Syllabus

MSc Nanotechnology (M-NT)

2017 / 2018 (version July 2017)

*Please note that even though the information in this syllabus is gathered with the utmost care, you cannot derive any rights from this syllabus. At the moment of composing this syllabus not all course descriptions were available. **Please check Osiris regular for the most up-to-date information.**

TABLE OF CONTENTS

GENERAL INFORMATION

BLOK STRUCTURE

The MSc Nanotechnology programme is a 2-year programme (120 EC). As all other BSc and MSc programmes at the University of Twente the year starts in September and ends at the beginning of July. Each year is divided into 4 blocks, which are referred to as 1A, 1B, 2A and 2B.

Block		Weeks	Dates
Block 1A	Instruction weeks	36 – 43	Sept 4 – Oct 27
	Exam weeks	44 – 45	Oct 30 – Nov 10
Block 1B	Instruction weeks	46 – 3	Nov 13 – Jan 19
	Exam weeks	4 – 5	Jan 22 – Feb 2
Block 2A	Instruction weeks	6 – 14	Feb 5 – Apr 6
	Exam weeks	15 – 16	Apr 9 – Apr 20
Block 2B	Instruction weeks	17 – 25	Apr 23 – Jun 22
	Exam weeks	26 – 27	Jun 25 – Jul 6

NOTE: Blocks are sometimes referred to as quarters, which were numbered 1 to 4.

With a total of 120 EC over 2 years, each block is equivalent to 15 EC, which is roughly equivalent to 3 courses (as most courses are 5 EC). 1 EC is equivalent to 28 hours of study, making 1680 hours per year.

For a typical course having a load of 5 EC, this means 140 hours study load on average. This includes lectures, tutorials, project work, report, assignments, self-study and examination.

All courses of the MSc Nanotechnology are provided in the English language.

COURSE SCHEDULES

The course schedule ('rooster' in Dutch) is providing detailed information on the location and times, where and when lectures, tutorials, assignments, etc. related to specific courses are given. These schedules also contain information on examinations, re-sit opportunities and closing dates for exam registration.

For up-to-date schedules for each educational activity at the University, go to: **https://rooster.utwente.nl**

Here you can create your personal schedule based on the courses/programmes you select. If you use the log-in feature, this page saves your schedule. It is also possible to integrate the schedule into your personal digital agenda (for more information, please consult the help-pages on the website).

LECTURE TIMES

Lecture times are indicated with numbers from 1 to 9. Most lectures are scheduled as double-hours, meaning 1-2, 3-4, 6-7 and 8-9. Number 5 is the lunch break. These numbers refer to the following times:

Number	Time
1	8.45 – 9.30 hrs
2	9.45 – 10.30 hrs
3	10.45 – 11.30 hrs
4	11.45 – 12.30 hrs
5	12.45 – 13.40 hrs

Number	Time
6	13.45 – 14.30 hrs
7	14.45 – 15.30 hrs
8	15.45 – 16.30 hrs
9	16.45 – 17.30 hrs

LOCATIONS

The location where a lecture, tutorial, or exam is given is mentioned in the schedule using different 2-letter codes. The number following right after the code is the room number within that building, the first number in most cases referring to the floor.

Code	Building	Code	Buiding	Code	Building
CU	Cubicus	VR	Vrijhof	HT	Horsttoren
HO	Hogekamp	WA	Waaier	NH	Noordhorst
RA	Ravelijn	ZI	Zilverling	OH	Oosthorst
SP	Spiegel	CR	Carré	WH	Westhorst
SC	Sportcentrum	NA	Nanolab	ZH	Zuidhorst
TE	Temp	HR	Horstring	ME	Meander

STUDENT SERVICES

For questions related to the administrative part of your study, such as:

- switch to another study programme
- enrol in a second programme
- (temporarily) quitting your programme
- receive refunds of tuition fees
- get information on validity of (foreign) diplomas
- get information concerning student cards
- study card
- Osiris
- Bank account
- Accommodation
- Etc.

Please contact Student Services online at https://www.utwente.nl/ces/studentservices/en/ or visit them in the Vrijhof.

Location: Vrijhof, room 239 B
Opening hrs: Mo – Fri 10.00 – 16.00 hrs
Tel: 053 - 489 2124
Email: studentservices@utwente.nl

STUDENT CARD

Upon enrolment as a student you will get the student card (Dutch: 'collegekaart'). This card is your ID-card to be used at the university and serves as proof of you being enrolled as a student. Have this card with you at all times. This card also works as access card for many of the campus facilities (such as Union Card and Student Union Activity Card).

In case you lose your card, please contact the Student Services immediately.

UNIVERSITY LIBRARY (UB)

The University of Twente has an extensive library. The library (also known as UB) has a large collection of books and magazines on a huge number of research areas. Depending on the information they are available on-line, hard copy, lendable or only-on-inspection.

Furthermore the library provides study facilities, such as desks in reading halls, private study rooms and small rooms for groups.

With a valid student card you can access the library and use all the services offered. For specific information on how to do that you can turn to the desks at the different library locations.

A lot of the services can be accessed through: www.utwente.nl/ub

Here you will find on-line catalogues, databases and search engines. A huge number of journals can be accessed via this website and allow you to download specific research papers.

The University library is located in the Vrijhof building. For precise opening hours, check the website.

IT SERVICES

Once registered as a student, you will receive a student account which consists of your unique student number, an email address and a password. This student number and password can be used for all the web applications of the University of Twente.

Web applications can be accessed through the Student Portal: http://my.utwente.nl/ut/index.html

ICTS SERVICEDESK - NOTEBOOK SERVICE CENTER

For information on discounts on notebooks, installation of software and hardware, repairs and other services related to notebooks and computers, you can consult the website (https://www.utwente.nl/lisa/nsc/) or visit the ICTS Servicedesk at the ground level in the Citadel building. The desk is opened from Monday to Friday between 8.30 and 17.00. You can also call at 053-489 5577 or email at servicedesk-ict@utwente.nl.

OSIRIS

REGISTRATION FOR COURSES AND EXAMS (OSIRIS)

For all courses you need to register through the Osiris-student website (https://osiris.utwente.nl/student/StartPagina.do). Use your personal codes (student number and email password) to logon to this web application.

You can register and deregister for exam from 40 to 14 days before the examination. Deregistration can be done up to and including the day before the examination. In case of problems, contact the BOZ-NT (BOZ-NANO-CES@utwente.nl) office.

If you did NOT register for an exam, you are not allowed to take the exam.

The examination schedule may change after you have registered, e.g. an examination may be moved to a different location. Before the examination, consult the educational announcements, BlackBoard or the examination schedule available on Osiris for any changes.

NOTIFICATION AND AVAILABILITY OF EXAMINATION MARKS (OSIRIS)

Exams have to be corrected within 10 workdays after the exam date. Once the Educational Affairs Office (S&OA) has processed the grades, you can access your grades in Osiris (www.utwente.nl/osiris). Login with your personal codes (student number and email password). Examination results are confidential and are treated as such by BOZ.

ONLINE COURSE INFORMATION SYSTEM (OSIRIS)

For up-to-date course descriptions of all the courses offered at the University of Twente, you can use the online course-catalogue (part of Osiris). Also within this Master Guide you will find detailed information on the core modules and most elective modules that are considered relevant for the MSc Nanotechnology. Information on courses however is subjected to changes. For the most up-to-date information on courses, and course content, please consult the online course-catalogue.

Osiris course-catalogue is accessible through https://osiris.utwente.nl/student/OnderwijsCatalogus.do

BLACKBOARD

Blackboard is the digital learning environment of the University of Twente. Its main functions are:

- (un)subscribing for courses.
- the course schedule
- submitting and receiving feedback of assignments
- information, such as hand-outs of the lectures, news, announcements and additional course material

Access to Blackboard requires an internet connection and an account. You will get this with your registration as a student at the university.

Manuals for how to use Blackboard can be found on the website. Blackboard can be accessed via: http://blackboard.utwente.nl/

PROGRAMME RELATED INFORMATION

STAF NANOTECHNOLOGY

BEN BETLEM, PROGRAMME DIRECTOR NANOTECHNOLOGY

Within the Faculty each study programme has its own organisation with a programme director in charge. He bears the final responsibility for the educational quality of the study programme. This concerns the overall policies, regulations and performance in the programme, and also the daily management. The Programme Director constitutes the board of the study programme and plays an important role in the development of new courses but also in monitoring and improving the existing tracks and courses.

ALEXANDRA ELBERSEN, PROGRAMME COORDINATOR

The Programme Coordinator supports the programme director and is in charge of the organizational, procedural and content-related coordination of the study programme. She coordinates the connection and the quality assurance of the educational programme. Together with the students, the mentors, and lecturers, she evaluates the courses and initiates necessary changes.

RIK AKSE, STUDENT ADVISER FOR DUTCH STUDENTS, INTERNATIONAL STUDENTS & HBO STUDENTS

The student adviser can guide students during study problems they might encounter. Besides programme-related problems, students can talk about experiences with studying, planning, complaints, educational and examination regulations, legal position and possible other suggestions concerning the personal programme. The student adviser is the person of trust for students.

Rik is the study adviser for all international students. **To make an appointment with the study adviser, please visit tnw.planner.utwente.nl. Here you can make your appointment with the study adviser.**

WEBSITE

All important information about the programme can also be found on the website of the programme: www.utwente.nl/nt.

BUREAU OF EDUCATIONAL AFFAIRS (BOZ)

For all your affairs dealing with grades, courses, diplomas, etc., you will have to contact the BOZ-TNW office, of which the MSc Nanotechnology is part. You can contact the BOZ-NT office

Elke Vinke-Dinius
BOZ-NANO-CES@utwente.nl
Buitenhorst 217/218
Working days: Monday, Wednesday, Thursday

STUDENT'S CHARTER (INCLUDING OER)

The Student's Charter is a legal document stating the **rights and responsibilities** of both the institution providing the education (University of Twente) and the student (that is you). It gives details of the service you can expect from us and what we can expect from you.

