MASTER OF SCIENCE
APPLIED MATHEMATICS

UNIVERSITY OF TWENTE.

MASTER'S IN APPLIED MATHEMATICS

You will be trained to become a mathematical problem solver able to tackle challenging issues from technology to healthcare. You grasp the essence of a problem and see links between seemingly unrelated phenomena.

Can you predict when something goes viral? How do you model 5G? What happens in your brain when an epileptic seizure occurs? These questions all have one thing in common: mathematics is the way to come up with answers.

In this master's you will apply mathematics to challenging issues in the most diverse sectors, ranging from technology to healthcare. You will learn how to discover new patterns and how to predict them through mathematical models. As a graduate you will have an impact on society as well as be in huge demand on the job market.

SPECIALISATIONS

Your choice of specialisation and research group determines which courses you will be taking and the type of research you will be involved in during your internship and master's assignment. You can choose from four specialisations:

- Operations Research (OR)
- Mathematical Systems Theory, Applied Analysis and Computational Science (SACS)
- Mathematics of Data Science (MDS)
- Artificial Intelligence for Health (AI4Health)

CAREER PERSPECTIVES

After obtaining your master's you will have plenty of job opportunities to choose from. You could opt for a career in healthcare, e.g. using mathematics to improve certain diagnostics, or employing mathematical neuroscience models to better understand how the human nervous system works. You could also work in the media industry, applying deep learning networks to achieve better social network filtering, or use your knowledge of algorithms and machine learning to create models for predicting earthquakes. Of course, you can also choose to first expand your specialist knowledge base by pursuing a PhD or PDEng programme as offered by the UT's Twente Graduate School (TGS).

QUICK FACTS

Starting date	**September or February**
Degree	**Master of Science**
Language	**English**
Duration	**2 years, 120 credits**
Website	**www.utwente.nl/go/am**

WHY THIS PROGRAMME?

- Challenging specialisations: High-quality mathematics combined with real world issues
- Well-balanced two-year programme that incorporates modern mathematical techniques
- Only campus university in the Netherlands
- Ampel opportunity to tailor your programme

PROGRAMME STRUCTURE

The two-year Master's in Applied Mathematics is a programme with a strong international orientation and is taught entirely in English. Its educational profile is characterised by its four specialisations and an emphasis on mathematical modelling. Each specialisation is taught by different research groups and, during the final phase of the programme, you will operate as a junior member of the research group associated with your specialisation.

STUDY-SCHEDULE

The programme is organised in semesters. Each semester contains 20 weeks, and is subdivided in quartiles. The unit of credit is the European Credits (EC). One EC stands for 28 hours of study-load. An academic year counts 60 EC. The master's consists of 120 EC.

YEAR 1

While the built-up of the programme is guided by certain rules, the programme offers ample opportunity to take electives. Your choice of electives will partly depend on which specialisation you choose. In addition to courses at the University of Twente, you can also opt for courses offered by a nationwide consortium: mastermath.nl. All in all, the Master's in Applied Mathematics offers you plenty of scope to tailor the programme to your own individual wishes and interests.

YEAR 2

For the specialisations SACS, MOR and MDS, your second year starts with an internship, a period of practical training that takes place outside the university. The internship has a workload of 20 EC and has opportunities to be carried out abroad. The remaining 40 EC of the second year are devoted to your Graduation Project, which includes a literature review.

For the specialisation AI4Health, you take a few more courses, possibly together with a couple of case studies and then finally, execute a 30 EC Graduation Project at a health-related institution outside the university.

During the execution of your graduation project you are given the greatest opportunity to demonstrate that you have acquired the qualities outlined in the final qualifications of the programme on a research topic related to your chosen specialisation.

TEACHING DEGREE

You can also opt to obtain a teaching degree together with your master's AM diploma. In this case, you will go on your internship at a designated high school and your electives will consist of pedagogical and didactical subjects. This option is available to students who previously completed a similar course in their bachelor's.

