Opto-mechatronics is a specialized field combining many expertise areas and is widely present in the High-Tech industry. This track is an excellent start to becoming a multi-disciplinary researcher or system designer in micro-optics and opto-mechatronics.

**Opto-Mechatronics (OM)**
Opto-mechatronical systems and products are all around us. The zoom lens of a camera. The same but then in vacuum or cryogenic environment. Or robust enough to survive a rocket launch yet with sufficient precision to make detailed Earth observations. A wafer scanner writing structures as small as 10 nm on chips via its 15 meter long optical path comprising over 50 optical elements, controlled using a variety of optical sensors. Micro-optical systems, such as sensors integrated in catheters for diagnosis in the smallest blood vessels of our body. A telescope gathering star light photon-by-photon from the outskirts of the universe using a 40-meter primary multi-mirror composed of hundreds of actively controlled units, each suspended by thermally compensated precision mechanisms. High-end spectrometers analysing the stellar radiation helping us unravel the mystery of the origin of the universe. All these systems are examples of high-end opto-mechatronics or micro-optical systems. They are also products of the industries involved in our research programme in micro-optics and opto-mechatronics that defines the next steps for industry and science in subjects such as metrology with picometer accuracy, low-light astronomy, precision 3D printing, or optical fiber technology.

**Course Programme**
By nature the Opto-Mechatronics course programme is multi-disciplinary. We offer a curriculum which will educate you to become an excellent opto-mechatronics engineer. This track will teach you the fundamentals of optics in theory and practice, as well as understanding of high-end optical systems like microscopes, telescopes, interferometers and digital mirror devices. This expertise is combined with mechatronic system design treating dynamics and motion control; micro-system design expertise covering lithography-based micromanufacturing and optical fibers; adaptive optics on actively deformable mirrors and their integration in an opto-mechatronic system; and a course on design principles for precision positioning and thermomechanical stability.

In addition there is room for electives, such as for instance on more generic topics like engineering dynamics or sensors and actuators, or more specialized ones like space instrumentation or quantum optics, the choice is yours. The combination of these areas forms an excellent basis to becoming an opto-mechatronic scientist or system designer of high-end optical equipment. Experts from different faculties are involved in the curriculum. The programme has been developed in close collaboration with partners outside the university.
Opto-mechatronics is a very wide and multi-disciplinary field. Many specialties come together and one of the challenges is to combine all of these in functional systems that satisfy high performance demands. In the OM track we distinguish two main research areas, micro-optics and opto-mechatronics, each encompassing the above characteristics, yet each at a different length scale.

**Opto-mechatronics**
The field of opto-mechatronics deals with High-Tech systems where optical units dominate the speed and precision of operation. High end lenses and mirrors tend to be large and heavy yet need to be moved and positioned with extreme accuracy and repeatability. This is true for light operated manufacturing processes like lithography for semiconductor production and for 3D metal printing, as well as extreme accuracy measurement systems and telescopes for astronomy. Opto-mechatronics by nature is a multi-disciplinary field integrating optics and mechatronic system design, using actuators, sensors and control techniques for building smart and adaptive optical systems.

**Micro-optics**
An emerging trend is evolving towards micro-optics, providing solutions in high-capacity telecommunication, distributed measurement, as well as integration of optical and mechatronic elements for micro opto-electro-mechanical systems (MOEMS), and advanced optical elements for biological and chemical sensing. Of special interest are flexible photonic systems, with links to adaptive optics and compliant mechanisms, with application in flexible displays, and in waveguides for flexible integrated optical circuits. This entails many challenges in numerical modeling, design, materials such as polymer or (silicon) semiconductor nanophotonics, and production.

### Curriculum Opto-Mechatronics

<table>
<thead>
<tr>
<th>First year (60 EC)*</th>
<th>ME Obligatory for all tracks (20 EC)**</th>
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<tbody>
<tr>
<td>Physics and Measurement for Mechanical Engineers (6 EC)</td>
<td>Control System Design (3 EC)</td>
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<tr>
<td>Heat Transfer (3 EC)</td>
<td>Nonlinear Mechanics (4 EC)</td>
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<tr>
<th>ME-OM track Obligatory (25 EC)*</th>
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<tr>
<td>Optics (4 EC)</td>
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<tr>
<td>Optics Practical (2 EC)</td>
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<tr>
<td>Mechatronic System Design (4 EC)</td>
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<tr>
<td>Intro lab PME (2 EC)</td>
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<tr>
<th>Electives (12 EC)*</th>
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<tr>
<td>Eng. Optimization: Concept &amp; Applications (3 EC)</td>
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<tr>
<td>Sensors &amp; Actuators (4 EC)</td>
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<tr>
<td>Engineering Dynamics (4 EC)</td>
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<tr>
<td>Adaptive Optics (3 EC)</td>
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<th>Second year (60 EC) ***</th>
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<tr>
<td>Traineeship (optional) (16 EC)</td>
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*tentative, minor changes possible
** including a society oriented course
*** second year assignments can be joined in any combination
Graduation projects
The subjects of the graduation projects of some of the past students are listed below.

