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Introduction
Introduction

This is the guide for the training programme especially developed for the training of the PhD students of the JM Burgerscentrum, Dutch research school on fluid mechanics. The guide describes the general idea of the PhD programme and presents a framework in which individual training schedules can be developed. It gives a description of the courses in the year 2014-2015, with information about the conditions to participate and instructions for registration. As mentioned, the courses are in particular meant for PhD students of the JMBC. However, also PhD students from other research schools and post-docs can participate. Moreover, persons from industries and technological institutes can also attend the courses. Information about courses and more general information about the JM Burgerscentrum can also be found on our website www.jmburgerscentrum.nl

Prof.dr.ir. G Ooms  
Scientific director  
(untíl 1 July 2014)

Prof.dr. ir. GJF van Heijst  
Scientific director  
(as per 1 July 2014)
Structure of the PhD programme
Structure of the PhD programme

Purpose of the PhD programme

The purpose of the PhD programme of the JM Burgerscentrum is the development of PhD students into independent researchers in the field of fluid mechanics. To reach this goal a thorough and fundamental knowledge of fluid-mechanics and their mathematical and numerical modelling is required, as well as the ability to further develop this knowledge and to apply it to solve scientific and technical problems. An important part of the PhD programme consists of the execution of a scientific research project under the supervision of an expert of the JMBC. That part is not discussed in this guide. A smaller part, of the order of half a year, consists of the participation in courses. The details of that part of the programme (the training programme) are given in this guide.

Structure of the training programme

The training programme gives a framework, in which individual training schemes can be developed. It contains the following three components:

- MSc degree courses
- PhD degree courses
- Workshops, summer schools, seminars.

The different components are meant for broadening or deepening of knowledge, and also for specialisation in certain areas of fluid mechanics. Individual training programmes are composed from elements of the three components. In the next paragraphs the three components are discussed.

MSc degree courses

The MSc degree courses are meant for PhD students (or other interested persons), who have no earlier formal training in fluid mechanics. The courses will bring those PhD students to the same level of knowledge in fluid mechanics as PhD students who did receive their MSc degree in fluid mechanics. The courses are usually selected from the advanced courses of the study programme for the MSc degree. An overview of the most relevant MSc degree courses are given in this guide ordered according to the main research themes of the JMBC. Information about time and place of these courses can be obtained from the contact persons mentioned in the course descriptions given in this guide, or can be found in the study guides of the different universities participating in the JMBC.
The number of ECTS points for the MSc degree courses to be included in an individual training programme depends on the MSc study programme of the individual. Usually it is about 6 to 9 ECTS points.

**JMBC PhD courses**

For a PhD student it is essential to deepen his/her knowledge in fluid mechanics to a level significantly higher than that of a person with a MSc degree in fluid mechanics. The PhD degree courses of the JM Burgerscentrum fulfil this purpose. The deepening of knowledge is not restricted to the area of fluid mechanics, to which the research project of a PhD student belongs. The idea of the PhD degree courses is to continue the formal training of the PhD student in a number of areas in the field of fluid mechanics, but on a post-graduate level. After his/her PhD degree the PhD student must be able to quickly acquaint him (her) self with a new area of fluid mechanics and solve problems in that area. As a consequence each PhD student must at least participate in three PhD degree courses. In consultation with the supervisor a PhD student can decide to follow more courses. The number of ECTS points connected to the PhD degree courses must at least be 9. The content of the courses is composed in such a way, that the courses can be followed by all PhD students (independent of their knowledge from their MSc degree programme).

The different PhD degree courses of the JM Burgerscentrum are usually given once every two years, dependent on the number of participants. The courses are concentrated in time, usually during one week. The courses are given by the senior staff members of the JMBC, but also by (internationally well-known) guest lecturers. They determine the number of ECTS points for their course. The courses can contain several elements: theoretical training, own work, demonstrations, etc. An active role of the participants is stimulated.

