 2.5 are in front of the examiners and the tutors, the presentations at the end of period 2.6 will additionally be in front of the fellow students. In period 2.6, they furthermore have to hand in a report and attend a product and report examination.

Project 2-2 will start in period 2.4 and period 2.5 with weekly meetings. The credits for the projects will become available at the end of period 2.6.

Prerequisites

Students must have passed Project 1-2. Furthermore, the student has to have passed at least two out of the following three courses: Procedural Programming, Objects in Programming, and Data Structures and Algorithms. The student furthermore needs to be registered for or has already completed at least three courses of the programme in year 2, semester 2. This project is not a prerequisite for another project / course.

Recommended reading

None.

KEN2600

Semester 2

27 Jan 2025

20 Jun 2025

[Print course description](#)

ECTS credits:

6.0

Instruction language:

English

Coordinator:

- [K. Schneider](#)

Teaching methods:

Project-Centered Learning, Work in subgroups, Presentation(s), Skills

Assessment methods:

BA Data Science & AI Year 2 Electives

Theoretical Computer Science

Full course description

This course explores the theoretical underpinnings of computing by investigating algorithms and programs casted as language recognition problems. The influence of the theory on modern hardware and software system design is demonstrated. The following subjects will be treated: mathematical foundations, alphabets and languages, finite automata and regular languages, Turing machines, acceptance and decidability, recursive functions and grammars, time complexity classes, NP problems, NP-completeness.

This course is an elective: Second year students choose 1 out of the 2 electives in period 4.

Prerequisites

Desired Prior Knowledge: Introduction to Data Science and Artificial Intelligence, Discrete Mathematics, Data Structures and Algorithms.

Recommended reading

None.

KEN2420

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [G. Stamoulis](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Dept. of Advanced Computing Sciences

Multivariable Calculus

Full course description

Multivariable calculus develops calculus into more than one variable. Multivariable calculus can help to better understand techniques and algorithms used to analyze multidimensional data or optimization techniques used to train neural networks. In this course, we introduce power series and Taylor approximation/polynomials, as well as Taylor's theorem to approximate functions. We use vector calculus combined with calculus/analysis, and we introduce path functions, and how to calculate lengths of paths or to integrate along a path. We discuss extensions of the chain rule and product rule to higher dimensions, and the corresponding extensions of derivative and tangent lines/planes. We also cover part of optimization problems, and we introduce multiple integrals to compute areas and volumes, among others. Finally, we look at several types of differential equations.

Prerequisites

Desired Prior Knowledge: Calculus, Linear Algebra.

Recommended reading

Hass, Heil, Weir, Thomas, Calculus, 14th edition, Pearson, ISBN 978-1-292-25311-4.

KEN3250

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Coordinator:

- [S.J. Maubach](#)

Teaching methods:

PBL

Assessment methods:

Written exam

DACS Honours Programme - KE@Work (2-1)

Full course description

The DACS Honours Programme consists of KnowledgeEngineering@Work (KE@Work) and (MaRBLe 2.0). Students admitted to the KE@Work path are placed at a company or organization in the region through a careful selection and matching process. During the full second and third year of the bachelor's programme, they spend 50% of the time in class and 50% at the company, where they work on solving academic challenges and complex business problems, under supervision of dedicated business and DACS supervisors

Prerequisites

None.

Recommended reading

None.

KEN2310

Semester 1

2 Sep 2024

24 Jan 2025

[Print course description](#)

ECTS credits:

6.0

Coordinators:

- [A. Quaden](#)
- [K. Driessens](#)

Teaching methods:

Working visit(s), Assignment(s)

Assessment methods:

Final paper

DACS Honours Programme - MaRBLe 2.0 (2-1)

Full course description

During MaRBLe 2.0 you will get the opportunity to work on a state-of-the-art research project. Work will be organized in a similar way as in professional research institutes where participants work together as individual experts on a team project. Participation is open to excellent and motivated students.

Prerequisites

None.

Recommended reading

None.