SPECIALISATION

MATHEMATICAL SYSTEMS THEORY, APPLIED ANALYSIS AND COMPUTATIONAL SCIENCE

This specialisation focuses on fundamental and practical aspects of dynamical phenomena and computational and control aspects. You become an expert in developing and applying mathematical tools for physical en technical systems.

In the specialisation in Mathematical Systems theory, Applied Analysis and Computational Science (SACS) you will deal with mathematical models. The great thing about them is that they can be applied in totally different contexts. Omitting what's context-specific will allow you to create abstract models that can be objectively applied in any given context. In this specialisation you will learn how to outline practical problems and pinpoint their abstraction. To this end you will delve deeper into systems theory, applied analysis or numerical mathematics. You will learn how to design new mathematical models and apply current ones in order to make processes more comprehensible.

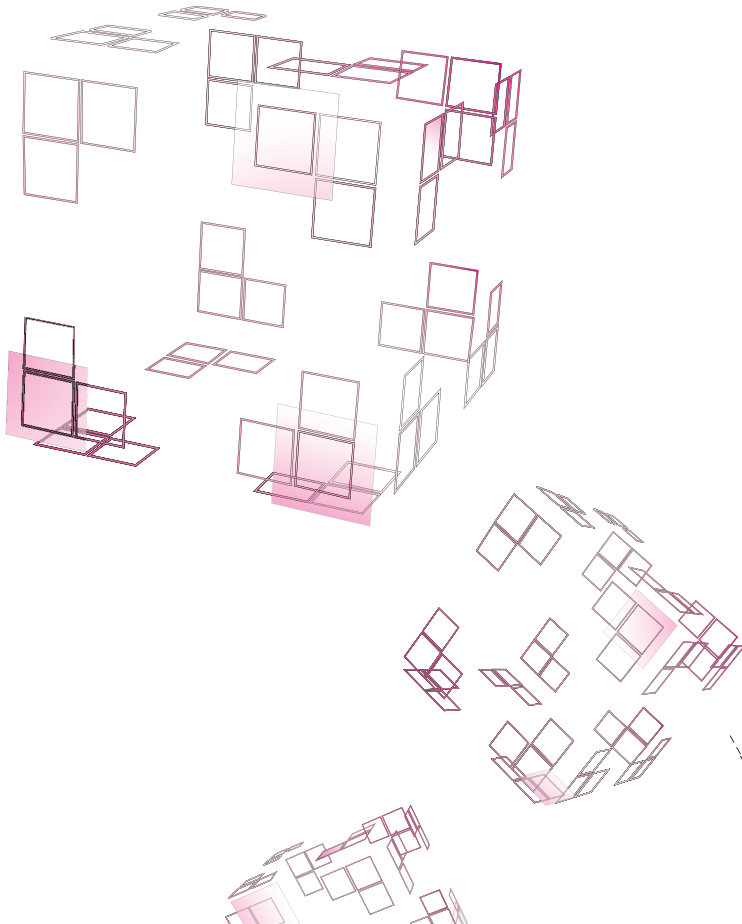
CORE COMPONENTS OF SACS

The research in **Applied Analysis** deals with the combination of modeling, analysis and simulation of problems from the natural, life and technical sciences with applications neuroscience and medical imaging.

Systems and Control Theory has roots in electrical and mechanical engineering. Nowadays its applications run from computer science to medicine. The two main fields of research are signal analysis, e.g. detecting a pattern in noise measurements, and control of flexible structures, such as large windmills or a wafer stage from the computer chip industry.

Computational Science focuses on the mathematical aspects of advanced scientific computing. The two main areas are numerical algorithms for the solution of partial differential equations and mathematical modeling of multi-scale.

Multiscale Modeling and Simulation focuses on the mathematical development and application of computational multiscale methods. Numerical mathematics, stochastic dynamics, structure-preserving calculus and variational mathematical modelling are the key areas of study. Applications are found in optimised meta-materials and transport processes for energy systems, multi-phase and turbulent fluid mechanics, and biomedical engineering.