**Workshops, summer schools, seminars or courses of other organisations**

Besides MSc degree courses and PhD degree courses there is also a less-structural part of the training programme of the JM Burgerscentrum, consisting of workshops, summer schools and seminars. They can be very valuable for the education of the PhD student, and will usually be in the area of fluid mechanics to which the research project of the PhD student belongs. It is, in particular, recommended that a PhD student participate in summer schools. Another component can be courses, not organised by the JM Burgerscentrum but by another organisation (courses from the Von Karman institute, ERCOFTAC, EUROMECH, etc.). The number of ECTS points of this part of the training programme will on average be 9.
Individual training programme

The total training load per PhD student is approximately 25 ECTS points. Deviations are of course possible; a minimum of 20 ECTS points is necessary. Taking these rules into account an individual training programme can be scheduled by a PhD student in consultation with his/her supervisor. The programme gives a listing of the components and their timing. It is recommended to set-up the programme during the appointment of the PhD student. The supervisor decides, whether exams about the followed courses are necessary. (Each PhD course counts for 3 ECTS points).

An example of a training programme (for a PhD student without a fluid-mechanics background) is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Courses</th>
<th>ECTS Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>MSc degree courses</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>PhD degree courses</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Workshop, etc.</td>
<td>1.5</td>
</tr>
<tr>
<td>2nd year</td>
<td>PhD degree courses</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Workshop, etc.</td>
<td>1.5</td>
</tr>
<tr>
<td>3rd year</td>
<td>Workshop, etc.</td>
<td>3</td>
</tr>
<tr>
<td>4th year</td>
<td>Workshop, etc.</td>
<td>3</td>
</tr>
</tbody>
</table>

An example of a training programme (for a PhD student with a fluid-mechanics background) is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Courses</th>
<th>ECTS Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>PhD-degree courses</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Workshop, etc.</td>
<td>1.5</td>
</tr>
<tr>
<td>2nd year</td>
<td>PhD-degree courses</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Workshop, etc.</td>
<td>1.5</td>
</tr>
<tr>
<td>3rd year</td>
<td>Workshop, etc.</td>
<td>3</td>
</tr>
<tr>
<td>4th year</td>
<td>Workshop, etc.</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Career orientation

It is important that PhD students prepare themselves well for their future job after finishing their PhD project. Therefore each PhD student selects in consultation with his/her supervisor a course dedicated to ‘career orientation’ and follows this course during the third or fourth year of his/her project. Such courses are given by universities and by FOM. Via the websites of universities and FOM more details about the courses can be found.
Registration for JMBC PhD courses
Registration for JMBE PhD courses

**Conditions**

The PhD degree courses organised by the JM Burgerscentrum are in the first place meant for the PhD students of the JM Burgerscentrum. They have priority with respect to registration for these courses. However, as mentioned, also PhD students from other research schools, post-doc’s and staff members from industries and technological institutes can participate.

**Fees**

- 250 Euro | Officially registered JMBE PhD students. Incl. course material, lunches, 1 general diner, travel expenses, and (if necessary) hotel accommodation.
- 250 Euro | Dutch PhD students, scientific staff, post doc’s, post-graduate students from universities. Incl. course material, lunches and 1 general diner. Travel expenses and hotel accommodation are not included.
- 400 Euro | International PhD students. Incl. course material, lunches and 1 general diner. Travel expenses and hotel accommodation are not included.
- 1,000 Euro | Staff members from industries, technological institutes, or other interested persons. Incl. course material, lunches and 1 general diner. Travel expenses and hotel accommodation are not included.

**Registration**

Registration is possible by filling in the online registrationform on [www.jmburgerscentrum.nl](http://www.jmburgerscentrum.nl) (Registration). The registration form is only necessary for the JMBE PhD courses.

**Certificate**

At request a participant in a JMBE course can receive from the JMBE secretariat a certificate concerning his/her participation.

**Course evaluation form**

Each participant of a JMBE course is asked to fill in a course evaluation form via the website of the JMBE [www.jmburgerscentrum.nl](http://www.jmburgerscentrum.nl) (Registration). The evaluation form is anonymous. The JMBE scientific director will discuss the evaluation results with the course leader.
Summary of the courses for the academic year 2014-2015

