



Courses available at TUE (<i>Partner n°10</i>)

This is a small selection of relevant Master courses (in English) at the Eindhoven University of Technology (within the master tracks "thermo fluids engineering" and "Micro- and Nanotechnology Engineering")

An overview of all Bachelor (in Dutch) and Master (in English) courses can be found at <http://owinfo.tue.nl/>

Semester 1 (in year 2008-2009)

3T120	<p>Gas dynamics</p> <p>In this course some important fundamental aspects of fluid mechanics will be discussed which one often encounters both in theoretical problems and in industrial applications. The first part of the course concentrates on the subject of 'vortex dynamics'. Topics like vortex theorems, vorticity production and diffusion, coherent vortices in 2D flows and 3D vortex structures will be discussed. The second part of the course concentrates on the application of 'complex function theory' in fluid dynamics (complex flow potential, Milne-Thomson circle theorem, forces on bodies in potential flows, and conformal mapping).</p>
4P540	<p>Multi-phase flow with heat transfer</p> <p>The topics of this course listed in their order of appearance:</p> <ol style="list-style-type: none"> 1. Prediction of pressure drop and heat transfer and their applications. Relative velocities, slip between the phases, triangular relationship. Practical applications illustrate the importance of these relatively simple considerations. 2. Adiabatic distribution phenomena. Migration of bubbles and particles in tubes, prediction methods and governing equations. Emphasis is on explaining the why and how, but the importance for heat exchangers in common practise is discussed. This is the flow part of phase-transitional flows. 3. Diabatic distribution phenomena. The phase-change part of phase-transitional flows. Boiling has a bigger chance of occurring in corners than at a flat plate, and a bigger chance to occur on a flat plate than in the bulk liquid. Emphasis is on the approach that is classical thermodynamics. This approach is considered to be of prime importance for engineers that deal with heat and flow. Applications are the improvement of design of beer cans, and condensation on dirty surfaces.

	<p>4. Condensation of multicomponent mixtures. Evaporation of a drop. The interaction of flow and mass transfer is highlighted. Practical expressions such as the Ackermann correction factor and the Mollier diagram are introduced. Applications are in combustion engines, climate control and environmental engineering.</p> <p>The mathematics applied are kept simple: some algebra for 1), some potential flow and fluid mechanics in 2), some homogeneous differential equations for 4).</p>
4P560	<p>Modelling of physical phenomena</p> <p>Modelling is an important topic in mechanical engineering and consists of the steps that are necessary to translate a physical problem into a mathematical model. For many problems in fluid dynamics and mechanics the mathematical model is a partial differential equation, which can only be solved if correct initial and/or boundary conditions are specified. In this lecture series a number of problems, mainly from fluid dynamics, will be studied with the emphasis on modelling. Moreover, attention will be paid to the properties of the solutions of different types of partial differential equations and the consequences for the choice of correct boundary conditions and solution methods. Solutions methods can be divided into analytical and numerical methods. Examples of both kinds of methods will be shown. Examples of problems that will be studied are:</p> <ul style="list-style-type: none"> ➤ Waves in shallow water, e.g. in a swimming pool with variable depth; ➤ Heat flow in a bar; ➤ Air flow around the wing of an airplane.
4P580	<p>Physics and measurement methods</p> <p>In this course a number of measurement methods is treated that are relevant for experiments in gaseous, liquid and flows (combustion). The physical background, practical implementation, and limitations are analyzed in depth. The knowledge prerequisites are covered partly by the course Transport Phenomena (3B470), with the missing parts (optics, lasers, and molecular physics) being treated during the course. The course is given as a series of lectures, with in-class training.</p> <p>A listing of the measurements methods:</p> <ul style="list-style-type: none"> • Flow visualisation. • Flow rate: orifices, rotameter, indicator, electromagnetic and ultrasound methods. • Velocity: Pitot-tube, hot wire and hot film anemometer, laser Doppler velocimetry, particle image velocimetry. • Temperatures and heat fluxes: thermocouples, liquid crystals, pyrometers, laser induced fluorescence. • (Molecular) densities: shadowgraphy, Schlieren imaging, interferometry, laser induced fluorescence. • Particle tracking velocimetry
4A780	<p>Fracture mechanics</p> <p>In continuum mechanics the material is supposed to be a continuum where</p>

properties change continuously from one point to the other. However, a real material contains discontinuities like interfaces between different components, inclusions and defects. Resulting stress concentrations can provoke initiation and growth of cracks.