This document consists of 4 different parts. The first part is general for all students enrolled in any educational programme at the University of Twente. This part can be consulted on the web at:

https://www.utwente.nl/en/ces/sacc/regulations/charter/

More specifically to the MSc Nanotechnology itself here are 3 other documents, which are referred to as the **Examination Regulations and Graduation Requirements** (the OER, "Opleidings en Examen Reglement"). These 3 documents describe the partnership between the organization (Faculty of Science and Technology, University of Twente) and its students in terms of the kind of performance that is expected of both those parties. This document outlines the rights and obligations of both parties within the educational process. Alongside of the commitment obligation on the part of the organization as described in this charter there is the commitment obligation of the student to satisfy all the requirements and gain the MSc degree Nanotechnology within the allocated time. The English version of this document has been endorsed by the Faculty Council in which both the dean, and the students are represented. The rights that the student can appeal to on the grounds of this charter are granted to him in order to make such appealing possible. The charter has its legal foundations in Art. 7.59 of the Higher Education and Scientific Research Act (WHW).

The **Examination Regulation and Graduation Requirements** for the MSc Nanotechnology comprises of:

- **General part,** a section that is applicable to all Master programmes within the faculty of Science and Technology
- **An NT-specific appendix** to this first document, which pertains only to the Master Programme in Nanotechnology
- **Rules of the Board of Examiners**

These 3 documents are available in English. Digital versions of these documents (in PDF) can be downloaded from: http://www.utwente.nl/nt.

TRANSITION REGULATIONS

If the regulations are changed, the programme director will make a transition regulation and announce these regulations to all students. More information on this can be found in article 13 of the OER.

ABSENCE

When it is not possible to attend a compulsory practical course, tutorial or an exam, due to illness or circumstances beyond your control, this may have consequences. It is therefore essential to inform your lecturer or supervisor as soon as possible. When an exam is missed beyond the student's control and the student is severely disadvantaged by this, the Board of Examiners may decide to permit the student to take an extra exam at a later time. In this case, the Board of Examiners will consult the student adviser. (Nevertheless, a special treatment is not always required if it is generally possible to join the next exam session.)

A long-term illness or other personal circumstances may hinder your study progress. In this case, contact your mentor or student adviser.

In some exceptional cases of illness and circumstances (in your family) - or in a broader sense: situations beyond your control - you may be financially compensated by emergency funds, medical-social funds or university funds. For such cases, contact the information desk of student counsellors ("red desk" located at the Bastille), preferably after counselling the student adviser of your study programme.

More information: https://www.utwente.nl/ces/sacc/

EXAMINATION PROCEDURES

For most courses, a block (or semester) is concluded with an exam. For all courses there two opportunities to take an exam sessions per year: one directly following the block in which the lectures are given and one after the following block. Consult the schedules, Osiris or contact the lecturer for the precise dates of exams. When you take the same exam more than once, the highest grade applies. Grades/marks you receive for the courses are integer numbers ranging from 0 to 10, where 10 is the maximum. The only exception is a 5.5. Grades 5.5 or higher are a passing grade.

DURING THE EXAMINATION SESSION

During the examination, one supervisor is present that can clarify any issues during the exam. If requested by the supervisor, you have to identify yourself with a student card and you also have to follow their instructions.

During examinations, no contact with other students is allowed. It is expected that you prevent disturbance of fellow students and therefore be on time at the examination session. During the first half an hour after start of the examination session, late-comers will be allowed to participate, and after that time will be prevented from participating. Due to this rule, it is not legitimate to leave the exam within this first half hour. The examination session ends at the set time, also for late-comers. At the end of your exam, every paper that you hand in must include a name and student number. If present, the attendance list should be signed.

FRAUD

Please make sure that you are aware of the rules regarding fraud and the consequences of it.

It is **not allowed**:

- to use materials (e.g. books, electronic devices, notes) during a test which is not permitted by the examiner prior to the start of the test;
- to cheat during the test
    - by the use of unauthorized material,
    - by copying from others or allowing others to copy,
    - by communicating about the test during the test with persons other than the invigilators.
- to plagiarize.

Consequences can be:

- not to be allowed to take one or more tests, examinations or final examinations for a certain period of time (determined by the Board of Examination) for a maximum of one year;
- or to be permanently expelled.

RIGHT OF INSPECTION AND APPRAISAL

During a period of at least 6 months after the results of a written examination have been

published, you have the right to inspect the assessed piece of work. When requested, you will be provided with a copy of the assessed piece of work and the examination criteria. You are furthermore entitled to an appraisal with the corresponding examiner. The appraisal will take place at a time and place determined by the examiner.

The examiner sees to it that written examinations are kept archived for at least two years after the examination date. In some cases, a lecturer organizes a general exam evaluation. It is recommended to make use of your right for inspection in case you did not pass your exam while you have put sufficient time in taking the course. In this way, you get a better idea of the course demands and of the gaps in your knowledge.

WORKSHOP ACADEMIC SKILLS

International students and students who finished their bachelor's degree at a University of Applied Sciences will have to follow the workshop Academic Skills. During this workshop students learn:

- how to search for literature at the University of Twente,
- how to write a report, and
- how to work in groups.

There will be 3-4 lectures students have to attend. This is an practical workshop, students are expected to participate during the workshops and to practice with the learned material.

INTERNSHIP & JOB ORIENTATION PROJECT

The Internship & Job Orientation Project (20 EC) is a compulsory part of the MSc programme Nanotechnology. The experience in this period is a great help in orientation on the career with an academic MSc diploma. Students will do the Internship & Job Orientation Project in industry in the Netherlands or abroad, at another university outside the Netherlands or at another university/research institute.

Judgement whether the project foreseen is of sufficient quality has to be performed by an academic supervisor. During this assignment, gained knowledge and skills at the study programme can be applied in an actual working environment.

UT students who will do their Internship & Job Orientation Project have to register via the registration system Mobility Online (https://www.utwente.nl/en/education/current-students/mobility-online/).

International students should also contact Rik Akse (h.a.akse@utwente.nl) during the arrangement of the internship.

Every year in an information session, the coordinator provides general information about the internship. Also, take care that you will be authorized to visit the Blackboard site **Internships TNW** (under organizations). At this site, you find the internship guide, information about experiences in the past, internship offers and all the necessary forms.

Internship coordinator
Betty Folkers

room : Horst HT-609

telephone : 053 489 2772

email: stage@tnw.utwente.nl

Assistant Internship

Monique Kolff

room : Horst HT-605
telephone 053 489 3932

email: stage@tnw.utwente.nl

MSC ASSIGNMENT

This section contains very important information on how to proceed if you have decided on a research group in which you wish to start your MSc thesis assignment within the MSc Nanotechnology programme. Please read this information very carefully.

BEFORE STARTING THE ASSIGNMENT

As soon as you have decided in which research group you want to do your final MSc thesis assignment, please contact the head of the research group to discuss the project in detail.

Before you may start with your MSc final project, you have to have the approval of the Board of Examiners. To get this you have to:

- Fill out the **MSc final project contract and course list**. In this document you need to provide information regarding the starting date of the assignment, a short description of the assignment, the committee members, an overview of the courses you have finished already, and a list of courses that still need to be done (if applicable).
- Make sure this form is sent to BOZ-NT (BOZ-NANO-CES@utwente.nl; att. Mrs. Elke Vinke-Dinius) **at least one month before** the starting date of the assignment.

After handing in the form you will receive a written letter with the decision made by the Board of Examinations. This could take a few weeks. **Please note that you cannot start before you have received this letter.**

MIDTERM EVALUATION

About halfway during the period of the MSc final project, you need to organize a midterm evaluation. Here you need to report on the progress of the assignment. Aspects related to the processing of relevant information (literature), analysis of the research problem, and actual progress on the work need to be included here.

WHEN YOU ARE READY FOR YOUR COLLOQUIUM

In order to set a date for your MSc final project colloquium, you will need to fill out the **Application MSc colloquium**. In this form you will indicate the date of your MSc colloquium and whether you have finished all the required courses of the master. *Please note that this is your final course of your MSc and you need to have finished all other courses of the curriculum.*

Please send this application form **one month before the date** of your MSc colloquium to BOZ-NT.

Also download the **Assessment Form MSc Final Project**, which is a list of criteria that are used in the assessment. Make sure all your committee members do have a copy of this.

FORMS AND DOCUMENTS

The different forms and documents can be found on the MSc NT website at http://www.utwente.nl/nt. Filled out forms need to be send to BOZ-NT (BOZ-NANO-CES@utwente.nl).

CURRICULUM NANOTECHNOLOGY

<table>
<tr><th colspan="5">Year 1</th></tr>
<tr><td></td><td>Quarter 1A</td><td>Quarter 1B</td><td>Quarter 2A</td><td>Quarter 2B</td></tr>
<tr><td></td><td>Characterisation</td><td>Fabrication</td><td>Design + Application</td><td>Internship</td></tr>
<tr><td rowspan="3">Core modules</td><td>Characterisation of Nanostructures
(7.5 EC; Schön)</td><td>Fabrication of Nanostructures
(7.5 EC; Huskens)</td><td rowspan="2">Design project
(10 EC; Tas)</td><td rowspan="3">Internship & Job Orientation Project
(20 EC)</td></tr>
<tr><td colspan="2">Nano-Lab: Fabrication & Characterization
(5 EC; Tiggelaar/Elbersen)</td></tr>
<tr><td>Nanoscience
(5 EC; Zandvliet)</td><td>SOL: Nano-electronics
BMM: Nanomedicine
SMS: Lab on a chip</td><td>SOL: AMM Adv. Mat. or Adv. Materials
BMM: Bionanotechn.
SMS: Nanofluidics</td></tr>
</table>

<table>
<tr><th colspan="5">Year 2</th></tr>
<tr><td></td><td>Quarter 1A</td><td>Quarter 1B</td><td>Quarter 2A</td><td>Quarter 2B</td></tr>
<tr><td></td><td>Nano-research</td><td colspan="4">Master's Final Project preparation, evaluation</td></tr>
<tr><td rowspan="4">Core modules</td><td>Continuation Internship & Job Orientation Project</td><td colspan="3" rowspan="2">Master's Final Project
(40 EC)</td></tr>
<tr><td>SOL: Nano-optics
BMM: (Bio)mol C&T
SMS: Soft & bio matter or Colloids & Interfaces</td></tr>
<tr><td rowspan="2">Elective
(5EC)</td><td colspan="3">1 Elective or C.S. research group5 in quarter 2, 3 or 4
(also subject from 1st year are allowed)</td></tr>
<tr><td colspan="3"></td></tr>
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	Electives			
	Quarter 1A	Quarter 1B	Quarter 2A	Quarter 2B
Electives	Theoretical solid state Physics, *Kelly*	Surfaces in thin films, *Wormeester*	Nanophysics, *Zandvliet & Brocks & Golubov*	
	Quantum optics, *Pinkse*	Nanophotonics, *Vos*		
	Biophysical techn. & molecular imaging, *Otto + Blum*	AMM Organic Materials Science, *Vancso*	Biomedical Signal Acquisition, *Olthuis*	
	Transducer science, *Krijnen*	EMstatics, *Krijnen*	MEMS design, *Tas & Wiegerink*	
	Systems-on-chip for embedded systems, *Kerkhof+ Gerez+vdZee*		Design Principles for Precision Mechanisms, *Brouwer (CTW)*	