- 27 - 31 October 2014
  PIV
  J. Westerweel, C. Poelma, G. Elsinga, F. Scarano
  Particle Image Velocimetry is a measurement technique able to determine the instantaneous velocity field in a planar or volumetric domain. It is widely applied in both fundamental and applied fluid mechanics research. In 2009 and 2011, one-week courses devoted to PIV were given at the TU Delft. Due to the success of these courses (more than 30 participants?), this course is offered again in the fall of 2014 (October 27-31). The course discusses the fundamentals of the technique and examples of specific applications, including typical problems in microfluidics, turbulence, multiphase flows and aerodynamics. Next to the classroom lectures, a number of practical sessions will be organized, where the participants can practice their skills and see some state-of-art facilities (e.g. tomographic PIV, high-speed PIV). The course is primarily targeted at PhD students from the J.M. Burgerscentrum, with priority on registration. Due to limitations on the available space in the practical sessions, the maximum number of participants is set to 35. Others interested researchers (postdocs, faculty, researchers from institutes and industry) are welcome to apply as well. Apart from a basic understanding of fluid mechanics, there is no prerequisite knowledge.
  **Topics**
  - PIV system components: tracers, lasers, optics, cameras
  - Measurement fundamentals: cross-correlation, image density, loss-of-pairs
  - Measurement regimes: stereoscopic PIV, multiphase flows, (laser-induced fluorescence? I do not see the pertinence of LIF within the PIV course, or is it meant for multiphase flows by fluorescent tracers?), microfluidics, high-speed systems, volumetric methods (3D-PTV, tomographic PIV, holographic PIV)
  - Data processing techniques: multi-pass correlation, multigrid methods, deforming windows, correlation averaging, multi-frame methods

Registration via the online form (www.jmburgerscentrum.nl)
Registration preferably one month before the start of the course
Data reduction and post-processing: vector validation, estimation of vorticity, detecting coherent structures, uncertainty quantification

Experimental design and lab demos are given in practical sessions.

*For more information contact*

F Scarano | 015 278 5902 | f.scarano@tudelft.nl

**November 2014**

**Compressible flows - TUD**

FFJ Schrijer, HWM Hoeijmakers, F Scarano

This four day course discusses the principles of compressible fluid mechanics. Although the course is of a fundamental nature, it discusses advanced topics which will provide the necessary background for a complete understanding of CFD methods, combustion physics, energy systems and aerospace systems. The course will be of interest for PhD students and people from industry working for example in turbo-machinery, turbo-pumps, pipe-flows, combustion, aeronautics and aerospace. Among the topics that are discussed in the course are: fundamental gasdynamics (derivation of the governing equations, unsteady wave motion, 1D acoustics, Burgers equation), steady supersonic flows (shock waves, expansion waves, adiabatic flows through convergent-divergent ducts), Fanno and Rayleigh flows (duct flows including friction and heat transfer) and an introduction to CFD methods for compressible flows. Supporting each lecture there will be sample problems to illustrate the application of the theory and hands on experiences (wind tunnel experiments).

*For more information contact*

FFJ Schrijer | 015 278 6386 | f.f.j.schrijer@tudelft.nl

**12 - 16 January 2015**

**CFD 2 - TUD**

FJ Vermolen, C Vuik

Finite element methods for the incompressible Navier-Stokes equations and iterative solution methods.

1. Finite element methods for the incompressible Navier-Stokes equations

A short introduction to the finite element method is given. The following fluid flow applications are used: Poisson equation, convection-diffusion equation and the incompressible Navier-Stokes equations. Subjects studied in more detail are: (streamline) upwind methods, problems originating from the incompressibility condition, and the linearisation of convective terms in the Navier-Stokes equations. Some remarks are given on time-dependent problems.

2. Iterative solution methods.

The solution of systems of linear equations. The main part of the course is devoted to modern iterative methods. Furthermore the following related topics are considered: direct and iterative methods for (sparse) linear systems, iterative methods to compute eigenvalues of matrices, implementation of these methods on vector- and parallel computers.
As applications systems are used which originate from fluid flow problems. To illustrate the theory, practical work is done in the afternoons using MATLAB and the finite element package SEPRAN. Preliminaries: A basic course in numerical analysis, partial differential equations and linear algebra.

For more information contact
C Vuik | 015 278 5530 | c.vuik@tudelft.nl

26 - 29 January 2015
Geophysical fluid dynamics - TUE
GJF van Heijst, LRM Maas, H de Swart, and others
This course will concentrate on fundamental aspects of rotating and stratified flows, aiming at a better insight in the dynamics of large-scale flows in seas, oceans and planetary atmospheres. Such insight is also useful for a better understanding of industrial flow configurations in which rotating and/or density effects play a role. Topics that will be discussed include: geostrophic flows, conservation of potential vorticity, Ekman boundary layers, spin-up phenomena, wind-driven ocean circulation, waves in rotating and stratified media, density currents, barotropic and baroclinic instability, sediment transport and bottom morphology, aspects of the atmospheric boundary-layer dynamics, and rotating convection. The course includes a number of laboratory and computer sessions, in which the participants can study aspects of the theoretical material presented and discussed during the lectures.
Registration for this course: m.j.a.m.rodenburg@tue.nl