In fracture mechanics attention is focussed onto one crack. Theoretical concepts and experimental techniques have been and are being developed, which allow answers to questions like:

- Will a crack grow under the given load?
- When a crack grows, what is its speed and direction?
- Will crack growth stop?
- What is the residual strength of a construction (part) as a function of the (initial) crack length and the load?

What is the proper inspection frequency ?

- When must the part be repaired or replaced?

To answer these questions, the geometry of and the load on the crack must be known. In practice this must be determined experimentally. Some experimental techniques are discussed in the course.

First, concepts and theories are discussed in which linear elastic material behaviour is an essential assumption. This is the case for Linear Elastic Fracture Mechanics (LEFM). Prediction of crack growth is based on an energy balance. The Griffith criterion states that "crack growth will occur when there is enough energy available to generate new crack surface." The energy release rate (G) is an essential quantity in energy balance criteria.

The crack growth criterion can also be based on the stress state at the crack tip. This stress field can be determined analytically. It is characterised by the stress intensity factor (K).

It is important to predict whether a crack will grow or not. It is also essential to predict the speed and direction of its growth. Theories and methods for this purpose are discussed.

Assumption of linear elastic material behaviour leads to infinite stresses at the crack tip. In reality this is obviously not possible: plastic deformation will occur at the crack tip. Using yield criteria (Von Mises, Tresca), the crack tip plastic zone can be determined. When this zone is small enough (Small Scale Yielding (SSY)), LEFM concepts can be used.

When the plastic crack tip zone is too large, the stress and strain fields from LEFM are not valid any more. This is also the case when the material behaviour is nonlinear elastic (eg. in polymers and composites). Crack growth criteria can no longer be formulated with the stress intensity factor.

In the Elastic-Plastic Fracture Mechanics (EPFM) or Non-Linear Fracture Mechanics (NLFM) criteria are derived, based on the Crack Tip Opening Displacement (CTOD). Calculation of CTOD is possible using models of Irwin or Dugdale-Barenblatt for the crack tip zone.

Another crack growth parameter much used in NLFM is the J-integral (J), which characterises the stress/deformation state in the crack tip zone.

Analytical calculation of relevant quantities (G , K , CTOD, J) is only possible for some very simple cases. For more practical cases numerical techniques are needed. Numerical calculations are mostly done using the finite element method. Special quarter-point crack tip elements must be used to get accurate results.

In the course the above concepts are discussed. Attention is also given to the experimental determination of critical values of the calculated quantities (G_c , K_c , CTOD_c, J_c).

3S370	<p>Introduction nanotechnology</p> <p>The course is intended to give a general introduction into state-of-the-art nanotechnology for students with either a physics or a chemistry background at the Bachelor level. Students will be taught the basics of electronic properties in (nanostructured) solid state systems and get an introduction into the principles of organic macromolecular chemistry. The lectures will give a first glimpse onto advanced techniques for the creation and manipulation of nanostructures such as lithographic methods, scanning probe techniques, and molecular bottom-up approaches and the peculiar physics that can occur in nanostructured materials.</p>
5MX10	<p>Modern physics and optics</p> <ul style="list-style-type: none"> • Introduction to quantum mechanics and solid state physics. • Introduction to basic concepts in modern physics that are relevant for the realisation and operation of electronic and opto-electronic devices. • The connection between optics, quantum mechanics and solid state physics. • The emphasis in the course is on the understanding of the concepts used in these areas. These concepts will be used in courses later in the masters program
4K700	<p>Thin film mechanics</p> <p>Thin Films are an essential part of today's advanced technological products, like Integrated Circuit (IC) chips, Micro Electro Mechanical Systems (MEMS), Hard Disk Drives (HDD), flat and/or flexible displays, optical storage systems, etc. The thickness of the films ranges from nanometers to micrometers, and they can be made from all sorts of materials: silicon, oxides, nitrides, metals, and polymers, to list some examples.</p> <p>The mechanical properties of the films determine to a large extent the reliability and the lifetime of a product. Excessive deformation, fracture, or plastic deformation of the films should be avoided to guarantee a proper functioning of the complete device. For applications like flexible displays or MEMS, the mechanical properties of the films even determine the product characteristics directly. For these reasons, knowledge about the mechanical behavior of thin films is essential for today's and future advanced applications.</p> <p>Thin film mechanics is different from the mechanics of bulk materials for a number of reasons. In the first place, the particular microstructure of the material will play an increasingly important role, whereas, in bulk material, the effect of the particular microstructure is simply averaged out. Second, the specific state of the boundaries has a direct influence. For example, the response is determined by whether the film is free-standing or sandwiched between two other films, and by the interactions at the interfaces with other materials. For these reasons, a thin film of material may show completely different behavior than its bulk counterpart. A third, more practical point is that conventional experimental techniques to characterize the mechanical properties of bulk materials cannot be used anymore and special, new test</p>