Electives n.s.	Chemistry of inorganic materials and nanostructures, Ten Elshof
	Modern topics in condensed matter, Houselt, Kooij, Wormeester, Zandvliet
	Macromolecular Nanotechnology, Vancso
	Advanced semiconductor devices, Salm

201600043 7.5 ec 1A	**Characterization of Nanostructures**
Lecturer(s)	Dr. ing. Annemarie Huijser, dr. Peter Schön, prof dr. ing. Guus Rijnders, dr. ir. Hans Kanger
Objective	**Lecture Part** To explain and identify the physical and instrumental principles of techniques used for the characterization of nanostructures including molecular and continuum (macroscopic) scale characterization of organic and inorganic materials and their application to specific questions. By the end of this course the students are able to estimate specific nanostructure materials and molecular properties from given examples and problems **Project Part** Read and understand a scientific paper: Identify the goal, method, result and conclusion of the research. Explain the content to a fellow student. Characterization of bio-nanostructures: Critically address the applied characterization technique(s) in relation to the application. Biology at the nanoscale: Name the basic biological building blocks (proteins, DNA, lipids) and their physical and chemical properties in relation to the choice of characterization techniques. Identify the biological system under study and place this in a larger context.
Description	This module includes a lecture part (5 EC) and an additional project part (2.5 EC). **Lecture Part (5 EC)** Within the lecture part a wide range of modern, state-of-the-art analytical techniques and tools (microscopy, spectroscopy and diffraction methods) to characterize structure and properties of nanostructures will introduced and discussed. The central goal is to provide a fundamental understanding of various aspects of molecular, nanoscale and continuum (macroscopic) scale characterization that are essential for the study of nanostructures. **Project Part (2,5 EC)** In this project you are going to study how biological nanostructures can be characterized. To this end you will, in a small team of students, perform a detailed analysis of a peer-reviewed scientific paper that describes research related to characterization of biological systems at the nanoscale.
Course material	Handouts; review articles; Powerpoint presentations of the lectures **(required)** Yang Leng, Materials Characterization John Wiley & Sons, 2nd edition 2013, the electronic version of the 1st edition of this book is available online via the UT library **(supporting book, not obligatory, covers only partly the course topics)** Project: selected scientific publications
Prior knowledge	Basics of physical chemistry, organic and inorganic chemistry, materials science and molecular biology
Assessment	**Lecture Part**: Written Exam, closed book. Includes homework bonus **Project part**: Lecture for fellow students and written report

201600042		Fabrication of Nanostructures
7.5 EC	1B	
Lecturer(s)		Prof.dr.ir. J. Huskens, dr. A.Y. Kovalgin
Objective		After following the course, the student can: 1. know the building blocks (fabrication steps) of technology to fabricate a microsystem, 2. adequately express in own words the principles and theory behind, 3. transfer the obtained knowledge to practical examples in designing microsystems, 4. identify the key building blocks of technology needed to realize particular examples of microsystems, 5. develop, by combining relevant information, own process flow to realize a particular microsystem, 6. evaluate, using motivated scientific arguments, the feasibility of the suggested process flow, 7. understand the position of nanofabrication in the field of nanotechnology and its relationships with other disciplines (chemistry, physics, microfabrication, engineering, electronics, biology,...); 8. understand basic concepts of nanofabrication, and its main classes (top-down, bottom-up, lithography, self-assembly); 9. To apply these concepts in (nano)chemical and materials contexts.
Description		The course will introduce the techniques that are available for creating nanostructures, both top-down (e.g. optical lithography techniques) as well as bottom-up (self-assembly/nanochemistry). The course is therefore divided into two sections: S1. Technology (teacher: Alexey Kovalgin); S2. Nanochemistry (teacher: Jurriaan Huskens) **S1.** The course provides a general introduction to the field of manufacturing technology of microsystems. The emphasis is put on the fabrication steps. The most commonly applied steps (techniques) are treated. The techniques having the same main goal are compared, their advantages and disadvantages are discussed, the choices of suitable techniques for the particular application/device are questioned. The important criteria (e.g. film properties, uniformity, the costs, the efficiency, the reproducibility and the reliability), to compare the different techniques, are demonstrated. It is shown how fabrication steps can be combined in a process flow to fabricate a functional microsystem. Several examples are given where the integration processes to fabricate microsystems are treated in an introductory manner, including realization of microprocessors, microfluidic systems, lab-on-a-chip, MEMS and nanoelectronic (spintronic) devices.Two main blocks are given. Block 1 considers the basics (main building blocks) of microtechnology and includes introduction and history, substrates and wafers, modification of materials, lithography, film deposition, wet and dry etching, wafer bonding and packaging. Block 2 consists of guest lectures and covers different application areas of the main building blocks to realize microsystems in the field of integrated circuits, biochips, nanoelectronics, spintronics, MEMS, and micro-fluidics. **S2 (Nanochemistry)**: topics:1. Introduction to Nanochemistry; 2. Gold; 3. Quantum dots; 4. Silica; 5. Polydimethylsiloxane; 6. Iron oxide; 7. Carbon
Course material		"Introduction to Microfabrication", Franssila, Sami ISBN: 9780470749838 (section 1) **(required)** "Concepts of Nanochemistry" by L. Cademartiri and G. A. Ozin; Wiley, ISBN: 978-3-527-32597-9 (section 2) **(required)**
Assesment		Exam

201600041		Nano-lab: Fabrication and Characterization
5.0 EC	1A+1B	
Coordinator		Dr. ir. Tiggelaar, A.S. Elbersen
Objective		The objective of this practical course is to train practical experimental skills that are needed in an interdisciplinary research laboratory environment in the field of nanotechnology. It includes skills needed for the fabrication of nanostructures by means of top-down as well bottom-up techniques and the characterization of nanostructures with various techniques

Description

This course will provide hands-on training in nanofabrication as well as characterization of realized nanostructures in the Nanotechnology cleanroom as well as at a number of research group labs.

Organization:
All students will be divided in 2 groups (A and B), and will do experiments according to the scheme below:

	Block 1A 8 weeks, 2 days a week		**Block 1B 8 weeks, 2 days a week**	
Group A	Cleanroom Experiment 1	Cleanroom Experiment 2	Research grp Experiment 1	Research grp Experiment 2
Group B	Research grp Experiment 1	Research grp Experiment 2	Cleanroom Experiment 1	Cleanroom Experiment 2

Cleanroom experiments
Students will work in groups of 3 and each group takes part in 2 out of 3 experiments, which are listed in Table 2. The module starts with an introductory lecture on the fundamentals of three nanolithography techniques, i.e. electron-beam lithography (EBL), laser-interference lithography (LIL) and displacement Talbot lithography (DTL). Subsequently, by means of these lithography techniques nanometer-sized features will be fabricated in the NanoLab cleanroom.

The cleanroom experiments are listed in the following table:

#	**Fabrication**	**Characterization**	**Contactperson(s)**
1	electron-beam lithography (EBL)	SEM	Tiggelaar, Jenneboer
2	laser-interference lithography (LIL)		Tiggelaar, Van Wolferen
3	displacement Talbot lithography (DTL)		Tiggelaar, Van Vossen

Research group experiments
Students will work in groups of 2 and each group will do 2 experiments. The two experiments one group is doing cannot be within the same category of materials: molecular or soft-matter versus solid-state.

Assessment

1. Cleanroom (30% of grade)
The grading is individually. The grade is based on two questionnaires covering the theory and two reports for both explored lithography methods. In the reports you have to

	describe your activities and results as obtained in the cleanroom. A guideline for the report will be available. 2. Research group lab (70% of grade) The grading is per group. The grade is based on two experiments at different groups. For each experiment the group is tested on: knowledge of theoretical background, experimental work in the lab, and report. For each experiment a concise report of about 10 pages has to be delivered in which you have to describe the activities and results as obtained.
Remark	**This Nanolab course is only accessible for Nanotechnology students**

201600045		**Intro Nanoscience**
2.0 EC	**1A**	
Lecturer(s)		Prof.dr.ir. H.J.W. Zandvliet
Objective		The main aim of this course is to become familiar with the elementary/basic concepts in quantum mechanics. The course is developed for Nanotechnology students that want to follow/enter the course Nanoscience (NT), but do not have any knowledge/experience with quantum mechanics.
Description		The following topics will be addressed: Duality (particle/wave nature), wave function, Schrödinger equation, quantum mechanical particle in a box, harmonic oscillator, quantum mechanical tunnelling, free electron model and uncertainty relation of Heisenberg.
Assessment		Written examination
Remark		**This course is only obligatory for students that did not have quantum mechanics and/or solid state physics in their BSc programme. This course is scheduled in the first 2 weeks of the quarter.**
Course material		Fundamentals of Nanoelectronics By George W. Hanson. Pearson, Prentice Hall (Upper Saddle River, New Jersey) ISBN 978-0-13-195708-4 **(recommended)**

193400050		**Nanoscience**
5.0 EC	**1A**	
Lecturer(s)		Prof.dr.ir. H.J.W. Zandvliet, dr. A.A. Golubov,
Objective		Introduction to the fundamentals of nanoscience
Description		Fundamentals of nanoscopic physics. Introduction to Nanoelectronics (top-down vs bottom-up approach, relevant length scales). Wave/particle duality, wave functions, wave packets and Heisenberg uncertainty relations. Free and confined electrons, free electron model, density of states, band theory (periodic potential), tunnel junctions/resonant tunneling, single electron tunneling. Electronic structure of quantum dots, quantum wires and quantum wells and their transport properties. Coulomb blockade and single electron transistor
Prior knowledge		Solid state physics, quantum physics/mechanics (B2 level)
Assessment		Written examination
Course material		Fundamentals of Nanoelectronics By George W. Hanson. Pearson, Prentice Hall (Upper Saddle River, New Jersey) ISBN 978-0-13-195708-4 **(recommended)**
Assessment		Exam