Lecturers
Matias Duran-Matute (TU/e), GertJan van Heijst (TU/e), Rudie Kunnen (TU/e), Leo Maas (NIOZ & UU), Huib de Swart (UU), Bas van de Wiel (TU/e)

For more information contact
GJF van Heijst | 040 247 2722 | g.j.f.v.heijst@tue.nl

March 2015
Particle technology - UT
S Luding, R van Ommen, V Magnanimo
Particles can be found as granular materials in our kitchen (coffee/starch/sugar), in chemical and pharmaceutical industry (tablets/medicine/powders) in nature (sand/soil), or as solids with microstructure (ceramics/composites/metal-alloys). They are everywhere in nature and constitute over 75% of all raw material feedstock to industry – providing many challenges for innovation and fundamental science. The discrete, particulate nature of these materials leads to usually unwanted and sometimes fatal phenomena. Particle technology is the branch of science and engineering that deals with the production, handling, modification, and use of a various particulate materials (wet or dry) in sizes ranging from nanometers to centimeters; its scope and applications span a range of industries including chemical, mechanical, petrochemical, agricultural, food, pharmaceuticals, mineral processing, advanced materials, energy, and the environment.
The purpose of this course is to give a broad overview of most fields and applications of particle technology. Due to the broad range of particle technology, only few issues can be discussed in depth and addressed by exercises. During the course, reference will be made to various more specialized courses that are given in the near future. Participants can be PhD students in the fields of fluid-mechanics and –physics, process technology, chemical and mechanical engineering as well as geo-sciences, informatics or mathematics. However, also other researchers who want to gain a broader overview and industrial researchers and technicians will find this course interesting.

Recommended reading: M. Rhodes, Introduction to Particle Technology, Wiley

For more information contact
S Luding | 053 489 4212 | s.luding@utwente.nl

April 2015

Capillarity-driven micro fluid mechanics - UT
F Mugele, J Snoeijer, AA Darhuber and MT Kreutzer

Wetting and interfacial tensions play a crucial role for the behavior of fluids on length scales below the capillary length, which is typically of order 1 mm.

Typical application areas include well-established traditional fields such as coating technology, emulsification and oil recovery as well as recent fields such as microfluidic systems, inkjet printing technology, and immersion lithography. The course will cover the basic theoretical models used to describe thin film flows in coating, wetting, and dewetting flows. Topics addressed during the course include wetting of patterned surfaces, superhydrophobic surfaces, contact line dynamics, theory of thin film (lubrication) flows, surface-stress driven flows, (Marangoni, thermocapillarity, electrowetting), two-phase flow micro-fluidics, drop generation. Next to approximately 20 lectures, the program also contains ample time for discussions in the form of tutorial and in extended case studies for the evening program. Friday morning is reserved to the presentation of the results of the cases by the participants of the course.

Location: University of Twente / Enschede
Hotel Drienerburght (www.drienerburght.nl)

A number of hotel rooms have been reserved at the Drienerburght.

For more information contact
F Mugele | 053 489 3094 | f.mugele@utwente.nl
October 2015

**Particle-based modeling techniques - UT**

F Toschi

The course covers particle-based techniques that are commonly employed to model flows at different time- and length-scales. Aside from lectures on theory, the course includes exercises and computer practical sessions where participants can experience the theory and computational methods. The course is addressed to PhD students and postdoctoral researchers working on fluid mechanics. Topics covered include: Multi-Particle Collision Dynamics, Molecular Dynamics Simulations, Lattice Boltzmann techniques, Smoothed-particle hydrodynamics.

*For more information contact*

F Toschi | 040 247 3911 | f.toschi@tue.nl

March 2016

**Soft and granular matter - UT**

D van der Meer, S Luding

Statics and dynamics of soft and granular materials

Many materials, often grouped together using the term ‘soft matter’, share common characteristics and behavior: For example, the materials consist of macroscopic particles, larger than the molecules that build up the world around us. They jam when flow is about to stop, and unjam just before flow starts. The static (‘solid’) situation is often characterized by a high degree of disorder, inhomogeneity and anisotropy, while the dynamic (‘fluid’) situation is frequently dominated by dissipative interaction forces leading to a dissipation time scale that interacts with other time scales in the system. Finally, there is the role of the interstitial fluid that resides between the particles and may mediate thermal (Brownian) motion, in the case of colloids, or hydrodynamic interactions (drag) in the case of macroscopic grains. This course, aimed at graduate students, will provide an introduction to this type of materials and discuss many of the phenomena mentioned above both as an overview and in the context of actual research.