KEN2320

Semester 1

2 Sep 2024

24 Jan 2025

[Print course description](#)

ECTS credits:

6.0

Coordinator:

- [R. Cavill](#)

Teaching methods:

Work in subgroups, Research

Assessment methods:

Final paper

DACS Honours Programme - KE@Work (2-2)

Full course description

The DACS Honours Programme consists of KnowledgeEngineering@Work (KE@Work) and (MaRBLLe 2.0). Students admitted to the KE@Work path are placed at a company or organization in the region through a careful selection and matching process. During the full second and third year of the bachelor's programme, they spend 50% of the time in class and 50% at the company, where they work on solving academic challenges and complex business problems, under supervision of dedicated business and DACS supervisors.

Prerequisites

None.

Recommended reading

None.

KEN2610

Semester 2

27 Jan 2025

20 Jun 2025

[Print course description](#)

ECTS credits:

6.0

Coordinators:

- [A. Quaden](#)
- [K. Driessens](#)

Teaching methods:

Working visit(s), Assignment(s)

Assessment methods:

Final paper

DACS Honours Programme - MaRBLLe 2.0 (2-2)

Full course description

In MaRBlE 2.0, you will get the opportunity to work on a state-of-the-art research project. Work will be organized in a similar way as in professional research institutes where participants work together as individual experts on a team project. MaRBlE takes place in year two of the bachelor's programme.

Selection of honours students will happen in the second semester of year 1. If you successfully complete the honours programme, this will be certified on an honour's diploma supplement.

Prerequisites

Eligibility requirements for MaRBlE 2.0 entail that students:

- have passed all courses/components in the first year of the Bachelor's programme at first opportunity;
- have obtained a GPA of at least 7.5 for all courses of year 1 (to be eligible for pre-selection a GPA of at least 7.5 has to be obtained for blocks 1 to 4);
- have not been convicted of fraud and have not been reprimanded for a violation of house rules or code of conduct.

Recommended reading

None.

KEN2620

Semester 2

27 Jan 2025

20 Jun 2025

[Print course description](#)

ECTS credits:

6.0

Coordinator:

- [R. Cavill](#)

Teaching methods:

Work in subgroups, Research

Assessment methods:

Final paper

Third year courses

If the student has obtained at least 60 credits in the first year courses and at least 40 credits in the second year courses, they may register for the third year courses.

Third year students choose three electives **per period** out of the optional courses during period 1 and 2.

BA Data Science & AI Year 3 Electives

Digital Society

Full course description

Digitalization has a profound impact on our society. We can observe changes in different areas. What digital technologies do, what they look like and how they relate to each other is not identical worldwide, but dependent on local practices as well. Usually new technologies are understood as innovation and progress: and indeed, digital technologies improve a broad range of domains, such as healthcare or education. New possibilities as e.g. participation in our digital cultures arise but also new inequalities, as the access and competences needed for participation are not evenly distributed and the platforms that allow for participation also harbour new mechanisms of control and surveillance. The pace and diversity of these developments ask for continuous investigation and reflection. It requires work to shape and use technologies in ways that contribute to the public good. Moreover, digital technologies have also led to highly problematic developments such as electoral manipulation, fake news and algorithmic discrimination.

Technological developments are often conceived as predefined or given. Does a society's technology drive the development of its social structure and cultural values? Scholars in science and technology studies have shown that technology and society are deeply intertwined. Technology is inherently social. Technologies are shaped by people; they emerge and are embedded in social practices. The aim of this course is to investigate the consequences of digitalization for our society/societies. These consequences have been differently valuated: participation vs. exploitation of users, innovation as enhancement vs. challenge, ethics and techno-moral change vs./and sustainability. We will discuss digitalization from:

- a social perspective when we read about digital participation and how technology and society are intertwined
- a political perspective when we discuss activism, digital citizenship but also problems of manipulation and verification (as in the case of fake news and deep fakes)
- a cultural perspective when we analyze imaginaries and discourses around innovation of technology and promises being made
- a legal perspective when we discuss privacy and the attempts to adapt privacy laws
- an ethical perspective when we discuss design decisions, privacy but also techno-moral change and questions of environment and sustainability.