<table>
<tr><td>201600044</td><td></td><td rowspan="2">Nanotechnology Design Project</td></tr>
<tr><td>10.0 EC</td><td>2A</td></tr>
<tr><td colspan="2">Lecturer(s)</td><td>Dr. ir. N.R. Tas,_dr. R. Harms</td></tr>
<tr><td colspan="2">Objective</td><td>Students should be able to design a nano-device, both in terms of device physics and clean room fabrication process.
More in detail, students should be able to:
• Formulate and specify the required functionality
• Carry out a systematic literature search to know the state-of-the-art
• Make a conceptual design
• Make a physical model of the device (“physical design”)
• Choose dimension, materials and driving parameters (like voltage, pressure etc.) based on the model
• Design a clean room implementation of the device (process flow and masks)

For the business component, additional learning aims are:
• Familiarize with the Lean Startup Methodology such as the build-measure-learn loop and the utilization of the Lean Canvas
• Learn about and apply basic techniques of qualitative market research such as emphatic design, the problem interview, and the solution interview
• Learn about and apply basics of finance for entrepreneurs such as the cost model, the revenue model, and basics of venture valuation
• integrate key information to design a unique solution to solve a customer problem with the help of a nanotechnology-based device</td></tr>
<tr><td colspan="2">Description</td><td>In the Nanotechnology Design Project, students will work in groups of 4 – 6 people on the design of a nano-device of their own choice, and consider business aspects / opportunities for this device. The project starts with a small number of lectures to define and explain the physical “domains” involved. Focus is on the fields of MEMS, Lab-on-a-Chip and (unconventional) Nano-Electronics. After this, a literature search is carried out to get an overview of the state-of-the-art in the field of choice. Basic functionality and requirements are formulated next. A possible implementation will be proposed (“conceptual design”), after which detailed modeling is carried out to help define exact dimensions, material choice and driving parameters (electrical, hydraulic, ..). Finally, a (clean room) process flow is developed for the device fabrication. Major phases in the design will be presented by the groups and evaluated by the lecturers. Besides the presentations, important deliverables are a literature report, and a design report which includes all important phases of the design process (conceptual design, physical design, process flow design and mask design). Parallel to the technical design, the groups try to develop a business case for their device of choice. Important milestones are the initial business canvas presentation and the final business pitch.</td></tr>
<tr><td colspan="2">Assessment</td><td>Report</td></tr>
</table>

201700174		Internship & Job Orientation Project
20.0 EC	**2B**	
Coordinator		Ing. A. Folkers
Objective		- to perform an assignment applying the principles and methods of Nanotechnology in a practical situation, - to gain insights into the functioning of a professional organization, - to obtain specific competencies necessary for working in a professional institute or company, - to gain insights about the field of Nanotechnology.
Description		The Internship & Job Orientation Project is a compulsory part of the MSc programme in Nanotechnology (course code 201700174). The internship has to be scheduled in fourth quarter of the first year of the master, has to cover at least 13 weeks (20EC) and should be conducted preferably at a company but can also be conducted at a research institute or an foreign university. The TNW master programmes offer several opportunities for adding an international dimension to the knowledge and the practical experience of a student. Therefore the Internship & Job Orientation Project may be carried out in the Netherlands or abroad. We believe a stay abroad is a valuable component of the study; therefore stimulating measures like the Twente Mobility Fund (TMF-fund) and the Erasmus-scholarship are available. The 20 EC is a minimum study load. The Internship & Job Orientation Project is coordinated by the internship coordinator. Orientation for the Internship & Job Orientation Project has to start half a year prior to national internship and a year prior to international internship. This time is required for actual arrangements of the internship, such as getting an accommodation, visa and all formalities. Application for the Internship & Job Orientation Project has to be submitted by Mobility Online https://www.utwente.nl/en/education/current-students/mobility-online/ All relevant information, internship posts and all required forms for the internship can be found on the Blackboardorganization 'Internships TNW'. International students should also contact Rik Akse during the arrangement of the internship. (h.a.akse@utwente.nl)

193409100/200	MSc Thesis Assignment
35.0 – 45.0 EC	
Contact person	Dr. ir. B.H.L. Betlem
Description	The individual MSc thesis assignment is the completion of the MSc programme. For this assignment you will spend 6 to 7 months in one of the participating research groups and conduct a full research project. Under guidance and supervision of a PhD student and/or senior researcher, you will start with an extensive literature survey (reported in a literature report), followed by some experimental work. At the end of the experimental work, you will write up your results in a MSc thesis report that you will defend in a presentation in front of a public audience. Occasionally, the assignment can be (partially) conducted at an organization outside the UT.
Objective	Perform a scientific research project in an academic environment

Assessment	You will receive 2 marks for the MSc thesis assignment. The first mark represents the *scientific aspects* and the second mark represents the *general aspects (each for 50%)*. For more detailed information on what aspects are evaluated, check the M-NT website (www.utwente.nl/nt) .
More information	Before you start with your MSc thesis assignment, the assignment itself and your study programme must be evaluated by the Board of Examinations. Please send in the required form (see elsewhere in this guide) about one month before you want to start. The MSc thesis assignment is the final course in your MSc programme, so before giving your colloquium you must have finished all the other course modules.

NANOTECHNOLOGY TRACK COURSES

SOLID STATE MATTER

193400131		**Nano-optics**
5.0 ec	**1B**	
Lecturer(s)		Dr. S.M. García Blanco, dr.ir. H. Offerhaus, prof. W.G. van der Wiel
Description		Nano-Optics is the study of optical phenomena and techniques on the nanometer scale, even below the diffraction limit. It is an emerging field of study motivated by the rapid advance of nanoscience and nanotechnology and enabled thanks to the development of very advanced nanofabrication, manipulation and characterization tools (i.e., scanning probe techniques, optical tweezers, high-resolution electron microscopes, nanolithography tools, focused ion beam, and others). Nano-Optics deals with the interaction of light and matter at the nanoscale. Applications span from nano-optical instrumentation (i.e., confocal microscopy, near-field microscopy) and nano-optical devices (i.e., nano-lasers, photonic crystals, optical nano-waveguides) to a full range of basic research topics on nanometer sized structures. In this course, topics such as the fundamentals of light-matter interaction at the nanoscale, plasmonic propagation, nanowaveguides, nanolasers, photonic crystals, near-field microscopy and the optics of quantum confined structures will be covered. The lectures will be complemented by weekly assignments, realization of simulations of nanostructures using the commercial software Lumerical FDTD Solutions and a student seminar at the end of the course in which students will present a nano-optics topic of their choice based on recent literature.
Prior knowledge		Fundamentals in optics/photonics, electromagnetism.
Assessment		The final mark of the course will be based on the final exam which will consist of a written part (60%) and a simulation project (40%). A maximum of two extra points can be obtained by doing the bonus assignments and participating in the student seminar. These points will add to the final mark of the exam.

193400141	Nano-electronics	
5.0 ec	1B	
Lecturer(s)	Prof. W.G. van der Wiel, dr.ir. M.P. de Jong, dr.ir. F.A. Zwanenburg	
Description	Nanoelectronics comprise the study of the electronic and magnetic properties of systems with critical dimensions in the nanoregime. Hybrid inorganic-organic electronics, spin electronics and quantum electronics form important subfields of nanoelectronics and are being discussed in this course. For those who want to get a thorough introduction into the new exciting directions that will contribute to future electronics, this course is indispensable. Recommended for MSc students Nanotechnology. Applied Physics and Electrical Engineering.	
Prior knowledge	Nanoscience (193400050)	
Course material	Lecture slides, exercises, review articles, reader	
Assessment	Exam	

193530020	Advanced Materials	
5.0 ec	2A	
Lecturer(s)	Dr. E.S. Kooij, dr. G. H. L. A. Brocks, prof.dr.ir. G. Koster	
Objective	To understand and apply the relation between structure/composition and properties of advanced materials.	
Description	The course gives an introduction to advanced materials that are of interest in today's society. The course consists of lectures on general physical aspects of materials that play an important role in present technology or constitute possible major advances. Topics include magnetic and dielectric properties.	
Note	A part of this course will be organised together with the AMM - Inorganic Materials Science course (19370040).	
Course material	Powered by the teacher	
Assessment	Exam	

193700040	AMM Inorganic Materials Science	
5.0 ec	2A	
Lecturer(s)	Prof. dr.ir. G. Koster, prof.dr.ing. A.J.H.M. Rijnders, prof.dr. H.J.M. Bouwmeester	
Objective	The aim is to provide knowledge of fundamental aspects of the structure/composition in relation to the properties and performance of advanced inorganic materials.	
Description	These are novel materials or modified materials with new or enhanced properties to cope with the increased demands in technological applications. These are, amongst others, electronic applications (dielectrics and ferroelectrics), optical applications (transparent conducting oxides) and materials for energy production and storage (ionic conductors, and mixed electronic/ionic conductors). The course consists of three parts: Landau theory (e.g., ferroelectrics), defect chemistry (oxides) and group theory of crystal symmetry (e.g., ferroelectrics). These topics will be discussed using recent articles.	
Note	This course will be partly organized together with the Applied Physics course 'Advanced Materials' (193530020)	
Assessement	Exam	

193700020	AMM – Molecular and Biomolecular Chemistry and Technology
5 ec / **1A**	
Lecturer(s)	Prof.dr. J.J.L.M. Cornelissen, prof.dr.ir. J. Huskens
Objective	Molecular recognition is an essential phenomenon in living systems as well as in artificial ones. It describes the specific interaction between molecules, ranging from discrete complexes to large architectures. The course will discuss supramolecular systems going from basic molecular recognition (involving single, monovalent interactions), to systems with cooperativitye and/or multivalency, and finally to large polyvalent systems. For all subclasses, molecular and biomolecular examples will be discussed as well as materials applications.
Description	1. Noncovalent interactions, development of supramolecular chemistry (incl. the Excel modeling of thermodynamec equilibria) 2. Synthetic host-guest chemistry I: cation-binding hosts 3. Synthetic host-guest chemistry II: binding of guests in solution 4. Molecular recognition in biological systems, enzyme catalysis 5. Sensor concepts and sensor devices 6. Cooperativity: molecular and biomolecular (e.g. hemoglobin) examples 7. Multivalency: effective molarity concept, cyclization, cell membrane recognition 8. Polyvalent systems I: macromolecular assembly + supramolecular polymers 9. Polyvalent systems II: coordination polymers, MOFs 10. Polyvalent systems III: proteins an protein folding 11. Polyvalent systems IV: virus assembly 12. Polyvalent systems V: DNA + artificial DNA constructs 13. Polyvalent systems VI: layer-by-layer assembly 14. Polyvalent systems VII: supramolecular materials
Prior knowledge	Required: Organic chemistry & Thermodynamics
Course material	Supplementary handouts (review articles, presentation files) **(required)** "Supramolecular Chemistry", J.W. Steed & J.L. Atwood, 2009, 2nd edition, Wiley **(required)** "Organic Chemistry", Paula Y. Bruice, 2007, 5th edition, Pearson International Edition/Prentice Hall (or older/newer edition) (chapters and paragraphs on structure of carbohydrates, proteins, and nucleic acids **(recommended)**
Assessment	Exam