- Design of a 2DOF eye-scanning device
- Design of a ceramic wafer chuck with integrated mirrors (Mapper Lithography)
- Smart sensor design for a 3 DOF planar positioning stage
- Development of a retinal eye tracker for 3D optical coherence tomography (TNO)
- Design of a linear guide for an optical fibre used in pressure sensitive spectroscopy using a compliant rolling mechanism
- 5DOF precision alignment system for optical fibre with high stability
- Adapt “picodrift” interferometer for vacuum application (VSL)
- Apply vision and low cost microcontrollers for fast positioning of a 3 DOF stage; an internal feasibility study
- Micro-fluidic pump fo integration in a microjet drug delivery device (Philips)

Career prospects
Dutch High-Tech industry, including ASML, Hittech, TNO, Antheryon, VDL, Zeiss, NXP, Demcon, NTS, FEI and Focal, has great demand for OM engineers and are excited about the OM track. The strong involvement of the industry will also lead to interesting and challenging assignments for those students who are seeking an MSc assignment in these industries.

Student Association Taylor
The very active student association Taylor, aims to establish an active link between students and the department staff. By organizing various activities such as lectures and receptions, communication between MSc students and PhD researchers improves. Visits to industries are also organized. Aside from all these great activities the absolute highlight of the year is the annual “Taylor Trip”. During this international study trip companies are visited, whose core business align with the fundamentals and application fields of the track. Most activities will team up with the High-Tech Engineering track as both belong to the department of Precision and Microsystems Engineering (PME).

For my master thesis, I designed, built and validated a planar precision stage for 3D microscopy applications. The thesis combined optics, sensing, actuation and control. My positioning system uses a cost-effective image sensor to determine the position of the stage. By detecting the position of QR-like codes attached to the stage, micrometer precision was obtained. I developed Lorentz actuators to drive the stage. The entire system was implemented in an experimental setup. What I enjoyed most was the combination of theoretical design using first principles and the implementation of the system in reality. Being fully responsible for the completion of this project has been challenging and was a great learning experience. The working atmosphere created by staff members and fellow students has been amazing and helped me enormously to improve the quality of my work.

After finishing my studies I found a good match at TNO’s Opto-Mechatronics department (@ the TU Delft campus). The work at this department shows that the combination of mechatronic system design with optical engineering makes you valuable for nearly every engineering branch, e.g. quantum computing & communication, aerospace engineering, astronomy, nuclear fusion engineering, the semiconductor industry, you name it.

I graduated for my Mechatronic System Design MSc and PhD with an emphasis on optics and metrology. My research was about improving the measurement accuracy of ‘heterodyne displacement interferometry’ for measuring wafer- & reticle-stage displacement of ASML’s EUV lithography systems.

If there would have been an Opto-Mechatronics track ‘back then’, I would have chosen it!
Admission requirements and application procedure

Dutch BSc degree
In most cases, if you hold a BSc degree and the Master's programme is closely related to your Bachelor's programme, you will be admitted directly into the programme. However, if the Master's programme does not follow directly from your undergraduate programme, you will be required to take additional courses in what is called a bridging programme. This may be a standard programme, or it may be tailored to your specific situation.

To see which Master's programmes are open to you on completion of your Bachelor's degree Dutch university, go to www.doorstroommatrix.nl.

Application goes through Studielink: tudelft.studielink.nl

Dutch HBO degree
An HBO Bachelor's degree does not qualify you for direct admission to a TU Delft Master's degree programme. To start a Master's degree programme, you will first need to complete a supplementary programme in order to bring your knowledge to the required level. You can do this during your HBO programme by completing a bridging minor or by means of a bridging programme after securing your HBO diploma.

Entrance requirements for mathematics and English (some exceptions) apply for both the bridging minor and the bridging programme. See www.hbodoorstroom.tudelft.nl for detailed information.

Application goes through Studielink: tudelft.studielink.nl

International applicants
To be considered for admission to a MSc Programme you'll need to meet TU Delft's general admission requirements.

1. A BSc degree (or a proof that you have nearly completed a BSc programme) in a field closely related to the MSc programme.
2. A BSc Cumulative Grade Point Average (CGPA) of at least 75% of the scale maximum.
3. Proof of English language proficiency:
   - TOEFL with a minimum score of 21 for each section and an overall band score of at least 90 (internet-based test). Please note that we only accept the TOEFL internet-based test.
   - or IELTS (academic version) with a minimum score 6.0 for each section and an overall Band score of at least 6.5.
   - or proof that you have passed the University of Cambridge ‘Certificate in Advanced English’ with a minimum grade B or the University of Cambridge ‘Certificate of Proficiency in English’.

For international students, the application period starts in October and closes on 1 April. To start an MSc application, fill in the online application and pay the refundable application fee of €100. Then send hard copies of the application documents to TU Delft's International Office. Please note that you should apply early when you want to be considered for a scholarship as well!

For more information about the application procedure and studying at TU Delft in general, go to: www.admissions.tudelft.nl.

Further information
Please visit the webpage for all details, complete requirements, deadlines and contact information:
www.me.msc.tudelft.nl

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Introduction Week
At the start of the academic year an Introduction Week is organized. You will be presented with introductions to the staff and the research groups, and get introductions to the main courses. At the end of the week you will be challenged to propose a preliminary study program. Hands-on assignments, communal lunches, drinks, a BBQ and the additional games & sports day on Friday are all aimed to build the OM community.

Cover credit
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