The course is structured in the following way:

Transformations

(digital participation, digital citizenship, data-activism)

Imaginaries

(innovation and techno-moral change)

Disruptions

(fake news and deep fakes, sustainability and e-trash)

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

None.

Recommended reading

None.

KEN3111

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Coordinator:

- M.B. Archer

Teaching methods:

Project-Centered Learning

Assessment methods:

Presentation, Final paper, Participation, Oral exam

Game Theory

Full course description

We introduce the field of Game Theory. Game Theory is the mathematical study of problems, called games, that involve two or more decision makers, called players, who each have their own individual preferences over the possible outcomes. In a game, each player always aims to maximize his individual payoff and chooses his actions accordingly. These actions may be probabilistic or deterministic, depending on the situation. Meanwhile he reasons logically about actions that might be taken by the other players. A basic difference exists between strategic and non-strategic models. Both types of models and their solution concepts will be discussed. Issues like value, fairness, manipulations, threats, optimality and rationality will be addressed.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Discrete Mathematics.

- [Discrete Mathematics](#)
- [Linear Algebra](#)

Recommended reading

None.

KEN3130

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [F. Thuijsman](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Semantic Web

Full course description

Most of the information available on the World Wide Web (WWW) is not directly understandable for computers. For instance, web pages are designed for human readability. Computer programs have difficulty in interpreting the information presented on web pages. The focus on human readable information introduces restrictions on what computer programs can do to support human users in tasks such as:

- finding information
- buying goods
- making travel plans

The Semantic Web should eliminate these restrictions by separating the content of what is presented on a web page from the way it is presented. In recent years, the focus has shifted to providing data, independent of webpages (for example: Linked Open Data (LOD))

Ontologies are used to provide a shared conceptualization of information. Ontologies form the basis of the Semantic Web, Knowledge Based System, Databases, etc., and they play an important role in data exchange and interoperability in many domains. Ontologies are applied in the bio-medical domains, in data mining applications, in Linked Open Data (LOD), in websites based on semantic technology, etc.

Since ontologies are intended to be shared between different systems, defining an ontology is a challenging task.

This course will focus on the standards the World Wide Web Consortium (W3C) is defining in order to realize the Semantic Web. The course also addresses the underlying knowledge representation formalisms of the current semantic web standards. Moreover, the course will address the

engineering principle of creating an ontology. Note that the course does not address standards for making websites.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Desired Prior Knowledge: Logic.

Recommended reading

The documents on the site of the World Wide Web Consortium (W3C).

KEN3140

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [R. Celebi](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Participation, Assignment

Recommender Systems

Full course description

Recommender systems play an important role in helping to mediate many of our everyday decisions and choices, including the music we listen to, the news that we read, and even the people that we date. They do this by learning from our past interactions, inferring our interests and documenting our preferences. To make the right suggestions at the right time recommender systems must not only understand our preferences but also our current needs and perhaps our immediate intent. Thus, the core focus of most recommender systems is devoted to profiling users and matching items based on these profiles and current context.

Much of the research to date on recommender systems has focussed on the engineering and evaluation of core recommendation algorithms. Researchers have developed a variety of approaches to harness different forms of preference data in the pursuit of more accurate recommendations. For example, researchers have used simple ratings for collaborative, rich meta-data for content-based

methods, and even the opinions and sentiment expressed within user-generated reviews.

When evaluating recommender systems, there has been a heavy emphasis on measuring the accuracy of suggestions, or the error of predictions. However, in practice it is important to consider evaluation metrics beyond accuracy, such as diversity, novelty, and serendipity. This in turn has led to increased attention being given to the nature of the interactions between users and recommender systems, and the influence that the user interface and interaction style can have on user behaviour and the overall recommendation experience. This course focuses on:

- Non-personalized and Stereotype-based Recommender Systems
- Classical recommender systems algorithms, e.g., Content-based Filtering, Collaborative-based Filtering
- Offline Evaluation e.g., protocols, criteria, metrics
- User-centered evaluation
- Interfaces and interaction in Recommender systems, e.g., explanations and conversational recommender systems
- Ethics, bias, and fairness in recommender systems
- Advanced methods, e.g., Matrix Factorization, Hybrid recommender systems, Contextual Recommender systems

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Machine Learning.