	<p>methods have to be used.</p> <p>In this course we will:</p> <ul style="list-style-type: none"> • Discuss the advanced applications in which thin films, and in particular their mechanical behavior, play a crucial role. • Get to know the various thin film technologies that can be used to make thin film devices. • Learn about the specific mechanical properties of thin films, and in particular about small-scale effects and the influence of boundary conditions, for a broad spectrum of material systems. • Discuss the possibilities and challenges of modelling these effects. • Learn about a number of special experimental methods for the determination of thin film mechanical properties. • Discuss the consequences and opportunities for applications, focussing on microsystems (MEMS) and microelectronics applications.
4J560	<p>A numerical-experimental approach in dynamics</p> <p>In the W-2.1 course Mechanical vibrations (4A460) concepts have been introduced for generation and evaluation of numerical models for accurate description of the dynamic behaviour of mechanical structures; in addition the global plan has been presented for the development of experimental methods for the analysis of this dynamic behaviour.</p> <p>The course 'A Numerical-Experimental Approach in Structural Dynamics' builds further on this course. The accent lies partly on the extension of the aforementioned disciplines but in particular on the integration of a numerical approach on one side and an experimental approach on the other side to tackle complicated dynamic problems. It will be pointed out that in many cases only a combined numerical-experimental approach will offer a solution. For a detailed description of the topics that will be treated in this course is referred to the course specific learning objectives (see below).</p> <p>In this course also issues are illustrated, which are met when the methods presented are implemented in engineering practice. This is done via examples worked out with the software package MATLAB. In this way the direct application of the methods is demonstrated (in this way one can also get an idea of what is expected for the completion of the course).</p> <p>Course specific learning objectives The student acquires knowledge of, obtains insight in, and learns to apply:</p> <ul style="list-style-type: none"> ➤ A first order formulation of the equations of motion (often formulated using the Finite Element method) for generally viscously damped, linear dynamic systems with many degrees of freedom. ➤ Left- and right eigenvalueproblems; additionally the student obtains insight in the bi-orthogonality property of left and right eigenmodes, in the physical meaning of complex eigenmodes, and in the normalization of these eigenmodes. ➤ Several damping models (modal damping factors, Rayleigh damping,

	<p>general viscous damping, hysteretic damping).</p> <ul style="list-style-type: none"> ➤ Frequency response functions (FRF's) of generally viscously damped systems and of systems with hysteretic damping and insight in the relationships of these FRF's with FRF's of undamped and proportionally damped systems derived in 4A460. ➤ Sensitivity analysis of modal parameters in case of changing system properties. ➤ Several (dynamic) reduction techniques in the time domain (component mode synthesis techniques) and in the frequency domain (impedance coupling). These techniques are applied to complex linear dynamic systems, which may be divided in substructures. Subsequently the reduced substructures are coupled. ➤ The basic principle of experimental modal analysis (EMA) in order to experimentally determine the modal parameters (eigenvalues and eigenmodes) of the system. ➤ A technique for optimal sensor positioning. ➤ Basic steps in EMA: Fast Fourier Transformation (FFT), theory of random signals (auto- en crosscorrelation functions, auto- en crosspowerspectra), system estimation (estimation of FRF's using experimental data, coherence functions) and several modal parameter fit procedures (in the frequency domain and in the time domain). ➤ Quantitative methods for comparison of numerical and experimental data such as the MAC criterion, mode reduction and -expansion and system error matrices. ➤ Model updating techniques for improving mathematical (Finite Element) models based on experimentally derived eigenvalues and/or eigenmodes. Least squares methods are used to update parameter values in the mathematical (FE) model.
3S290	<p>Crystal growth methods for thin films & nanostructures</p> <p>This course provides a brief introduction in the crystal structure of elemental and compound semiconductors including their phase diagrams. The course will then focus on modern crystal growth methods, i.e., molecular beam epitaxy, chemical beam epitaxy and metalorganic vapor phase epitaxy for fabrication of thin film semiconductors and their heterostructures, and the characterization methods of the basic structural and electronic properties. Fabrication methods for the realization of lateral semiconductor nanostructures based on strain and step engineering and growth on patterned substrates of layered semiconductors will be discussed in depth for applications in next generation photonic devices</p>
8W150	<p>Multi-fluid mechanics</p> <p>The course will illustrate how the conservation of mass, momentum and energy together with principles from non-equilibrium thermodynamics form the basis of the mathematical description of multi-component systems as for instance relevant for physiological transport processes and food-industry. Taking these fundamental description as point of departure, the most simple models for physical phenomena like phase-separation, interfacial tension, diffusion and Marangoni convection will be derived. Insights from these fundamental descriptions will be used to analyse important processes that occur in structure development in mixing and dispersion. Examples are diffusion induced phase separation (DIPS), flow</p>