SPECIALISATION

MATHEMATICS OF DATA SCIENCE

In the specialisation Mathematics of Data Science you will deal with mathematical models and algorithms that can be used to analyse data, draw conclusions and make decisions. With this specialisation you will become an expert data scientist or a researcher who continues to push this field forward.

Our world is becoming increasingly digital and data is everywhere. It's in your social network timeline, in your fitness tracker, in MRI scans or in the transactions of a bank. All these huge amounts of data are full of valuable information, but how do you extract that information in such a way that you can actually put it to good use?

In the specialisation Mathematics of Data Science (MDS) you will deal with mathematical models and machine learning algorithms that are essential for analysing data and thus providing a basis for evidence-based decisions in a wide variety of fields. You will learn how to use the underlying theory from, for instance, statistics, numerical analysis or graph theory, to optimally employ data science, but also to further develop the field into exciting new directions.

APPLICATION AREAS OF MDS

- The courses in Deep Learning and Statistical Learning will provide you with the skills to analyse machine learning algorithms from the underlying mathematical principles, to improve their performance, and to further develop them for novel applications.
- In the course Spatial Statistics you will learn how to use available regional data to, for instance, pinpoint the best locations for specific facilities such as fire stations.
- The course in Complex Networks will give you the required knowledge of mathematical models with which you could, for instance, predict when posts go viral.

COLLABORATIONS

Data science is a multidisciplinary field. In this specialisation you will get many opportunities to work with professionals from other fields of study, such as computer scientists, medical professionals, seismologists, or electrical engineers. By collaborating you will learn to view subjects from different angles while simultaneously developing a fundamental view on data science. This is a perfect preparation for your subsequent professional career as a data scientist or researcher in the field.

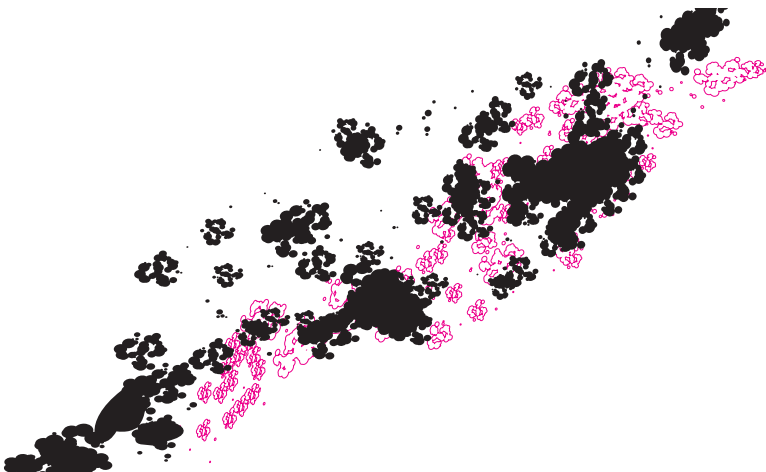
BE AN ESSENTIAL LINK

As a mathematician you will sometimes cross the borders of current mathematics by creating new expansions where necessary. With the mathematician's flexible thinking enabling you to come up with practical answers to questions in many fields, you are likely to find yourself working in multidisciplinary teams. As mathematics is the common language of engineers, you will be an essential link in optimisation processes in virtually every field. For instance, when you're a member of an engineering team, your team mates may need your skills to adapt an existing model to suit the application they're working on.

CAREER OPPORTUNITIES

With this specialisation you will easily find work as a data scientist. As such you will help companies to collect and organise data and apply certain algorithms (such as machine learning algorithms). The results of your work will facilitate making evidence-based decisions, making predictions and gaining insights.

As a mathematically educated data scientist you will also be welcomed by the healthcare sector, high-tech companies such as Thales or ASML, and of course the ICT industry. Your background in mathematics will allow you to go the extra mile, since algorithms are at the very core of data science.



SPECIALISATION

OPERATIONS RESEARCH

UNIVERSITY OF TWENTE APPROACH

Operations Research (OR) is also referred to as Management Science or Business Analytics in business environments.