Desired Prior Knowledge: Natural Language Processing, Human Computer Interaction & Affective Computing

- [Machine Learning](#)

Recommended reading

Jannach, Dietmar, et al. *Recommender systems: an introduction*. Cambridge University Press, 2010.
Additional research papers and online articles

KEN3160

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Coordinator:

- [N. Tintarev](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Robotics and Embedded Systems

Full course description

Nowadays, a variety of products require that algorithms from data science and artificial intelligence are adapted to and implemented in robotic and embedded systems. Applications that heavily rely on intelligent robotic and embedded systems include self-driving cars, autonomous drones, intelligent industrial robots in (semi-) autonomous factories, smart phones, intelligent medical devices, and distributed intelligent embedded devices in smart homes.

In this course, students receive an introduction to the fields of robotics, embedded systems, and real-time control. Students obtain an overview of state-of-the-art intelligent robotic and embedded systems in academia and industries. Students gain hands on experience in programming embedded robotic systems using embedded processors and a modular robotic system developed at DACS. Students learn about communication standards for embedded systems, sensors, and actuators. Student practise and strengthen their expertise in data science and knowledge engineering by applying mathematical methods for controlling robotic systems: They study control techniques including PID control, forward and inverse kinematics as well as locomotion control and learning using central pattern generators. The course concludes with a robot competition where students build and program robots using a modular robotic system.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Maximum number of 80 students can follow this course.

Prerequisites

Procedural Programming (formerly known as Introduction to Computer Science 1) and Objects in Programming (formerly known as Introduction to Computer Science 2).

- [Procedural Programming](#)
- [Objects in Programming](#)

Recommended reading

None.

Desired prior knowledge: Calculus, Linear Algebra, Machine Learning.

KEN3236

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [R. Möckel](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Introduction to Quantum Computing

Full course description

This course offers an introduction to the interdisciplinary field of quantum computation. The focus will lie on an accessible introduction to the elementary concepts of quantum mechanics, followed by introducing the mathematical formalism and a comparison between computer science and information science in the quantum domain. The theoretical capability of quantum computers will be illustrated by analysing fundamental algorithms of quantum computation and its potential applications.

Quantum technology has become one of the most prominent interdisciplinary fields of recent research. This course will focus on introducing the mathematical concepts underpinning quantum computation, and on explaining how this new computational paradigm might potentially offer possibilities beyond the scope of conventional computers. Topics that will be introduced and discussed include: (i) most common models of quantum computation (e.g., quantum circuits and measurement-based quantum computing). (ii) An exposition of the machinery borrowed from quantum mechanics, such as superposition of states, quantum entanglement, (de)coherence etc., which gives rise to the potential speed-up of quantum algorithms over their classical analogs. (iii) Some of the most common quantum algorithms (searching, factoring etc.) and protocols (quantum teleportation, EPR paradox). The course will finish with an exposition of potential applications of quantum computation and algorithms in other fields (such as security/cryptography, AI, optimization etc.)

Important: no prior knowledge in quantum mechanics is assumed or required, and all necessary concepts will be introduced and motivated from a mathematical and theoretical computer science point of view. Possible quantum architectures and/or related hardware issues will not be discussed.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Linear Algebra.

- [Linear Algebra](#)

Recommended reading

- Isaac Chuang, Michael Nielsen, “Quantum Computation and Quantum Information”, 10th Anniversary Edition, Cambridge University Press, 2011.
- N. David Mermin, “Quantum Computer Science: An Introduction”, 1st Edition, Cambridge University Press, 2007

KEN3241

Period 1

2 Sep 2024

25 Oct 2024

[Print course description](#)

ECTS credits:

4.0

Coordinator:

- [D. Dibenedetto](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Computer Security

Full course description

Computer security is the process of securing information systems against unauthorized access. As information systems have become mandatory in the modern world, coupled with the increased frequency of security incidents, organizations now recognize the need for a comprehensive security strategy. The course will introduce a wide range of topics in computer security and online privacy. The main objective of the course is to cultivate a security mind set by discussing various attack techniques and defenses. The topics we will explore are information security (cryptography, cryptanalysis), software security and network security, as well as designing secure systems. The class will consist of lectures in which several computer security issues will be discussed. In parallel, there will be bonus assignments where the students will have to solve some of the most important issues we discussed in classroom.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Desired Prior Knowledge: Introduction to Computer Science (1 & 2), Data Structures and Algorithms, Software Engineering, Databases.