	induced phase separation but also deformation, break-up and coalescence of drops and the role of surfactants. This, for instance, is of importance for polymer processing and drug-delivery systems.
4K440	<p>Non-linear finite element methods for solids</p> <p>Nonlinear finite element analysis is nowadays an essential component of computer-aided design. Experimental testing of prototypes is increasingly being replaced by nonlinear finite element simulations (so-called virtual prototyping) because this provides a more rapid and less expensive way to evaluate design concepts. In most companies nonlinear finite element software packages are used as a simulation black box. However, a nonlinear finite element analysis confronts an engineer with many choices and pitfalls. Selections made in the model formulation, mesh discretizations, element types, the solution procedure etc. may have a tremendous effect on the final results. Therefore, an engineer must to be aware of these influences in order to provide an adequate interpretation of the results.</p> <p>This course will focus on the basic aspects of the nonlinear finite element analysis for solids. The following topics will be discussed: geometrical and material nonlinearities; linearization and general solution approaches for nonlinear problems; numerical strategies for large deformation analysis, e.g. total Lagrangian and updated Lagrangian formulations; implementation of hyperelastic as well as hypoelastic material models; some aspects of element technology for nonlinear solid analyses, e.g. the element performance, the patch test, convergence and stability of an element, different types of elements for (nearly) incompressible material behaviour, stabilization of underintegrated elements, etc.</p> <p>Throughout the course, the theory will be complemented by illustrations and practical experience in terms of programming, running analyses and interpreting the results. For this purpose (parts of) a basic finite element program in MATLAB will be provided. Use of a notebook is required.</p>
8C030	<p>Molecular simulation</p> <p>Equations of motion, molecular dynamics, bonds, empirical potentials, phase space, numerical methods for solving the equations of motion, thermodynamic and statistical physics descriptions and their relation, temperature and pressure coupling, radial distributiefunctions, diffusion computations.</p>
8H010	<p>New developments in fluorescence microscopy</p> <p>The student knows:</p> <ul style="list-style-type: none"> • the most important physical aspects of light microscopy • the relative importance of the various factors • the most important principles of special microscopic techniques as phase contrast and differential interference contrast • the most important physical aspects of fluorescence • the most important physical aspects of fluorescence microscopy: single and two-photon excitation microscopy • the possibilities of fluorescence lifetime microscopy • the possibilities and limitations that all these microscopy techniques have

