Data and Algorithmic Foundations for Mathematics elective package

Data and Algorithmic Foundations for Mathematics		
Offered by	Department of Mathematics and Computer Science	
Language	English	
Primarily interesting for	All students, but most relevant for students with background in Applied Mathematics and other BSc students interested in a Master program in Data Science (e.g., Data Science in Engineering)	
Prerequisites	Required courses: Propositional logic, predicate logic, set theory, calculus, imperative or object-oriented programming	
	Recommended courses: -	
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Content and composition

This package provides courses to students in the Applied Mathematics major, who wish to advance their knowledge in the computer-science foundations of Data Science: data storage, management, and algorithmic processing. Data modeling and databases introduces the standard model for storing and retrieving data through relational databases and the required algebraic operations. The Data structures course teaches various basic and advanced data structures and their usage in solving computational. Finally, the Algorithms course studies more advanced design techniques and algorithms and their efficiency with a particular focus on solving optimization problems.

This elective package is one of two packages intended for students in the bachelor program Applied Mathematics and other programs (except the bachelor program Computer Science), who are interested in a technical master program on Data Science (e.g., Data Science in Engineering).

• Elective Package: Data and Algorithmic Foundations for Mathematics

• Elective Package: Data Analysis Foundations for Mathematics

Following both packages gives Mathematics students the necessary prior knowledge to enroll in a technical master program on Data Science (e.g., Data Science in Engineering).

Course code	Course name	Level classification
2ID50	Data modelling and databases*	2.
21L50	Data structures	2.
2ILC0	Algorithms**	3.

* 2ID50 may be replaced by Data management for data analytics (JBI050, 3/D)

** 2ILCO may be replaced by Algorithmic Aspects of Data Analysis (JBI045, 4/B)

Precedence relationships within the package

The courses should be taken in the order indicated in the table.

- 1. 2ID50 Data modeling and databases
- 2. 2IL50 Data structure; describes and handles more advanced data structures and data operations than 2ID50

3. 2ILCO Algorithms; builds on knowledge about algorithms and data structures taught in 2IL50

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Course description

Data modelling and databases (2ID50)

Our lives are awash in data (e.g., social, business, web, ...) which only continues to grow in both quantity and variety. Database management systems are the key technologies which facilitate our practical use of these massive data sets. In this course, we study fundamental concepts, such as data model design and formulation of queries against databases, which underpin the effective practical use of industrial strength data management systems. This course teaches students to design (the data structures of) information systems. With "design" we mean that the students learn to translate a natural language description of a business' information needs into a data model, expressed in the entity relationship model. Students must be capable of translating that model into a relational database structure. They must be able to optimize this structure by means of constraints and decomposition algorithms. Students also must become fluent in query languages, in order to express natural language questions in query languages, and in order to express queries in natural language.

Data Structures (2IL50)

There are many aspects to the study of data structures, and the algorithms that operate upon them. In this course, the student will learn the basic skills and knowledge to develop efficient algorithms to solve computational problems and to make informed choices between different solutions for the same problem. These include standard data structures and algorithms for frequently appearing problems, algorithm design techniques, how to establish that an algorithm is correct, and how to analyse the efficiency of an algorithm.

Algorithms (2IL50)

The efficiency of algorithms is of crucial importance in many applications. In the course Data Structures (2IL50) you have learned how to mathematically analyze efficiency, how to use design techniques like divideandconquer, and you have seen efficient algorithms and data structures for basic problems such as sorting and searching. In the course Algorithms we will take this one step further, by studying more advanced design techniques and algorithms, and by studying other aspects of efficiency. Many of the topics that are covered concern optimization problems, where one wants to find not just some solution to a problem but an optimal solution. The course consists of three parts. In the first part we study three general techniques for solving optimization problems: backtracking, dynamic programming, and greedy algorithms. The second part of the course deals with algorithms for optimization problems on graphs: computing shortest paths, computing maximum flows, and finding so-called matchings. In the third part of the course we study computational complexity theory by looking at NP-completeness, which investigate the limits of what is efficiently computable.