Recommended reading

- J. Buchmann. Introduction to Cryptography. Springer.
- Tanenbaum & Bos. Modern Operating Systems (4th edition). Pearson.

Data Science and Artificial Intelligence

KEN2560

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Coordinator:

- [B. Küppers](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Assignment

Software and Systems Verification

Full course description

Have you ever written a program with a bug in it? Then this course is for you! Software verification tools can check whether your program works by showing that it correctly satisfies its specification, or finds a case in which it can go wrong. Unlike unit testing and other software validation methods, verification tools use formal methods to rigorously prove correctness. Similar techniques can be used to show that (mathematical models of) cyber-physical systems work as designed.

In this course, we will start by introducing the main notions of object-oriented program verification, including pre- and post-conditions for methods, and class invariants. We shall use Hoare logic to convert programs and their specifications into logical statements to be proved. We shall apply these techniques to the verification of simple programs written in Java.

In the second part of the course, we consider formal models of software and systems as labelled transition systems (automata), using temporal logics for specification, and consider the fundamental algorithms for verification. We shall apply these algorithms to simple discrete verification problems, such as vending machines and communications systems, modelled using a specification language such as SMV. Finally, we will look at simple continuous systems, such as robots and electronic systems, and show how to verify these using rigorous numerical methods based on interval arithmetic.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

□

Prerequisites

Desired prior knowledge: Reasoning Techniques, Theoretical Computer Science

Recommended reading

J.B. Almeida, M.J. Frade, J.S. Pinto & S. Melo de Sousa, "Rigorous Software Development: an Introduction to Program Verification", Springer, 2011.

C. Baier & J.P. Katoen, "Principles of Model Checking", MIT Press, 2008.

L. Jaulin, M. Kieffer, O. Didrit & E. Walter, "Applied Interval Analysis", Springer, 2001.

KEN3150

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Coordinator:

- [P.J. Collins](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Logic for Artificial Intelligence

Full course description

Logics form the formal foundation of knowledge representation and reasoning, which is a fundamental topic in Artificial Intelligence. Logics play a role as an analysis aid and as a knowledge-representation formalism. Moreover, the semantics of logics enables us to evaluate the intended meanings of knowledge representation formalisms, and the correctness and completeness of reasoning processes.

Humans make assumptions in their day-to-day reasoning. Examples of reasoning with assumptions are: common sense reasoning, model-based diagnosis, legal argumentation, agent communication and negotiation, and so on and so forth. The assumptions humans use in their reasoning may be incorrect in the light of new information. This implies that conclusions may have to be withdrawn in the light of new information. Therefore this form of reasoning is called non-monotonic reasoning and the underlying logics are called non-monotonic logics.

The course will cover model-based diagnosis as an application of reasoning with assumption, standard logics extended with defeasible rules, argumentation systems, the semantics of reasoning with assumptions and defeasible rules, and closure properties of the reasoning systems.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

Logic

- [Logic](#)

Recommended reading

A syllabus and scientific literature.

KEN3231

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [N. Roos](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Parallel Programming

Full course description

Parallel programming introduces the students to the paradigm of parallel computing on a computer. Nowadays almost all computer systems include so-called multi-core chips. Hence, in order to exploit the full performance of such systems one needs to employ parallel programming.

This course covers shared-memory parallelization with OpenMP and java-Threads as well as parallelization with message passing on distributed-memory architectures with MPI. The course starts with a

recap of the programming language C followed by a brief theoretical introduction to parallel computing. Next, the course treats theoretical aspects like MPI communication, race conditions, deadlocks, efficiency

as well as the problem of serialization. This course is accompanied by practical labs in which the students have the opportunity to apply the newly acquired concepts. After completing this course students will be

able to write parallel programs with MPI and OpenMP on a basic level, and deal with any difficulties they may encounter.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2

Maximum number of 35 students can follow this course.