	<ul style="list-style-type: none"> • the relationship between microscopic imaging and electronically acquired images • the possibilities and dangers of application of these techniques to living tissue <p>The student can:</p> <ul style="list-style-type: none"> • work with a standard microscope • describe and select in a correct way the most important properties of the various microscope types • advise of the choice of various microscope parts on the basis of product information • advise of the coherence the various components of a microscope • indicate what type of microscope require for a certain research question • understand and interpret literature in the field of microscopy • advise of the use of various types of microscopes for living tissues.
4K200	<p>Mechanics of micro-electronics</p> <ul style="list-style-type: none"> ➤ Overview and trends of micro-electronics ➤ Thermo-mechanics of integrated circuits and packages ➤ Virtual thermo-mechanical prototyping and qualification ➤ Application of fracture mechanics: theory, FEM and experiments ➤ Future developments and challenges
4P630	<p>Application of FEM to heat and flow problems</p> <p>The course is divided into two parts.</p> <p>In the first part the partial differential equations for the description of heat and flow problems are introduced and properties of parabolic, hyperbolic and elliptic equations are briefly discussed. Beside the Finite Element Method (FEM) the Finite Difference Method is introduced together with the upwinding technique to avoid oscillations in the approximate solution. Next the general working method of the FEM is described. Finally, general aspects as quadrature rules, automation and accuracy are discussed.</p> <p>In the second part the FEM is applied to the Navier-Stokes and energy equation to solve heat and flow problems. The discretisation of the set of equations together with several solution methods and the special role of the pressure are discussed. Besides, some time integration schemes to solve unsteady flow problems and the coupling between the Navier-Stokes and energy equations for forced and natural convection flow problems is elucidated. Finally, a short introduction is given to solution techniques for radiation problems.</p>
4J530	<p>Engineering optimization: concepts and applications</p> <p>In the design of technical systems and components it is of crucial importance to reduce costs and shorten time of development. The use of rigorous methods of decision-making, such as optimization methods, coupled with modern tools of computer-aided design may be effective in this. Besides gain of time, this may lead to better solutions and enhance the creative process of conceptual and detailed design of technical systems.</p> <p>A number of well-known techniques for engineering optimization is subject of</p>

	<p>the course 'Engineering Optimization: concepts and applications'. They will be illustrated with applications from the field of Mechanical Engineering, such as (dynamical) mechanical systems, manufacturing systems, and systems in processing industry. Main topics to be treated are:</p> <ul style="list-style-type: none"> ➤ Optimization problem formulation. ➤ Model construction and Model boundedness. ➤ Design optimization methods: interior optima, boundary optima, numerical algorithms and local computation. ➤ Principles and practices: selecting numerical algorithms and software, interpreting numerical results. <p>The use of computer and software is integrated throughout the course. The course 'Engineering Optimization: advanced topics, 4T700, is complimentary to the present course, focusing on the optimization of engineering systems using information from physical experiments or from numerical/computer models (such as discrete-event, FEM, or ODE based models).</p>
3N220	<p>Theory of microscopically disordered media</p> <p>Microscopically disordered media are media in which structure and properties are strongly varying on a length scale larger than that of the molecules, but much smaller than that of the normal observation. This implies that it is often possible already to give locally a description in terms of macroscopic properties, but that for the global macroscopic properties a second statistical averaging is necessary. Such disordered media are encountered in Nature (suspensions, porous materials,...), but are also being made in view of their particular properties (isolator/conductor composites, reinforced materials, heterogeneous catalysts,...). The course consists of two parts. In the first part practical examples are discussed and it is explained that between totally different media, and the physical processes in these (e.g. diffusion in porous media), large similarities exist, which permit a unifying description of the effective behaviour via methods of mathematical physics and statistical mechanics. A number of approximations are dealt with that lead to explicit expressions for the effective constants of microscopically disordered media. Finally it is shown how a self-consistent theory predicts a percolation transition from isolator to conductor in an isolator/conductor mixture. The second part of the course discusses the statistical lattice theory of percolation in isolator/conductor composites and similar systems. Explicit calculations are given of cluster size distribution, correlation length and percolation threshold in an exactly-solvable model. Subsequently it is made clear how this leads close to the percolation threshold to universal scaling behaviour of large clusters, and what is here the role of fractal structures. Finally the sofar purely geometrical percolation model is translated into scaling laws for the effective conductivity close to the percolation threshold of isolator/conductor composites.</p>

Semester 2 (in year 2008-2009)