201200220	Nanomedicine
5 ec / **1B**	
Lecturer(s)	J. Prakash, S. le Gac, dr. R. Gill, dr. T.G.G.M. Lammers, J.M. Metselaar
Objective	The following are the learning objectives of the course. After the course, students . a) are able to distinguish between active and passive targeting and explain their applicability for different diseases; b) can explain the concept of active targeting, biological barriers for nanoparticles and cell-specific targeting and gene delivery; c) are able to apply the knowledge of targeting technologies for in vivo diagnosis/imaging, image-guided drug delivery; d) understand the concepts of microfluidics in nanomedicine such as point-of-care devices, molecular and single cell analysis and drug screening, in vitro diagnostics; e) are able to explain design of a study, methods and interpret results of the given paper as well as critically analyze research papers on the topic a), b), c) and d); f) are able to write and present a research proposal and can fulfil the following criteria thereof –

	- identify and define a research problem, and take a scientific approach to solve the problem. - are able to design experimental plan. - describe the application of the expected results. - are able to work in a team.
Description	Nanomedicine is one of the most dynamic fields, which holds a high potential to make a huge impact on the medical science. Nanomedicine is in general defined as medical applications of nanotechnology. In recent years, nanotechnologies have been applied for drug delivery, imaging/diagnostics, biosensing, in vitro diagnostics, and tissue engineering. One of the largest areas for nanomedicine is the drug delivery/targeting. Conventional medicine, which are either administered orally or with injections, are not always successful for achieving the desired therapeutic effects but rather show high side effects. Therefore, novel drug delivery systems are highly crucial to develop, using which the drugs can be specially delivered at the targeted site or even to the specific cell types. Using these novel approaches, high therapeutic effects and low/no side effects can be achieved. A large part of the course will be devoted to the drug delivery. Besides drug delivery, nanomedicine includes applications of nanomaterials for imaging and diagnostics as well as theranostics (therapeutics + diagnostics), which will be covered up during this course. Applications to drug delivery and imaging are mostly related to applications of nanotechnologies in vivo. In addition, nanomedicine also covers up in vitro applications such as diagnostics using biosensing techniques and microfluidics. Students will also write a research proposal during this course on an assigned topic of nanomedicine, which allows them to further develop their knowledge on this subject. Altogether this course provides a broader and in depth understanding of the emerging field of nanomedicine.
Assessment	Exam

193400111		**Bionanotechnology**
5.0 ec	**2A**	
Lecturer(s)		Dr. ir. M.L. Bennink
Objective		Objective of this course is to teach you different concepts, techniques and applications in the field of bionanotechnology.
Description		Bionanotechnology is a field of research and applications that sits at the interface between nanotechnology on one hand and life sciences on the other. This module provides you with (I) an introduction into this field, (II) some basics in nanobiology, (III) the methods and techniques used, (IV) some applications in the field of bionanotechnology. **A. Biological nano-objects** (2-3 weeks) is an introduction into the objects this field is concerned with (biomolecules nanoparticles). It contains some molecular biology, biochemistry etc. Chapters are: (1) Structure and function of DNA, (2) Proteolipid assemblies and biomimetic nanostructures, (3) Supramolecular complexes of DNA, (4) Functionalized mineral nanoparticles for biomedical applications, (5) Nanomachines of life, (6) Structure and motion on the nanoscale. **B. Nanobiotechnology methods and techniques** (3 weeks) is an overview of the techniques and methods used in nanobiotechnology to study the nano-objects. Chapters are (7) Optical techniques, including fluorescence, (8) Nanoforces and imaging: atomic force microscopy and spectroscopy, (9) Nanoforces and imaging: optical and magnetic tweezers. **C. Nanobiotechnology applications** (1-2 weeks) are applications of nanobiotechnologies to show the potential in the direction of nanobiology and nanomedicine. This part is done in an assignment form.

Prior knowledge	Basics in organic chemistry Thermodynamics
Course material	Nanoscience: Nanobiotechnology and Nanobiology, by Patrick Boisseau, Philippe Houdy and Marcel Lahmani (book is available online) All other course material (video lectures, slides, exercises, quizzes) can be found at http://sites.google.com/site/bionano2016/ .
Additional info	This course is given in a flipped-classroom format with recorded videolectures which enables you to take up this course at any time (not necessarily in block 2A). If you interested in doing so, please contact the lecturer.
Assessment	Exam

SOFT MATTER COMBINED WITH COMPONENTS AND SYSTEMS

193735060		**Colloids and Interfaces**
5 ec	**1A**	
Lecturer(s)		J.A. Wood
Objective		Learning objectives of this course include: - Gain insight in important interfacial aspects including interfacial energy and surface potential. - Be able to explain and describe different interfacial phenomena, such as: wetting, colloidal stability. - Become familiar with experimental techniques for measurement of various colloidal and interfacial properties (ex. zeta potential, streaming potential, contact angle, etc.) and interpretation - Understand the applicability and limitations of various colloid-related theoretical frameworks, such as DLVO. -Critically evaluate scientific literature on interfacial phenomena.
Description		Description of colloids, surfaces and interfaces. All kinds of interfaces between different phases are treated. Thermodynamic descriptions of these interfaces are deduced. Several techniques for characterizing interfaces are discussed. During contact hours, the contents of will be presented and discussed, and exercises will be made and discussed. For each topic, a case assignment will be offered. Topics include: - Lifshitz-van der Waals Interactions - Polar/Acid-Base Interactions - Wetting and Contact Angles - Electrostatics - Electrokinetic Phenomena - Electrostatic and Polymeric Stabilization of Colloids - Colloidal Phenomena (Marangoni-Effect, Ouzo effect, etc.)
Course material		Handouts and other literature will be provided during the course
Assessment		Exam

201300135		**Soft and Biological Matter**
5.0 ec	**1A**	
Lecturer(s)		Dr. J.R.T. Seddon, dr. M.H.G. Duits, prof.dr. S.J.G. Lemay
Objective		The objective of the course is to understand the physics underlying the functioning of biological systems, with particular emphasis on the molecular scale. The emphasis is on

	physical concepts drawn in particular from statistical physics. The relevant knowledge of biology will be introduced as needed, but does not represent the core of the course.
Description	1. Introduction to molecular biology 2. Microscopic diffusion 3. Entropic forces 4. Chemical forces and self-assembly 5. Colloids 6. Cooperativity and macromolecules 7. Molecular machines 8. Membrane physics 9. Nerve impulses
Course materials	Biological Physics: Energy, Information, Life (updated first edition) by Philip Nelson. ISBN-13: 9780716798972
Assessment	Exam/presentation

191211120		**Lab on a Chip**
5 ec	**1B**	
Lecturer(s)		prof. dr. J.C.T. Eijkel
Objective		To obtain understanding of the working principles, the basic elements and most relevant applications of Lab on a Chip.
Description		The Lab on a Chip course will take the student to the world of miniaturised systems used in various fields of chemistry and life sciences. A "Lab-on-a-Chip" consists of electrical, fluidic, and optical functions integrated in a microsystem, and has applications in (bio)chemical and medical fields. The core of most lab-on-a-chip system is a microfluidic channel structure, through which nanoliter amounts of liquids with dissolved molecules are propelled by hydraulic, electrokinetic or surface forces. The fluidic structures are machined in materials like fused silica, borofloat glass, or polymers. The course will treat all aspects of such microsystems in a number of full day problem-based learning sessions and a number of practicals. Microfluidic theoretical principles are treated with emphasis on the transport of liquid and dissolved molecules. This is followed by aspects of microfabrication and a hands-on practical in rapid prototyping. Electrochemical and optical detection methods are subsequently treated. Then the manipulation of cells in microfluidic systems is considered, with a hands-on practical. Finally measurement methods are treated, including statistical interpretation of measurement data. The course is aimed at MSc students of Biomedical Engineering, Electrical Engineering, Nanotechnology, Chemical Engineering, Mechanical Engineering or Applied Physics. **Contents** Principles of fluidics and molecular transport at the micro- and nanoscale; Microfabrication; Chip-based systems for cell studies; On-chip detection methods; Fundamentals of on-chip measurement methods. *Students who already followed the module Lab on a Chip (201500054) in the bachelor phase are not allowed to follow this course, since there is extensive overlap between the two courses.*
Prior knowledge		General physics at bachelor level **(required)**; Biomedical Signal Acquisition (191210720), Micro Electro Mechanical Systems (191211050), Technology (191210730) **(desirable)**
Course material		Reader, will be avaiable via BlackBoard
Assessment		Exam (90%), written report of practicum (5%) and presentation of PBL (5%)

193400121		Nano-fluidics
5.0 ec	2A	
Lecturer(s)		I. Sîretanu, dr. J.C.T. Eijkel
Objective		- Understand principles of fluid dynamics on micro- and nanoscales - Solve practical problems - Understand, present and explain current scientific research questions in the field
Description		This course gives an introduction into Nano fluidics, considering fundamental aspects, intrinsic length scales and geometry. A number of different selected topics in the field of Nano fluidics are discussed, such as: • basic fluid dynamics for micro- and Nano channels • solid-liquid interfaces (interactions, adsorption/desorption) • electric double layer theory • hydrodynamics at small scales (laminar flow, slip versus no-slip, mixing) • 3-phase systems (capillary forces, wetting, super hydrophobicity) • electro kinetic effects (electroosmotic pumping, electro viscous effect) • electrophoresis and separation techniques • (Nano)colloidal particles and colloidal assembly
Prior knowledge		Basics in fluid mechanics, capillarity and wetting phenomena, advanced fluid dynamics, statistical mechanics.
Course material		Hand-outs and review papers **(recommended)** Brian J. Kirby: Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices (Cambridge Univ. Press) **(recommended)**
Assessment		Exam