Prerequisites

Procedural Programming (formerly known as Introduction to Computer Science 1);
Objects in Programming (formerly known as Introduction to Computer Science 2);
Data Structures and Algorithms.

- [Procedural Programming](#)
- [Objects in Programming](#)
- [Data Structures and Algorithms](#)

Recommended reading

Parallel programming with MPI; Peter Pacheco; Morgan Kaufmann (1996); (a very early revision is available online).

KEN3235

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [B. Küppers](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Large Scale IT and Cloud Computing

Full course description

The course offers a comprehensive introduction to the field of scalable IT systems, so-called "Big IT", and cloud computing. After a technical introduction to the available methodologies of setting up and running scalable systems, use cases are presented. These use cases emphasize the correlation of the processes and requirements of large institutions and possible technical solutions. A special focus is put upon the question which technological platform is best used for which use case as well as process aspects of scaling. Security aspects specific to cloud computing are discussed along the use cases. Cloud computing, as a special case of scalable IT, is discussed in detail. Different cloud providers are presented and evaluated in the context of university requirements, i.e. requirements posed by research and teaching processes.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

None.

Recommended reading

None.

KEN3239

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Coordinators:

- [T.T. Eifert](#)
- [B. Küppers](#)
- [M. Politze](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Assignment, Assessment

Introduction to Bio-Informatics

Full course description

This course presents a general introduction to the fundamental methods and techniques of bioinformatics in biomedical and biological research. The objective is that the students will acquire a general understanding of bioinformatics methods at the algorithmic level and will therefore be able to read and understand publications in this field, and - to some extent - apply their knowledge to concrete biological problems. This relates to the major areas of bioinformatics like sequence alignment, phylogenetic analysis, gene finding, and omics data analysis. This course consists of a series of closely related lectures and computer classes, based on relevant case-studies using real data. In the lectures the main theoretical aspects are presented. In the computer practicals, the students work to analyse real data using the techniques they have encountered. By extensively exploring the case study, the students acquire a thorough understanding about the subject.

This is an optional course: Third year students choose three electives per period out of the optional courses during period 1 and 2.

Prerequisites

None.

Desired Prior Knowledge: Procedural Programming (formerly known as Introduction to Computer Science 1), MatLab.

Recommended reading

Introduction to Computational Genomics, A Case Studies Approach, Nello Cristianini, Matthew W. Hahn, Cambridge University Press, 2006, Hardback and Paperback (ISBN-13: 9780521856034 | ISBN-10: 0521856035).

KEN3440

Period 2

28 Oct 2024

13 Dec 2024

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [R. Cavill](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Project 3-1

Full course description

Project 3-1 consists of two distinct paths: projects at DKE with focus on university research and DKE/BSSC/BISS projects with focus on applied research proposed by companies that are affiliated with BSSC (Brightlands Smart Service Campus). The DKE/BSSC/BISS projects are facilitated in cooperation with BISS (Brightlands Institute for Smart Society). In the first week of period 1, students indicate their preference by ranking these projects. Groups are created by means of an algorithm that minimizes regret and allocates students to their most preferred options.

About the DKE projects: Students work in small groups, guided by teachers of the subjects concerned and by the tutors. During the project, students apply their knowledge in data science, knowledge engineering, and artificial intelligence to robotic and other intelligent and autonomous systems. Depending on their chosen specialization within their project group, students study and search for solutions in at least one, typically in multiple of the following fields: control, machine learning, computer vision, signal processing, human-computer/robot interaction, multi-agent and distributed systems, optimization, data visualization as well as modelling and simulation.

About the DKE/BSSC/BISS projects: Students participate in small groups and receive guidance from a tutor, a teacher with knowledge of the subjects concerned, and a content expert from the company. Furthermore, the students receive business related skills such as creating business presentations from a teacher at BISS. Students learn how to apply their knowledge in data science, knowledge engineering, and artificial intelligence to solve real-world problem that arise in a professional environment, and how to interact with a client from the industry.