OR aims to develop mathematical and computational support for the evaluation and optimisation of operational and logistical questions in industry, servicing (e.g. healthcare) and business.

OR at the University of Twente has a number of rather unique, appealing characteristics. First of all, it offers a well-balanced two-year programme: one theoretical year of fundamental and advanced courses and one applied year with an internship and thesis. You can compose your own course programme by choosing different OR related courses. Both deterministic and stochastic operations research are strongly represented. Secondly, it has staff members with excellent scientific records as well as two specialised research centres. Finally, it has an active group of over thirty master's and PhD students organising student seminars, alumni activities and meetings with industry. Accordingly, career possibilities are excellent.

WHAT IS OPERATIONS RESEARCH?

OR is closely associated with Applied Mathematics and Computer Science. In the Netherlands, it has strong links with Econometrics and Industrial Engineering.
The following brief description covers the main points:

"Operations Research can be regarded as applied mathematical analysis for logistical decision-making in industry, services and business. OR aims to develop mathematical and computational techniques to provide objective, analytical and quantitative support for the evaluation and optimisation of complex situations of an operational and logistical nature in industry, service and business environments."

HOW IS OPERATIONS RESEARCH USED?

Profit organisations generally aim to maximise profitability, while non-profit organisations focus on improving services and quality. The goal of both is therefore to optimise the effectiveness of resources within the context of all kinds of external and internal constraints. Key concepts within OR include:

- planning and scheduling
- efficiency and productivity
- throughput, delay and waiting times

Nowadays OR is used to achieve optimisation in a wide range of fields from business environments (multinationals, sales companies, financial firms) to industry (production, distribution and supply chain networks). Transport is another major sector, from aviation (airports and airlines) to public transport and railways. Utilities and public services such as energy, communications, hospitals and healthcare are another relevant field. Last but not least, OR plays a leading role in the field of consultancy (logistical, healthcare, technical, simulation, financial, IT, supply chains).

SPECIALISATION

ARTIFICIAL INTELLIGENCE FOR HEALTH

In the specialisation Artificial Intelligence for Health (AI4Health), you will gain a thorough understanding of artificial intelligence (AI) as a multifaceted technique and develop AI-based solutions for real-world problems in healthcare.

ARTIFICIAL INTELLIGENCE IN HEALTHCARE

Artificial intelligence (AI) is permeating our day-to-day life. There is a high chance that you are already using AI to translate between languages, recognise objects in photos, or navigate to your destination. Globally, there are high expectations of what AI could mean for healthcare. For example, AI could assist clinicians in day-to-day decision-making, monitor patients after complex surgery, or make healthcare more accessible in developing countries.

However, with all of this enthusiasm comes some healthy skepticism. Indeed, AI is often perceived as a black box, and when applied to healthcare, given its high-stakes nature, there are obvious ethical concerns about the fairness and explainability of AI methods. In the AI4Health specialisation, you will take a peek inside the black box and see how mathematics works at the core of this technology. You will gain a solid foundation in statistics, machine learning and operations research, and learn how to leverage the potential of AI for high-stakes real-world applications in healthcare.

AI FROM THEORY TO PRACTICE

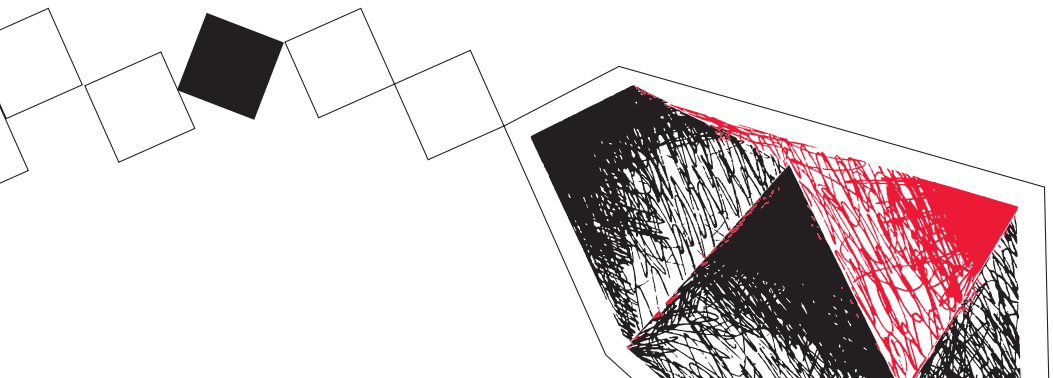
One unique aspect of this specialisation is that you will work on three or more healthcare-related case studies. These real-world case studies have been developed in collaboration with clinical partners in hospitals and demonstrate the versatility of AI applications in healthcare. You will put your theoretical understanding of the mathematics behind AI into practice. We challenge you to dive into domain-specific conditions and cross boundaries to disciplines like computer science and medicine.