2WN13	<p>Scientific computing in partial differential equations</p> <p>The course deals with numerical methods for partial differential equations. It discusses and analyses those methods for various types of problems. In particular it will give insight in questions like (in)stabilities of numerical approximations, dissipation, conservation and dispersion. These notions are used in solving diffusion equations (elliptic and parabolic type) and convection equations (hyperbolic type). An important area of application is fluid mechanics, where one often encounters convection-diffusion equations. Although some emphasis will be on understanding the phenomena behind the approximation, a number of practical issues will be discussed as well.</p>
3T100	<p>Advanced fluid dynamics</p> <p>In this course some important fundamental aspects of fluid mechanics will be discussed which one often encounters both in theoretical problems and in industrial applications. The first part of the course concentrates on the subject of 'vortex dynamics'. Topics like vortex theorems, vorticity production and diffusion, coherent vortices in 2D flows and 3D vortex structures will be discussed. The second part of the course concentrates on the application of 'complex function theory' in fluid dynamics (complex flow potential, Milne-Thomson circle theorem, forces on bodies in potential flows, and conformal mapping).</p>
3T190	<p>Aero-acoustics</p> <p>Aeroacoustics is the study of sound generation by flows. The basic concepts of acoustics are introduced. We consider acoustics of pipes and of free field. Then we focus on the theory of Lighthill for sound generation by flows and the vortex-sound theory. Theory is illustrated as much as possible by examples of applications (speech production, whistling, woodwind musical instruments, turbine sound, aircraft noise,...).</p>
4P710	<p>Micro-heat transfer</p> <p>To understand the heat transfer on the micro-scale, several molecular aspects are treated first and then extended to the micro- and macro-scale. The course is subdivided into three blocks:</p> <ul style="list-style-type: none"> • Conduction on the molecular level for <ul style="list-style-type: none"> ○ Ideal gasses ○ Fluids ○ Solids • Multi-scale modelling of convection using <ul style="list-style-type: none"> ○ Molecular Dynamics ○ Monte Carlo techniques ○ Lattice Gas and Lattice Boltzmann methods • Radiation <ul style="list-style-type: none"> ○ The dual character of radiation ○ Interactions of photons <p>Length and time scales</p>

4K590	<p>Micro-robotics</p> <ul style="list-style-type: none"> ➤ Introduction and definitions: course learning objective / Mechanics for microrobotics I (Kinematics of mechanisms) ➤ Mechanics for microrobotics II (some results from rigid body dynamics, some element of robotics) ➤ Scaling effects on physical laws and adhesion forces at the microscale / Concept from material science used in microrobotics (physical properties of crystals) ➤ Element of micromechanism design (flexures, motion guidance) ➤ Actuators for microrobots I (piezoelectrics actuators, shape memory alloys, magnetostrictive, EAP) ➤ Actuators for microrobots II (capacitive actuators, thermal actuators, light driven actuators) ➤ Non-contact manipulation techniques (dielectrophoresis, laser trapping, acoustic) ➤ Sensors for microrobots ➤ Integration at the micro-scale / Summary
4K570	<p>Micro- and nano-structuring methods</p> <p>The course shall cover many aspects of micro- and nano- fabrication methods. Different lithographic techniques and their applications to microelectronics and micromechanics will be discussed. Moreover, attention shall be given to typical fabrication techniques used in micro- and nano-engineering like thin film deposition techniques, wet and dry etching methods, LIGA techniques, molding and embossing. Also concepts for micro- sensors and -actuators and techniques for the packaging of micro-devices shall be presented. Finally, attention shall be given to special nano-engineering topics.</p>
6SE15	<p>Hydrogen technology</p> <ol style="list-style-type: none"> 1. Introduction to the hydrogen technology. The strategy for transition toward hydrogen economy. Comparison of hydrogen with other fuels. 2. Handling, transmission and storage of hydrogen. Compression, liquefaction, adsorption, storage in hydride materials, irreversible hydrogen storage. 3. Non-catalytic hydrogen production. Overview of thermonuclear cycles. 4. Hydrogen production from fossil fuels. 5. Separation and purification of hydrogen for applications in fuel cells. Physical separation: pressure swing adsorption. Chemical purification: preferential oxidation, selective methanation. 6. Fuel cells. Concept of fuel cells. Types of fuel cells and operation conditions.
4H200	<p>Micromechanics of materials</p> <p>The mechanical behaviour of materials is strongly influenced by the structure of the material at the microscopic level. For many applications, such as applications where the length scale is relatively small with respect to the size of the microstructure, it is important to understand the role of the microstructure and to couple it to the continuum response of the material. Modelling this microstructure and the interactions between the components form an important tool for this purpose. The ultimate goal is to couple the developed</p>