ELECTIVES NANOTECHNOLOGY

193510040		Theoretical Solid State Physics
5.0 ec	1A	
Lecturer(s)		Prof. dr. P.J. Kelly
Description		This course builds on Introduction to Solid State Physics, treating the material in more detail and extending the scope to cover a number of additional topics: Tight-binding method Semiclassical Transport Theory Magnetism The emphasis of the course is on operationalizing the theoretical material treated in the lectures by doing homework. This is corrected and the mark contributes to the final mark.The course is based upon the following chapters of "Solid State Physics" by Ashcroft & Mermin, supplemented with lecture notes: §1 The Drude Theory of Metals §2 The Sommerfeld Theory of Metals §3 Failures of the Free Electron Model §10 The Tight-Binding Method §12 The Semiclassical Model of Electron Dynamics §13 The Semiclassical Theory of Conduction in Metals §14 Measuring the Fermi Surface §15 Band Structure of Selected Metals

	§16 Beyond the Relaxation-Time Approximation §17 Beyond the Independent Electron Approximation §31 Diamagnetism and Paramagnetism §32 Electron Interactions and Magnetic Structure §33 Magnetic Ordering
Prior knowledge	Entry Requirements: Students should have taken the courses Introduction to Applied Solid State Physics and Quantum Mechanics. Required: Introduction to Solid State Physics. Needed: Applied Quantum Mechanics.
Course material	N.W. Ashcroft and N.D. Mermin: Solid-State Physics (Holt-Saunders) **(required)**
Assessment	Exam

193515000		**Quantum optics**
5.0 ec	**1A**	
Lecturer(s)		Dr. P.W.H. Pinkse
Objective		To make students familiar with the concepts and some important historical results from quantum optics and quantum informationtechnology.
Description		In this course we study the quantum properties of light, taking ground-breaking experiments as our guide. The following subjects are treated: What is a photon? Operator quantum mechanics. Interaction between light and atoms. Coherence and the Hanbury Brown- Twiss experiment. Entangled states and the Einstein-Podolsky-Rosen experiment. Quantum information technology: Quantum cryptography and quantum computers. For further information please contact the teacher.
Prior knowledge		Introduction Quantum Mechanics (required, 191411281) Applied quantum mechanics (desired, 191411291)
Course material		"Quantum Optics - an introduction" by Mark Fox, Oxford University Press, ISBN 978-0-19-856673-1 **(required)** Handouts, Assignments
Assessment		Exam

193640020		**Biophysical Techniques and Molecular Imaging**
5.0 ec	**1A**	
Lecturer(s)		Dr. C. Otto, dr. C. Blum
Objective		Biophysical Techniques & Molecular Imaging (BT&MI) introduces a selection of advanced micro-spectroscopic techniques for molecular and cellular studies. The course treats imaging techniques based on fluorescence spectroscopy and vibrational spectroscopy. The general concepts of contrast, resolution, localization, sensitivity and signal-to-noise ratio will be presented and related to microscopic properties of molecules. Electro-magnetic properties of the light field, basic to contrast, will be put in the context of microscopic methods. Light distributions in the focus of microscope objectives will be presented to understand the basics of resolution. Micro-spectroscopic techniques are essential to modern biomedical sciences, such as in-vivo imaging, quantitative biology, stem cell research and studies of fundemental cellular proocesses, for example cell-division, apoptosis, phagocytosis, cell differation, carcinogenesis. Concepts will be illustrated with examples from the life and (bio)-material sciences.
Description		Luminscence: Fluorescence, phosphorescence, bioluminescence; advanced luminescence principles: polarization, lifetime; bulk and single molecule approaches; imaging and spectroscopy in a microscope; intrinsic and extrinsic fluorophores; protein fluorescence; genetically encodable fluorescent markers, nanoparticles

	Microscopy: wide-field, dark field, confocal, phase contrast, fluorescence microscopy (FRAP, FLIP, FLIM, FRET), micro-spectroscopy, hyperspectral imaging, polarization contrast, lifetime imaging, resonance energy transfer imaging, nano-particle imaging, non-linear microscopy. Vibrational Spectroscopy and Imaging: label-free contrast methods such as spontaneous Raman micro-spectroscopy, Infrared microscopy, CARS microscopy, non-linear fluorescence microscopy and single molecule micro-spectroscopy.
Course material	Lecture notes, relevant articles from the scientific literature, all available on the course website. A list of textbooks for reference will be provided. Sample problem sets will be provided.
Assessment	Exam, Study and presentation on a selected topic in advanced biophysics imaging will contribute for 20% to the final grade.

201400427		**Transducer Science**
5.0 ec	**1A**	
Lecturer(s)		Prof.dr.ir. G.J.M. Krijnen
Objective		The Transducer Science course focuses on energy buffering type transducers that can be used for sensing and actuation (examples: microphones and loudspeakers). The learning aims are that the student at the end of the course should: 1. understand the energy based description of transduction processes. Key-words are: two- and multiport systems, intensive and extensive quantities, energy buffering, coupling factor, stability, parametric effects, efficiency, resonance, 2. be able to apply this knowledge to transducers in arbitrary domains, e.g. to electrostatic, electromagnetic, electrodynamic and piezoelectric transducers, 3. understand performance metrics of transducers 4. understand how parametric effects can largely determine the use and performance of transducers, e.g. through electromechanical signal-processing 5. understand source and influence of noise 6. be aware of nonlinear effects and potential gains that can be obtained by utilising these effects, e.g. Stochastic Resonance.
Description		In modern electronic information systems transducers play an increasingly important role; where powerful computing, large data storage and high bandwidth digital communication can be harnessed in ever shrinking form-factors, transducers are indispensable in the interaction with the environment. On a personal level there seems to be an insatiable desire to know as much as possible from how much and how we move, our physical condition (blood pressure, heart rate), where we are (GPS), etc. But even more so in technical contexts transduction is at the heart of measurement & data gathering as well as locomotion, e.g. in robotics, process control, medical settings, automotive. In short: transducers (sensors and actuators) are an integral part of our modern information-system. Examples of transducers are loudspeakers, recording-heads for magnetic data-storage, microphones, pressure sensors, electric engines, etcetera. Central to the description of transducers are the concepts energy, ports, extensive and intensive quantities, Legendre transformation and co-energy, electrostatic-, magnetic-, piezo-electric and mechanical energy-density. Important characteristics of transducers such as energy-conversion efficiency, static and dynamic behaviour as well as stability in loaded and unloaded operation are discussed. The course examines the so-called ‘energy-buffering transducer’ in detail and explores how these type of transducers can beneficially be used to implement parametric effects, such as amplification, mechanical-amplitude modulation, etc. Noise is treated both with respect to its detrimental effects on sensors as well as how it can be effectively used to improve the

	signal to noise ratio in so-called 'Stochastic Resonance' schemes. A few short excursions to the field of bio-mimetics will be made, especially in the context of performance metrics and optimisation. In this course, some classical mechanics, network analysis and electro-magnetic field theory is used and basic knowledge from other physical domains is refreshed or, if necessary, offered to the students. The course forms valuable prior knowledge for the courses EMStatics (191211690) and MEMS Design (191211300).The content of the course consists of a number of fixed subjects with ample room for deeper digging / specialisation in the concluding phase of the course: • Transducers classification (dissipative, buffering, modulating, etc.) • Energy-buffering transduction in two- and multi-port transducers • Energy-minimisation in transducers operation (calculus of variations) • Parametric effects (amplification, amplitude modulation, etc) in energy buffering transducers and its description in terms of spectral component (Harmonic Balancing Method) • Noise and its impact on performance (sensitivity versus responsivity, impact of measurement time and bandwidth)• Sensor performance metrics and optimisation (with little excursion to biomimetics) • Nonlinear systems and effects of noise in nonlinear systems (stochastic resonance). • The load of the course will be compatible with other MSc courses, i.e. 5 European Credit (EC), or equivalently 140 hours. Educational form(s): depending on group size educational forms may be adapted. The preferred educational format is the so-called Problem Based Learning; in a series of problem assignments students cooperate in groups to come up with solutions and to share their insights with each other and other groups. The problems are formulated loosely ('ill-posed') to offer room for exploration and a certain degree of uncertainty with respect to the correct and complete answers is maintained to stimulate student lead learning. These sessions take up about 80 hours of the student's time. The remaining 60 hours are dedicated to in-depth literature research and writing of a (research) paper.
Prior knowledge	Basic understanding of classical mechanics
Course Material	Reader Transducers Science (pdf) Various papers (will be distributed during the course)
Assessment	Paper

191211590		**Systems-on-chip for embedded systems**
5.0 ec	**1A**	
Lecturer(s)		Dr. ir. H.G. Kerkhoff, dr. ir. S.H. Gerez, dr. ir. R.A.R. van der Zee
Objective		Learn to design and test a System-on-Chip at different levels of hierarchy
Description		The SoC design course focuses on design skills necessary for the realization of a System-on-Chip that consists of software, analog and digital hardware. Participating chairs are CAES and ICD. The course consists of three modules that deal with different aspects of SoC design. These modules consists of lectures, hands-on training and practical exercises: HDL-Based SoC Design This module covers: VHDL for simulation and synthesis, distinction between combinational and sequential logic, partitioning of hardware in data path and control, (manual) architectural synthesis, systems with a processor and hardware-software co-design. The main tools are Modelsim for VHDL simulation and Synopsis Design Compiler for VHDL synthesis. Physical SoC & IP Design/Testing Topics covered by this module include: power and clock distribution, digital circuit design at the transistor level (Tanner tools). Silicon compilation (Synopsis tools) and layout generation (Cadence) of IPs. Automatic test pattern generation, scan chains insertion (Synopsis), JTAG and IEEE1500 standard. Mixed-Signal SoC

	Design This module deals with: mixed-signal design basics, noise and mismatch modeling packaging and parasitics, analog building blocks and power efficiency. The main tool used is LT-Spice.
Course Material	PowerPoint Slides, user manuals, assignment sheets via Blackboard.
Assessment	Assignment