APPLICATION AREAS OF AI4HEALTH

- The COVID-19 crisis has shown how vulnerable the logistics of our healthcare system are. There is a prominent role that smart scheduling algorithms can play to more effectively use the resources available in hospitals.
- Clinical specialists like radiologists and pathologists look at hundreds of medical images to detect a needle in the haystack. AI-based algorithms could significantly improve image formation and analysis for diagnosis and prognosis.
- AI algorithms are good at providing a prediction for some input, but this prediction is often binary. To allow interpretation by humans and adoption of AI in healthcare applications, mathematically quantifying the uncertainty in an automated prediction is critical.
- More and more people are wearing watches and other wearables equipped for heart rate monitoring or electrocardiograms. These devices collect enormous amounts of data which AI techniques could analyse to improve the management of patients with heart diseases.

CAREER PERSPECTIVES

While there is a lot of buzz around AI, the big question is how AI can be safely and effectively used for healthcare applications. Answering this question requires experts who understand the mathematics of AI, consequently see its strengths and weaknesses for applications, and can communicate this with users. In this specialisation, you will get an in-depth knowledge of this versatile field. Our teaching staff collaborates with clinical partners in The Netherlands and abroad and companies in healthcare such as Siemens and Philips. This specialisation will give you a solid foundation to contribute to this rapidly developing field. AI experts with a mathematical background are in high demand in academic hospitals and the strongly growing healthcare industry.



CAREER OPPORTUNITIES

Graduates of the Master's programme in Applied Mathematics find employment in numerous sectors of industry and academia such as R&D departments in industry, consultancy firms, research and teaching positions, teaching at high schools and even higher management.

In our technology-dependent society, commercial and governmental organisations have a growing need for professionals with an up-to-date background in applied mathematics at an academic level. Naturally there are also numerous careers awaiting applied mathematicians in academia, where these skills are in high demand as well.

ADMISSION REQUIREMENTS

Applicants with a Bachelor's in (Applied) Mathematics are generally directly admissible to this master. Applicants that have completed a bachelor's programme in a technical field, such as Physics, Mechanical Engineering, Advanced Technology or Electrical Engineering are usually admissible after completing a pre-master's of no more than 30 EC.

ADDITIONAL REQUIREMENTS:

International students: English-language test results. Academic IELTS, overall band score of at least 6.5, or TOEFL, internet based (TOEFL-iBT) of at least 90, or Cambridge CAE-C (CPE). For the minimum CPGA of your country, please visit our master's website: **utwente.nl/go/master/country-list**

DUTCH UNIVERSITY OF APPLIED SCIENCES:

In the programmes offered by universities of applied Sciences (HBO) there is usually very little mathematics that can be used for qualifying for a pre-master's in Applied Mathematics. Applicants however may request a screening of their possibilities based on their previous study.

For more specific admission requirements, please visit our website: **utwente.nl/go/am**

ELIGIBILITY CHECK

Our eligibility check is designed to assist you as a student holding a non-Dutch diploma. It will give you an indication of your eligibility to be admitted to the Master's programme Applied Mathematics. The check will take about five minutes to complete. Please note that this is not part of the official admission procedure. No rights can be obtained from the outcome of the eligibility check.

Check your eligibility: **utwente.nl/go/am/eligibility-check**