*For more information contact*

D van der Meer | 053 489 2387 | d.vandermeer@utwente.nl
OSPT Courses

Registration & information for OSPT Courses via
http://www.ospt.eu/courses

OSPT Courses
Information about OSPT Courses can be found on their website.
http://www.ospt.eu/courses

EM Courses

Registration & information for EM Courses via
http://www.em.tue.nl

Experimental Engineering Mechanics
September 25 - September 26, 2014

Mechanics in microsystems
October 07 - October 08, 2014

Seventeenth Engineering Mechanics Symposium
October 28 - October 29, 2014

Multi-scale and micromechanics
November 17 - November 19, 2014 and November 24 - November 26, 2014

Mechanics of large deformations
December 02 - December 03, 2014

Continuum Thermodynamics
April 13 - April 14, 2015
MSc degree courses

General fluid mechanics

Advanced fluid mechanics I (357001)

J Snoeijer, UT
The objective of this course is to acquire a firm base in classical fluid mechanics. The emphasis is on analytical solutions and their physical implications. Advanced Fluid Mechanics will serve as an introduction to the basic equations and phenomena needed in CFD, turbulence, acoustics and granular flows. Subjects: Conservation laws, vorticity, potential flow in 2D and 3D, conformal mapping and 2D flow, Zhukovsky airfoils, waves, shallow water equations, flow at low Reynolds number, Stokes and Oseen solutions, Hele-Shaw flow, flow at high Reynolds number, boundary layers, self-similarity, hydrodynamic stability, compressible flow, Laval nozzle, shock waves.

For more information contact
J Snoeijer | 053 489 3085 | j.h.snoeijer@utwente.nl
Compressible flows

Gasdynamics I (AE4-140)

Prof.dr.ir. PG Bakker, TUD


4. Burgers equation for simple waves: non-viscous Burgers equation, shock equation, shock formation, entropy conditions, viscous Burgers equation, wave interactions.

5. Traffic waves: definitions, concepts traffic equation, characteristics and discontinuities, traffic light, chain collision

For more information contact
PG Bakker | 015 278 5907 | P.G. Bakker@tudelft.nl

Gasdynamics II (AE4-141)

Prof.dr.ir. PG Bakker, TUD
1. Two-dimensional unsteady flows: flow equations vector form of flow equations, diagonalisation, left- and right eigenvectors, 2D wave propagation, enveloping of waves.


4. Qualitative theory of 1D viscous flows, equations governing quasi 1D viscous flows, qualitative theory of 2nd order dynamical systems, qualitative aspects of the solutions of the quasi 1D flow equations, frictional effects, Fanno equation, internal structure of a shock wave.

For more information contact
PG Bakker | 015 278 5907 | P.G. Bakker@tudelft.nl
Aeroacoustics (115440)

Dr. SW Rienstra, TUE
Aeroacoustics is the study of sound production by unsteady flows of gas and liquids. By means of simple model problems, examples from real applications and exercises, the student is taught to identify various aspects of acoustics as a branch of fluid mechanics, more specifically sound affected or modified by flow, sound produced by flow, and sound interacting with flow. The course will be a selection of the lecture notes “An Introduction to Acoustics”, S.W. Rienstra & A. Hirschberg, http://www.win.tue.nl/~sjoerdr/papers/boek.pdf.

Contents: Wave equations for sound in fluid flow, sources of sound, acoustic energy. Simple waves, impedance, evanescent waves and related effects. One dimensional models, the Helmholtz resonator. 3D waves in free field, Lighthill’s theory, compact sources. Duct acoustics with applications from turbofan aeroengines. Effect of motion, Doppler shift.

For more information contact
SW Rienstra | 040 247 4603 | s.w.rienstra@tue.nl
**Multiphase flow, dispersed media and rheology**

**Multiphase flow and heat transfer (AP3181D)**

Dr. Eng. LM Portela, TUD

The course on multiphase flow covers basic parameters for design and operation of process equipment, interfacial phenomena, waves in two-phase flow, dimensionless numbers for scale-up, flow regime dependent modelling, two-phase pressure gradients and phase hold-ups for separated, slug and bubble gas/liquid pipe flow and flow regime maps for inclined tube flows. It will furthermore provide introductions to dispersed gas/liquid flows in simple and complex geometries and dispersed flows with solid particles. Moreover, it will address the two-phase heat transfer aspects of boiling liquids. The course is concluded with a brief introduction to the course on Computational Multiphase Flows.