193550020		**Surface and thin layers**
5.0 ec	**1B**	
Lecturer(s)		Dr. ir. H. Wormeester, dr. ir. J.M. Sturm, prof. dr. ir. H.J.W. Zandvliet
Objective		The objective of the course is to get the student acquainted with a few basic principles, processes and features in the field of surface and thin films. With this content the student should be able to read a typical article published in this field and be able to extract the important issues. The context of these issues in relation to the basic principles and processes can be given.
Description		The structure and (electronic) properties of both clean and adsorbate covered surfaces are described. The most common tools to study these phenomena, diffraction and scanning probe techniques are introduced in relation to the measured results. The adsorption and desorption of species from surfaces are described. Growth of thin films is an important part of this field and the thermodynamic and kinetic aspects of growth are discussed. The electronic structure of surfaces and thin films in relation to their properties is described. This course is part of the track Materials Science and is compulsary for students of this track.
Course Material		Handouts Physics of Surfaces and Interfaces H. Ibach. www.springer.com (book is electronically available at the library **(recommended)**
Assessment		Exam

201100074		**Nanophotonics**
5.0 ec	**1B**	
Lecturer(s)		Prof. dr. W.L. Vos, prof.dr. A. Lagendijk, prof.dr. P.W.H. Pinkse
Objective		In this course students learn the basic skills of the emerging field of nanophotonics and metamaterials. Nanophotonics deals with the behavior of light in materials that have structure on the scale of the wavelength or below. To describe light in such materials, we make use of the wave equation, and throughly study dispersion and light-matter interaction. As special classes of materials we study metamaterials and photonic crystals. These materials consist of nanostructured unit cells that are designed to allow for special types of light-matter interactions previously thought to be impossible. This course is strongly skills-oriented. Theoretical concepts will be supplemented with a few lab practica. Grading will be based on homework assignments (cooperation allowed) and reports of the experiments.
Description		The following topics are treated: Light scattering: Rayleigh, and Mie theory, point scattering formalism. Effective medium theory and Kramers-Kronig relations, light diffusion, coherent backscattering, Anderson localizations. Photonic crystals: optical Bragg diffraction, Bloch waves bandstructure local density of radiative states, photonic crystal cavities, imperfections in photonic crystals.

Learning objectives After following the course, the student	**Way of assessment**	**Level**	**Weighing**

	<table><tr><td>Can apply concepts of diffraction, dispersion, wave scattering in calculations</td><td>Homework assignments</td><td>Comprehend, describe, apply.</td><td>30%</td></tr><tr><td>Can understand the origin of Kramers-Kronig relations and multipole scattering expansions.</td><td>Homework assignments</td><td>Understand, explain, illustrate</td><td>10%</td></tr><tr><td>Can perform a simple light scattering experiment and analyze and report the results taking into account the acquired skills</td><td>Report</td><td>Understand, explain, apply, calculate, draw conclusions, propose, synthesize</td><td>40%</td></tr><tr><td>Can understand basic concepts of photonic crystals and scattering media such as photonic bandgaps and the relation to the Bloch theorem, scattering and transport mean free paths</td><td>Homework assignments</td><td>Understand, explain, apply, calculate, draw conclusions</td><td>20%</td></tr></table>There are 6 take-home assignments and 2 reports to be written. Cooperation between students is allowed, but all assignments must be turned in individually. Reports may be turned in per group. In some cases (e.g. if international experts are visiting or related scientific meetings are taking place) poster presentation or writing a summary of a colloquium talk may be substituted for one or more of the conventional assignments. Weighting: Reports are weighted by a factor 2; Homework assignments by a factor 1.
Prior knowledge	Please subscribe to the chair by a short motivation letter. Chair will provide the necessary preknowledge in a brochure.
Course Material	G. R. Fowles, "Introduction to Modern Optics (Dover, Toronto, 1989) **(recommended)** Exercises and articles are available at college.
Assesement	Examn, Review of homework assignments, any additional test.

193700030		**AMM – Organic Materials Science**
5 ec	**1B**	
Lecturer(s)		Prof. dr. G.J. Vancso
Description		Organic materials feature enormous variations in their physical properties as a result of the tremendous wealth of the different possible existing molecular structures of carbon based compounds. The consequence of this plethora of properties is that function and use of organic materials can be tailored by controlling molecular structure virtually at will by using modern synthetic approaches, allowing one to realize many advanced applications, which belonged to the realm of phantasy just a few decades ago. In this lecture molecular structure-property relations will be discussed for the different types of (advanced) synthetic and natural (macromolecular)organic materials, including man-made polymers, liquid crystals, carbon allotropes (nanotubes, fullerenes and graphenes), dendrimers, nucleic acids, proteins and polysaccharides. Materials selection diagrams will be used to compare organic, inorganic, metallic and other materials, focusing on mechanical properties. Similarities and differences on the basis of

	molecular/atomic structures among the different classes of materials will be elucidated. Approaches will be treated which allow materials engineers to quantitatively estimate physical properties based on the molecular structure (by the so-called group contribution techniques). Effects of processing on structure (texture) and hence on properties will be demonstrated. A description and comparison of the major classes of the most frequently used industrial polymers for different function will complement this course. This is an advanced level graduate course, thus basic knowledge of organic chemistry, materials science and polymer science taught in the bachelor curriculum is a prerequisite and will be assumed. - Introduction (course overview, keywords of knowledge required, exam expectations, recommended literature) (lecture notes) - Overview of structures of the major classes of organic materials (polymers, liquidcrystals, carbon allotropes (nanotubes, fullerenes and graphenes), dendrimers, nucleicacids, proteins and polysaccharides (lecture notes) - Materials selection diagrams, organic, metallic and ceramic materials contrasts and similarities (M.F. Ashby, Materials Selection in Mechanical Design) - Carbon allotropes as molecular building blocks (fullerenes, carbon nanotubes and graphenes) - Dendrimers and hyperbranched structures - Elastomers, rubber and hydrogels - Liquid crystals as functional materials - Relationships between polymer structure and properties Part I: main chain effects (H.R. Allcock et al., Contemporary Polymer Chemistry, 3rd Ed. Chapter 22) - Relationships between polymer structure and properties Part II: side chain effects(H.R. Allcock et al., Contemporary Polymer Chemistry, 3rd Ed. Chapter 22) - Group contribution techniques for estimating properties based on molecular structure (D.W. van Krevelen, Properties of Polymers); Calculation examples-Industrial polymers (H. Ulrich, Introduction to Industrial Polymers) - Influence of processing, texture and anisotropy Part I. (I.M. Ward, Editor, Structure and Properties of Oriented Polymers) - Influence of processing, texture and anisotropy Part II. (I.M. Ward, Editor, Structure and Properties of Oriented Polymers)- Electroactive organic materials- Photonic organic materials (solar cells, light emitting organics, photochromism, photonicband gap materials) - Natural organic engineering materials.
Prior knowledge	Chemie & Technologie van Organische Materialen (CTOM, 19135539)
Course material	“Soft condensed matter”, Richard A.L. Jones, ISBN 978-0-19-850590-7 **(required)**
Assessment	Exam

191211690		**EMstatics**
5.0 ec	**1B**	
Lecturer(s)		Dr. ir. H.G. Kerkhoff, dr. ir. S.H. Gerez, dr. ir. R.A.R. van der Zee
Objective		Being able to analyse and design electro- and magneto-static systems
Description		ThiThis course focusses on computation of quasi-static electrical and magnetic fields of technical constructions. Examples are capacitors, write/read transducers for magnetic recording, periodic systems like patterned recording media, EM-fields shields, particular transducers, MEMS & NEMS devices, transistors, etc. Analytical computational methods and FEM (Finite Element Method) will both take 50% of the time. Students will become familiar with the possibilities and (dis)advantages of both methods of approach. They will learn interpreting the FEM results and will apply the analytical methods for validating the FEM results. Some attention will be paid to the analogy of mathematical approach for different application fields such like electrical, magnetic, mechanical, diffusion and heat conduction.

	EMstatics is positioned between the more or less superficial approach (like for instance in freeFEM++ or Comsol), and the extensive and mathematically profound treatments in the established courses for mathematics and mechanical-engineering students. Attention will be paid to: 1. The fundamental mathematics of static EM-field problems. 2. The choice for an analytic method or a numerical (finite element) approach. 3. Analytical and numerical computation of one- two-, and three-dimensional electromagnetic fields. Finding the most useful method of approach. 4. Validation and interpretation of the computational results. 5. Recognising analogies for computation of fields in the electromagnetic domain on the one hand, and in analogical physical domains (mechanical, heat flow, fluid mechanics) on the other. The course will be setup with 7 assignments, which will lead to problem-based learning. These cases will be discussed with the instructors on an individual basis, or in small groups. The assessment will be based on the work on a final case. Student will apply the commercial software package “Comsol multiphysics”, using a licence which is valid during the course. Contents EMstatics focuses on computations for quasi-static electromagnetic problems. Two approaches: 1. Analytic methods, including the application of integration methods and Fourier transforms. 2. Numerical methods, including Finite element methods (FEM).
Course Material	J. van Kan et. al. "Numerical methods in scientific computing", ISBN 90-71301-50-8 **(recommended)** D.K. Cheng "Field and wave electromagnetics" ISBN 0-201-52820-7, or Feynman lectures on physics (online), or Griffiths “Introduction to electrodynamics”, 4E edition, ISBN: 978-9332550445 (or earlier) **(recommended)** W.B.J. Zimmerman et. al. "Multiphysics modelling with finite element methods", ISBN 978-981-256-843-4 **(recommended)** S. Humphries "Field solutions on computers", ISBN 0-8493-1668-5 **(recommended)**
Prior knowledge	Necessary knowledge, for instance from former courses EE: Theory of Electromagnetic Fields (Elektromagnetische veldtheorie) 191211290, or Fields & Waves (AT or EE) or APH: Electromagnetics (Elektriciteit en Magnetisme) 191403051.
Assessment	Individual assignment (70 hours). Assignment project can be related to the master thesis project.