	<p>structure-property relationships to the processing conditions. Then, it becomes possible to choose the processing conditions and therefore influence the structure and with it the properties of a material.</p> <p>In the first part of the course, an introduction into different aspects of micromechanics is given. A number of basic tools will be treated which will be used in the remaining of the course for various micromechanical concepts and theories. A number of relevant aspects from continuum mechanics will be repeated and several methodologies to describe microstructures will be discussed.</p> <p>In the second part of the course, various micromechanical approaches will be treated, such as homogenisation techniques for elastic media. A number of these techniques will be built upon in various multi-scale approaches for large deformations and arbitrary material behaviour. Averaging techniques such as the Taylor and Sachs approaches will be considered. Several techniques for modelling of microstructures via representative volume elements and unit cell approaches will be treated, after which the multi-level finite element approach will be discussed. Furthermore, attention is paid to the plasticity of porous materials, for which the Gurson model will be discussed.</p> <p>In part three, micromechanical approaches will be discussed that are based on physical processes in the material. In this part, the theory of crystal plasticity will be discussed, followed by the mechanics of dislocations and the use of these theories in crystal plasticity models. Finally, the micromechanical modelling of semi-crystalline materials will be treated, where previously discussed aspects will be used.</p>
4T300	<p>Microscopic measurement methods</p> <p>In many cases macroscopic material behaviour can only be understood by studying phenomena at much smaller (micron, nanometer) scale. This course treats a number of advanced measuring techniques that enable the study of microscopic properties of materials (metals, polymers, biological materials). With these techniques topographic, mechanical and chemical properties can be measured at a (very) small scale. Emphasis will be on techniques available within the faculty of Mechanical Engineering. Among others the following techniques will be treated: conventional optical microscopy, confocal microscopy, electron microscopy (ESEM) and elemental analysis (EDX), Scanning Probe Microscopy (AFM and the likes), nano-indentation. Underlying physical principles will be addressed concisely. Examples from faculty research and literature will be used to illustrate possibilities and restrictions of these techniques.</p>
4K620	<p>Computational material models</p> <p>For a good description of physical phenomena proper constitutive equations, describing the material behaviour, are essential. Although many constitutive equations are used since long and mostly successfully, they need continuous adaptation and extension due to both the use of new materials and the more extreme situations of their use. Experimental techniques to determine material parameters (-functions) need to be more and more sophisticate.</p> <p>Theoretical aspects of various material models are discussed in the course Constitutive Modelling of Solids. Experimental characterisation is the subject of the course Polymer Mechanics.</p> <p>In the course CMM attention goes to implementation of the constitutive equations in finite element software. When this is not done properly, the accuracy of the numerical solution and the efficiency of the solution process will</p>

	<p>be detrimental.</p> <p>In the course the background of the finite element method (weighted residuals, interpolation, numerical integration, assemblage, partitioning) is summarized for truss, 2D (plane strain and plane stress) and axisymmetric elements. Subsequently attention is focussed onto procedures which are needed for various material behaviour 1) to calculate stresses and 2) to calculate the current material stiffness. Attention is given to material models for:</p> <ul style="list-style-type: none"> • hypo- and hyper elastic behaviour • elastoplastic behaviour • viscoelastic behaviour • viscoplastic behaviour <p>Implementation is done in available Matlab programs. Results are compared to analytical solutions and to results from the FEM program MSC.Marc/Mentat.</p>
3S390	<p>Biosensors for medical diagnostics</p> <p>In this course, new developments will be discussed in the design of biosensors that can measure extremely low concentrations of proteins or nucleic acids (picomolar) in a small volume (microliter) of body fluid (e.g blood, saliva, urine). At present, a strong worldwide research competition is ongoing to apply (new) physical detection principles in fast and compact biosensors that can be used in "point-of-care" applications. After a short introduction in biochemistry for physicists, this course will start with the principles of molecular recognition through the use of various types of immunoassays. Subsequently the kinetics of the molecular recognition will be discussed which is, inside the biosensor, determined by a combination of reaction kinetics, convection and diffusion. Next, the physical detection principles of the new sensors will be addressed:</p> <ul style="list-style-type: none"> ➤ magnetic detection applying the Giant Magnetic Resistance or Hall effects ➤ electrical detection methods (impedance spectroscopy) ➤ optical detection techniques applying fluorescence, chemiluminescence and surface plasma resonance. <p>A critical evaluation of the sensitivity of different technologies will be given on the basis of recent literature .</p>