*For more information contact*
LM Portela | 015 278 2842 | l.portela@tudelft.nl

**Continuum mechanics**

Dr. D van den Ende, UT

The continuum model, kinematics, conservation laws, the stress tensor, simple materials, special constitutive equations, special types of flow, rheological material functions. This course will not be lectured on specific dates, but on an individual base in the form of self-study, after making an appointment with Dr. D van den Ende.

*For more information contact*
D van den Ende | 053 489 3105 | h.t.m.vandenende@utwente.nl

**Capillarity and Wetting Phenomena**

Prof. dr. F Mugele, UT

Many physical and technological processes are affected by Capillarity and Wetting (C&W) phenomena. C&W phenomena dominate many processes in fluid dynamics on small scales. Compared to other fluid physics courses within APH curriculum this course focuses on the effect of interfaces and the related interfacial energies that control fluid flows by indirectly by imposing well-defined boundary conditions. The course focusses on fundamental concepts described within the context of fluid dynamics and discusses a variety of classical phenomena of microscopic fluid flows. The course covers the following topics: Molecular interaction force and interfacial tensions; Derivation of the fundamental equations of Young and Laplace; Wetting in external fields; Wetting and molecular forces (disjoining pressure); Thin film flows and lubrication approximation; Linear stability analysis and classical instabilities (Rayleigh Plateau, Rayleigh Taylor); Contact line dynamics; Dewetting; Surface tension-driven flows (Marangoni); Electrowetting
The course is taught in the form of classical lectures (HCs) accompanied by seminars (WCs) in which homework problems prepared and submitted by the students beforehand are being discussed. The course will be given in the third quarter (Feb. – April 2014).

For more information contact
F Mugele | 053 489 3094 | f.mugele@utwente.nl

Elementary two-phase flow with heat transfer (4P540)

Dr. CWM van der Geld, TUE
This is an introductory course in two-phase flow. Averaging procedures and correlations to be used in practise to compute f.e. pressure drop and heat transfer with boiling. Distribution parameter to extend simple one-dimensional approximate computations. Forces on particles and bubbles, and trajectory computations. Lagally theorem, lift forces and variational approaches. Basic thermodynamics using the grand canonical to introduce interfaces and surface tension. Excess free energy and demonstration that boiling occurs on nucleation sites or at boundaries first. Classic two-component mass diffusion theory: Stefan, filmmodel of the air layer with condensation. Interaction of heat and mass transfer in the rapid evaporation of drops. Mollier diagram. Dropwise condensation.

For more information contact
CWM van der Geld | 040 247 2923 | c.w.m.v.d.geld@tue.nl

Nanoparticulate Materials

Prof.dr. A Schmidt-Ott
- What is special about nanoparticulate and nanophase materials? Basic properties (electrical, optical, magnetic, mechanical, chemical) and size effects
- Synthesis of nanoparticulate and nanophase materials, e.g.in flow reactors
- Characterization of nanoparticulate and nanophase materials, including on-line characterization of particles in gas suspension
- present and future applications of nano-composites including solar cells, fuel cells, hydrogen storage, catalysis, magnetic, optical, structural materials

For more information contact
A Schmidt-Ott | 015 278 3540 | a.schmidt-ott@tudelft.nl

Computational Multiphase Flow (AP3551)

Dr.Eng. LM Portela, TUD
This course consists of 12 weeks, starting in the beginning of September, in which the behaviour and description of flows, whereby one phase is dispersed in another phase, will be discussed. The Euler-Lagrange and Euler-Euler approaches to dispersed multiphase flows will be discussed.
During the course, the students will develop a small CFD code, to which subsequently the various important aspects of dispersed flows will be added. The influence of different interaction forces (drag, lift, added mass, etc.) between the phases and the effects of turbulence will be studied using the CFD code.

For more information contact
LM Portela | 015 278 2842 | L.Portela@tudelft.nl

Multiphase Reactor Engineering (CH3062)

Dr.ir. JR van Ommen, TUD
This is an elective course for MSc en PhD students, taught in the third quarter of the academic year. The course treats the various types of multiphase reactors, such as packed beds, fluidized beds, and bubble columns. A large part of the course consists of modelling assignments, to be made in teams of two or three persons (3 ECTS).