193530010		**Nanophysics**
5.0 ec	**2A**	
Lecturer(s)		prof.dr.ir. H.J.W. Zandvliet, A.A. Golubov, dr. G.H.L.A. Brocks
Description		In this course we focus on low-dimensional systems with typical length scales in the range of 1-100 nm. At this small length scale quantum mechanical phenomena play a dominant role in the physics of devices. Prominent topics are quantum electronic transport, both coherent and incoherent, Coulomb blockade, and the quantum Hall effect. The physical description of these phenomena is illustrated by examples from current research in nanophysics.
Prior knowledge		Necessary: Bachelor physics; Desirable: Applied Quantum Mechanics, course code 191411291; Theory of solid state physics, course code 193510040.
Course material		"Electronic Transport in Mesoscopic Systems", S. Datta, ISBN 0521599431 **(recommended)**
Assessment		Exam

191210720		Biomedical Signal Acquisition
5.0 ec	2A	
Lecturer(s)		Dr. ir. Olthuis
Objective		To learn and understand about the way relevant biomedical signals from the human body can be measured using chemical and physical sensor systems
Description		The electrochemical detection methods form a beautiful comprehensive part of this course: starting from electrochemical processes at an electrode and the subsequent mass transport phenomena result in the three basic operational principles (potentiometry, amperometry and conductometry). When the relation between the variable to be determined (ionic species and/or its concentration) and the measured quantity (voltage, current or conductance) is known, the relevant examples follow: the oxygen electrode (Clark electrode), the carbon dioxide sensor (Severinghaus princinciple) and the pH sensors (glass electrode and ISFET). Additionally, other chemical biosensors like the glucose sensor, and biosensors based on optical detection principles are treated. The treatment of physical sensor systems is guided by the biomedical application: blood pressure and flow, lung volume and capacity. A bridge to the course Lab-on-a-Chip is formed by some examples of micro Total Analysis Systems, of which the detector is based on one of the mentioned sensor principles. This course is open for TM, MBE, AP, NT and EE students. General knowledge from your bachelor programs is required. For TM students, this course bridges the gap between biophysiology and biomedical signal processing and -analysis. This course consists of 12 lectures, where you actively participate in discussions to reach the learning objectives. Additionally, some demos will be given in the lecture room. You will write your critical review paper in teams of two students to train and improve your knowledge and understanding via the original papers you have to review. Moreover, a 4-hr practical project concerning synchronous sensor data retrieval into a computer is one of the instructional modes of this course.
Course material		John G. Webster, Medical Instrumentation, Application and Design, Wiley, ISBN: 0-471-15368-0 3rd or 4th edition). This book is the preferred choice. **(recommended)** or: John Enderle et al., Introduction to Biomedical Engineering, Elsevier, 2005, ISBN: 0-12-238662-0 (only if already in your posession): lecture notes (copy of all sheets, etc) in one 'blokboek' (available as pdf-file) **(recommended)**
Assessment		Assessment by a written exam counting for 65 % of the final mark, and writing of a critical review paper (remaining 30%). Both parts must be sufficient (>= 5,5). Remaining 5% for the practical project. Only the failed part has to be redone. As the written exam is an open-book exam, conceptual knowledge and understanding is tested. Notwithstanding, problem solving is part of the questions. Obtainable points per part of every question are indicated on the written exam itself. The written exam consists of several open questions with sub-questions. The review paper is requested to be critical, i.e., it should contain original conclusions based on the reviewed papers, and thus being more than a mere summary of the reviewed papers.

191211300		Micro Electro Mechanical Systems Design
5.0 ec	2A	
Lecturer(s)		Dr. N.R. Tas, dr.ir. R.J. Wiegerink
Objective		Aim is to learn how to design micromechanical or devices and systems (sensors, actuators and fluidic devices or systems) based on a fixed fabrication process. The student will learn to make a conceptual design, a physical design based on relevant device physics, a mask design based on the fixed fabrication process and a design verification by device characterization.

Description	Micro electro mechanical systems design addresses the design of silicon based micromechanical and micro/nanofluidic devices and systems with an emphasis on their functionality. In the lectures different design principles are derived from the theory of elastic mechanics, transducer science and fluid mechanics and practised in exercise sessions. A major part of the course is the design lab in which the students design and test a device of their own choice which is realized in a foundry process offered by the MCS/TST group. The design of silicon based micromechanical (including fluidic) devices and systems based on physical modeling. Topics: Elastic mechanics of beams and membranes; actuator theory including electrostatic actuation, design of electrostatic motors; sensor transduction and read-out electronics, design of acceleration -, angular velocity -, force -, and pressure sensors; introduction in fluid mechanics for low Reynolds numbers, surface tension and capillarity, electrical double layer and elektro-osmosis; adhesion, stiction and friction in micro and nano-systems.
Course material	S.D. Senturia, Microsystem design, Kluwer 2004, ISBN 0-7923-7246-8 **(recommended)** M. Elwenspoek, R. Wiegerink, Mechanical Microsensors, Springer 2001, ISBN 3-540-67582-5 **(recommended)** J.A. Pelesko, D.H. Bernstein, Modeling MEMS and NEMS, Chapman & Hall / CRC 2003, ISBN 1-58488-306-5 **(recommended)**
Assessment	Written exam (1/3), assignment (2/3)

191131360		**Design Principles for Precision Mechanisms**
5.0 ec	**2A+2B**	
Lecturer(s)		Prof. dr. ir. D.M. Brouwer, prof. dr. J.L. Herder
Objective		After the course the student comprehends the principles of conceptual design of precision mechanisms and is able to recognize problem areas, to generate design alternatives and to make adequate choices. After the course the student is able to... 1. Analyse, design and evaluate precision mechanisms with respect to stiffness: 2. Analyse, design and evaluate precision mechanisms with respect to degrees of freedom and constraints 3. Design, analyse and evaluate precision mechanisms based on flexure elements 4. Design and analyse precision mechanisms which inherently have hysteresis and microslip 5. Design and analyse precision mechanisms with bearings, rollers and webs 6. Design and analyse precision mechanisms with respect to dynamics and energy managem
Description		This course gives insight in the conceptual design of precision mechanisms used in products, tools and equipment. Characteristic to all precision systems is the high level of determinacy required. Predictable and reproducible behavior are key-qualities that can only be achieved when mechanics and control systems (if present) are carefully designed and robust to disturbances. Their mechanical design is the subject of this course. The insight in precision mechanisms enables the student to recognize problem areas, generate design alternatives and make the appropriate choices. Considerable attention will be paid to details, because these can be crucial and decisive for the quality of the design. Important principles for precision mechanism design which will be focused on during the course are: Designing for light and stiff mechanisms, exact kinematic constraint design, design of low-hysteresis mechanisms and designing precision manipulators.

Course material	Soemers HMJR, Design Principles for Precision Mechanism, 978-90-365-3103-0 online verkrijgbaar via http://www.t-pointprint.nl/?page id=21 **(required)**
Assessment	Written exam, group assignment (the written exam and the group assignment both count for 50% of the final grade.)

xxxxxxxxx		**Capita Selecta**
5.0 ec	**-**	
Description		All research groups offer 5 EC Capita Selecta (C.S.) modules that you can take as an elective in your MSc programme. For detailed information on these, please contact the group leader for more information on the format and content.

193770090		**Chemistry of Inorganic Materials and Nanostructures**
5 ec	**-**	
Lecturer(s)		Prof.dr.ir. J.E. ten Elshof
Objective		Chemistry of advanced functional inorganic materials.
Description		The design and synthesis of advanced functional materials by chemical processing methods requires a thorough understanding of the basic reaction mechanisms and physical phenomena that play a role in the sequence of steps that lead from starting molecular precursors via nanoparticles to the final functional solid. This course provides an introduction into the chemistry of inorganic materials, the most common chemical synthesis methods, and their deposition into low-dimensional nanostructures, thin films and micropatterns. Topics that are discussed in the course include inorganic molecules; structural solid state chemistry; physical chemistry of inorganic surfaces; nucleation and growth of nanoparticles; morphogenesis of particles with fractal-like structure; synthesis of inorganic materials; soft chemistry; thin films; low-dimensional nanostructures; soft lithography; sintering. The course is given once or twice per year in Q1 and/or Q4, depending on the number of registered students in a certain quartile. **Students that want to follow this course are advised to contact the lecturer directly via email.**
Prior knowledge		Required: Inorganic Chemistry (191330012) Desired: Colloids and Interfaces (193735060)
Course material		"The Inorganic Chemistry of Materials", P.J. van der Put, Plenum Press, New York, 1998 **(recommended)** "Nanostructures & Nanomaterials", G. Cao, Imperial College Press, London, 2004 **(recommended)** "Basic Solid State Chemistry", A.R. West, 2nd edition, Wiley, Chichester, 1999 **(recommended)** "Sol-Gel", J.D. Wright, N.A.J.M. Sommerdijk, CRC Press, Boca Raton, 2000 **(recommended)**
Assessment		Oral examination plus report

201500167		**Modern topics in condensed matter**
5 ec	**-**	
Lecturer(s)		Dr. A. van Houselt, dr. E.S. Kooij, dr.ir. H. Wormeester, prof. Dr. Ir. H.J.W. Zandvliet
Objective		Modern topics in condensed matter physics will be introduced and studied form recent literature. After an introductory lecture on the topic, students should deliver an oral report on recent literature articles. The topics are: 1) Dynamics of molecules and atoms at surfaces

	2) Tunable interactions of colloidal assembly 3) Wetting of functionalized surfaces 4) 1-D physics at interfaces 5) Fundamental catalysis
Course material	Handouts
Assessment	Test

191211000		**Macromolecular Nanotechnology**
5.0 ec	**-**	
Lecturer(s)		Prof. dr. G.J. Vansco
Description		This course covers the following subjects: - Controlled Polymerizations-Organometallic Polymers, Synthesis and Use in Functional Surfaces. - Single-Chain Chemistry and Physics of Smart, Responsive Polymers. - Confinement Effects and polymers. - Materials Chemistry and Nanofabrication with Block Copolymers. - Micro- and Nanoscale Defined Surface - Functionalization and Structuring for Controlled (Bio)Chemistry, Patterning and Biointerfacing. - Depending on the background and need of interested students, individual assignments (theoretical, as well as practical) are considered. The course is offered in form of self-study, encompassing topics chosen together with the student. Support is offered in personal consulting sessions with the student. A written assignment and an oral exam complete the course.
Assessment		Test

191211000		**Advanced Semiconductor Devices**
5.0 ec	**-**	
Lecturer(s)		dr.ir. C. Salm
Objective		Hands on experience with "advanced semiconductor devices"
Description		This course in "Advanced Semiconductor Devices" can be finished by an assignment or literature study on one of the topics concerning an "advanced device", for example deep-submicron device, silicon-on-insulator devices, RF applications or molecular electronics. The assignment can be done all year around. Practical study into one or more topics in advanced semiconductor devices. Precise topics determined later. Examples are device characterisation, device or circuit simulations or literature study.
Prior knowledge		Halfgeleider Devices (191217060) or Introduction to Semiconductor Devices (191217061) or module Device Physics (201400430) or solid state physics or equivalent for students APh, NT, international exchange students.
Course material		Will be provided by the lecturer.
Assessment		Assignment