Project 3-1 will start in period 3.1 and period 3.2 with weekly meetings. The credits for the projects will become available at the end of period 3.3.

Prerequisites

Project 2-1.

- [Project 2-1](#)

Recommended reading

None.

KEN3300

Semester 1

2 Sep 2024

24 Jan 2025

[Print course description](#)

ECTS credits:

6.0

Instruction language:

English

Coordinators:

- [K. Schneider](#)
- [R. Möckel](#)

Teaching methods:

Project-Centered Learning, Work in subgroups, Presentations, Skills

Assessment methods:

Assignment, Presentation and paper, Participation

DACS Honours Programme - KE@Work (3-1)

Full course description

The DACS Honours Programme consists of KnowledgeEngineering@Work (KE@Work) and (MaRBLe 2.0). Students admitted to the KE@Work path are placed at a company or organization in the region through a careful selection and matching process. During the full second and third year of the bachelor's programme, they spend 50% of the time in class and 50% at the company, where they work on solving academic challenges and complex business problems, under supervision of dedicated business and DACS supervisors.

Prerequisites

None.

Recommended reading

None.

KEN3310

Semester 1

2 Sep 2024

24 Jan 2025

[Print course description](#)

ECTS credits:

6.0

Coordinators:

- [A. Quaden](#)
- [K. Driessens](#)

Teaching methods:

Working visit(s), Assignment(s)

Assessment methods:

Final paper

DACS Honours Programme - MaRBLe 2.0 (3-1)

Full course description

In MaRBLe 2.0, you will get the opportunity to work on a state-of-the-art research project. Work will be organized in a similar way as in professional research institutes where participants work together as individual experts on a team project. MaRBLe takes place in year two of the bachelor's programme.

Selection of honours students will happen in the second semester of year 1. If you successfully complete the honours programme, this will be certified on an honour's diploma supplement.

Prerequisites

Eligibility requirements for MaRBLe 2.0 entail that students:

- have passed all courses/components in the first year of the Bachelor's programme at first opportunity;
- have obtained a GPA of at least 7.5 for all courses of year 1 (to be eligible for pre-selection a GPA of at least 7.5 has to be obtained for blocks 1 to 4);
- have not been convicted of fraud and have not been reprimanded for a violation of house rules or code of conduct.

Recommended reading

None.

KEN3320

Data Science and Artificial Intelligence

Semester 1

2 Sep 2024

24 Jan 2025

[Print course description](#)

ECTS credits:

6.0

Coordinator:

- [R. Cavill](#)

Teaching methods:

Work in subgroups, Research

Assessment methods:

Final paper

Study Abroad

Full course description

DACS offers its students the possibility to study a semester abroad at one of DACS partner universities. Third year bachelor's students and 2nd year master's students can get the opportunity to study a semester abroad, as part of their education programme in Maastricht. The credits received abroad will be transferred / part of your programme at DACS in Maastricht. Of course, this is only possible after approval of the Board of Examiners. There are several universities where DACS can send its students to.

For current first year master's students, the next possibility to study a semester abroad is in the fall semester of the subsequent academic year or during the spring semester (for February intake students). This section will explain your possibilities and the necessary procedures to undertake. If you might be interested in studying a semester abroad, please read this complete section and all attached documents very carefully!

If you still have questions afterwards you may contact our Exchange Coordinator Luc Giezenaar via: dacs-iro@maastrichtuniversity.nl

Prerequisites

You have to obtain at least 40 ECTS of year 1 courses.

KEN3600

Data Science and Artificial Intelligence

Semester 1

2 Sep 2024

24 Jan 2025

Semester 2

27 Jan 2025

20 Jun 2025

[Print course description](#)

ECTS credits:

30.0

Coordinators:

- [Luc Giezenaar](#)
- [M. Musegaas](#)

Assessment methods:

Written exam, Attendance, Assignment

BA Data Science & AI Year 3 Core Courses

Operations Research Case Studies

Full course description

Operations Research (OR) is concerned with the best way to assign scarce resources to competing activities. It is for this reason an important branch of mathematics that is widely used in industry to support economically efficient decision making, but also in other application areas where discrete or stochastic optimization has a central role. In this course we will explore a number of themes both within deterministic OR (where all the problem data is known at the beginning) and stochastic OR (decision problems involving uncertainty and randomness). Themes within deterministic OR include the network simplex method (used for solving minimum-cost flow problems), integer linear programming and non-linear programming. Stochastic themes include queuing systems, Markov chains and Markov decision problems. As background students will be introduced to the methodological similarities and differences between OR and data science.