For more information contact
JR van Ommen | 015 278 2133 | j.r.vanommen@tudelft.nl

Nanofluidics

Nanofluidics is a key element of nanotechnology. Nanofluidics plays a central role in many Lab-on-a-chip systems and is key for filtration and separation processes (e.g. water purification, desalination, environmental remediation). Moreover the physical principles discussed in the course are essential for many biophysical questions and modern material science of soft (colloidal) matter. This course gives an introduction into nanofluidics, considering fundamental aspects, intrinsic length scales and geometry. A number of different selected topics in the field of nanofluidics are discussed, such as:
- basic fluid dynamics for micro- and nanochannels
- solid-liquid interfaces (interactions, adsorption/desorption)
- hydrodynamics at small scales (laminar flow, slip versus no-slip, mixing)
- 3-phase systems (capillary forces, wetting, superhydrophobicity)
- electrokinetic effects (electroosmotic pumping, electroviscous effect)
- electrophoresis and separation techniques
- (Nano)colloidal particles and colloidal assembly
The course is taught in the form of classical lectures (HCs) accompanied by seminars (WCs) in which homework problems prepared and submitted by the students beforehand are being discussed. Each student gives a final presentation on a specific topic based on a set of original articles from the literature. The course will be taught in the third quarter (Feb. - April 2014).

For more information contact
F Mugele | 053 489 3094 | f.mugele@utwente.nl
Numerical computations and modelling

Elements of computational fluid dynamics A (WI4011)

Dr.ir. DR van der Heul, TUD
Topics: The governing equations; finite volume methods; stability theory; singular perturba-
tions; numerical methods for the incompressible Navier-Stokes equations; efficient iterative
solution methods. MATLAB software is available at http://ta.twi.tudelft.nl/users/wesseling For
more information look at http://ta.twi.tudelft.nl/users/wesseling/cfdcourse.html
For more information contact
DR van der Heul | 020 511 3113 | d.r.vanderheul@tudelft.nl

Advanced Numerical Methods (WI4212) 6 ECTS

Prof.dr.ir. C Vuik and dr.ir. JE Romate TUD
This course is an introduction to hyperbolic partial differential equations and a powerful class
of numerical methods for approximating their solution, including both linear problems and
nonlinear conservation laws. These equations describe a wide range of wave propagation and
transport phenomena arising in nearly every scientific and engineering discipline. Several
applications are described in a self-contained manner, along with much of the mathematical
theory of hyperbolic problems. High-resolution versions of Godunov’s method are developed,
in which Riemann problems are solved to determine the local wave structure and limiters are
then applied to eliminate numerical oscillations. These methods were originally designed to
capture shock waves accurately, but are also useful tools for studying linear wave-propagation
problems, particularly in heterogeneous material.
More information : http://ta.twi.tudelft.nl/nw/users/vuik/wi4212/wi4212_eng.html
For more information contact
C Vuik | 015 278 5530 | c.vuik@tudelft.nl

Scientific Programming (WI4260TU) 3 ECTS

Prof.dr.ir.H.X.Lin and Ir.C.W.J.Lemmens TUD
This course tries to bring students to a level where they are able to change algorithms from
e.g. numerical analysis into efficient and robust programs that run on a simple computer. It
comprises: 1. Introduction to programming in general; 2. (Numerical) Software design; 3. Data
Structures; 4. Testing, debugging and profiling; 5. Efficiency issues in computing time and
memory usage; 6. Optimization and dynamic memory allocation; 7. Scientific software sour-
ces and libraries. This course only talks about simple sequential programming. More advanced
topics like threads or parallel (MPI/GPU) programming on supercomputers are not covered by
this course (they are covered by other courses).
Computational modelling of flow and transport (CIE4340)

Dr.ir. M Zijlema, TUD
Introduction to computational modelling of flow and transport, to be able to recognize the strengths and weaknesses of the various numerical recipes, and understand how numerical algorithms used by many well-known numerical packages work. The following topics are dealt with during the course:
1. Ordinary Differential Equations (ODE), box models and spring-mass systems.
2. Time integration for ODE, consistency, convergence, stability and stiffness.
4. Space discretization for PDE, finite differences, Von Neumann stability analysis, CFL condition, amplitude and phase error analysis and numerical diffusion.
5. 1D shallow water equations, Leapfrog and Preissmann schemes, staggered grids and applications.