Prerequisites

None.

Recommended reading

None.

KEN3410

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinators:

- [S.M. Kelk](#)
- [B. Franci](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam

Intelligent Systems

Full course description

The course offers an introduction to intelligent systems, their components, design issues and possible development paths. Based on the metaphor of a computational agent (that is, a software program or a robot which acts and interacts flexibly and autonomously in order to achieve some goal), basic concepts and methods from agent technology are discussed. Topics covered are the concept of artificial intelligence, expert systems, characteristics of an agent and agent architectures, agent cooperation and competition among agents, behaviour-generation and -learning with the added complexity of a multi-agent environment, agent oriented world views and possible future paths to general artificial intelligence. An emphasis is made on the complexity of interacting systems, both between different agents, but also between the subsystems of a single agent. In the practical part of the course, the students build up their experience with the implementation of a number of different types of agents.

Prerequisites

None.

Recommended reading

None.

KEN3430

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [K. Driessens](#)

Teaching methods:

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Data Analysis

Full course description

This course aims at preparing students on how to be a successful “data scientist”. The crucial processes of inspecting, cleaning, transforming, restoring and preparing data for modelling are tackled. Different types of data are going to be explored through case studies ("clinics") that a modern “data scientist” has to deal with. Furthermore, several techniques from machine learning and mathematical modelling (multiple regression, classification, tree-based models, dimensionality reduction, etc.) are presented from the data analysis perspective and students learn how to apply these techniques to different types of data. Finally, the cornerstone of data analysis is presented: correct communication of the analysis outcome (storytelling, visualization, etc.).

Prerequisites

None.

Desired prior knowledge: Simulation and Statistical Analysis.

Recommended reading

Selected chapters from the following textbooks:

- A. Downey, Think Stats: Exploratory Data Analysis
- James, G., Witten, D., Hastie, T., Tibshirani: An Introduction to Statistical Learning (with Applications in R)
- J. Vanderplans, Data Science Handbook
- S. Skiena, The Data Science Design Manual
- J W. McKinney, Python for Data Analysis
- Chris Albron, Machine Learning with Python Cookbook

KEN3450

Period 4

27 Jan 2025

28 Mar 2025

[Print course description](#)

ECTS credits:

4.0

Instruction language:

English

Coordinator:

- [G. Spanakis](#)

Teaching methods:

Data Science and Artificial Intelligence

Project-Centered Learning

Assessment methods:

Written exam, Assignment

Bachelor's thesis

Full course description

At the end of the Bachelor's study in Data Science and Computing Sciences each individual student has to write a thesis. This thesis has to be designed as a scientific paper of 8 to 10 pages using a standard (LaTeX) design. Students are expected to conduct a pro-active and independent research on their topics. This includes the search and reading of related work. The topics must be discussed with the potential thesis supervisor(s) and a research plan must be submitted to and approved by the Board of Examiners as an initial step. The thesis has to be accompanied by relevant attachments and software. Students will present the thesis in a conference.

This means that a strict submission form will be used.

Prerequisites

In order to start working on the thesis, a student needs to have obtained at least 138 ECTS (among which are 60 credits of the first year, and 40 ECTS of the second year).

For the complete procedure and relevant forms see

<https://intranet.maastrichtuniversity.nl/en/dke-students/thesis>

Recommended reading

None.

KEN3500

Year

2 Sep 2024

31 Aug 2025

[Print course description](#)

ECTS credits:

18.0

Instruction language:

English

Coordinator:

- [E. Hortal Quesada](#)

Teaching methods:

Data Science and Artificial Intelligence

Paper(s)

Assessment methods:

Presentation and paper