For more information contact
M Zijlema | 015 278 3255 | m.zijlema@tudelft.nl

Computational hydraulics (CTwa5315)

Prof.dr.ir. GS Stelling and dr. JD Pietrzak, TUD
Description: Theory and practice of 2D and 3D nonstationary flow and transport computations.

For more information contact
JD Pietrzak | 015 278 5466 | j.d.pietrzak@tudelft.nl

Computational fluid dynamics

Prof.dr. AEP Veldman, RUG
Introduction to numerical methods for simulating viscous flow problems: discretization on nonuniform grids, convection-diffusion equation, incompressible Navier-Stokes equations, free-surface flow, Burgers’ equation, simulation of turbulent flow (DNS).

For more information contact
AEP Veldman | 050 363 3988 | veldman@math.rug.nl
Boundary-layer flow

Prof.dr. AEP Veldman, RUG
Physical modelling and numerical simulation of laminar and turbulent boundary layers: boundary-layer equations, integral formulation, turbulence modelling, asymptotic structure, flow separation, strong viscous-inviscid interaction.
For more information contact
AEP Veldman | 050 363 3988 | veldman@math.rug.nl

CFD 1 - Incompressible flows (AE4-151)

Dr.ir. MI Gerritsma, TUD
Subjects treated: Introduction to Computational Fluid Dynamics. Classification of partial differential equations and well-posedness. Finite volume methods, finite difference methods, finite element methods, boundary element methods and spectral element methods. For the incompressible Navier-Stokes equations two topics will be treated in depth: the relation between the (hyperbolic) convective terms and the (elliptic/parabolic) diffusive terms, and the role of the pressure in incompressible flows and the ensuing compatibility conditions between velocity and pressure approximation.Examination takes place in the form of an assignment in which the student writes and analyzes an incompressible Navier-Stokes solver. This assignment will be concluded with an oral examination.
For more information contact
MI Gerritsma | 015 278 5903 | m.i.gerritsma@tudelft.nl

Application of the Finite Element Method to heat and flow problems

Dr.ir. CCM Rindt, TUE
In this course the general method to construct a numerical solution of a second order partial differential equation with the Finite Element Method (FEM) is elucidated. Practical aspects like automation, quadrature rules and accuracy of the numerical solution are also highlighted. More specifically, the FEM-method is applied to the solution of incompressible flows (Navier-Stokes equations) and thermally driven flows (Boussinesq approach). Besides, several solution methods of the Navier-Stokes equations are presented like the penalty function approach and projection schemes. Finally, some numerical aspects are shown for time-dependent problems. Beside the oral courses, there is also the possibility to practice on some classical fluid dynamic problems like the flow over a backward facing step and the flow around a cylinder.
For more information contact
CCM Rindt | 040 247 2978 | c.c.m.rindt@tue.nl
Modelling of Physical Phenomena (4P560)

Dr.ir. JGM Kuerten, TUE
The subject is the modelling of physical phenomena, i.e. the steps necessary to translate a physical problem into a mathematical model and its solution. For many problems in fluid dynamics the mathematical model is a partial differential equation. In the lecture series a number of problems from thermal and fluid mechanics will be studied in this way. Moreover, attention will be paid to analytical and numerical solution methods. Examples which will be treated are: waves in shallow water, heat flow in a bar and air flow around the wing of an airplane.

For more information contact
JGM Kuerten | 040 247 2362 | j.g.m.kuerten@tue.nl

Advanced Programming in Engineering (191158500 - 5.0 EC)

Prof.dr. S Luding, UT
2nd-3rd quarter every year and in self-study possible anytime. Goal of the lecture is to teach the students the basics of various algorithms and methods used everyday in mechanical engineering, civil engineering, and physics. This will go deep into the basics, involving Advanced Computational Programming and Algorithms. The goal is not using commercial software packages or functions from, for example, Matlab, but to understand the Methods “from the inside”. There will be classroom lectures to teach basics and theory as well as practical exercises where the learned knowledge will be implemented on the computer. Several examples will be treated (we would like to receive ideas of examples which relate this lecture to other courses where there is not time to go that deep into the programming) which build upon other lectures (fill in examples or specific courses here). Unique about this lecture is that some of these examples will be treated by different methods in parallel (for example diffusion can be dealt with by finite differences, finite elements, or stochastic methods). Dependent on the number of participants, this will be either done by split groups, or sequentially so that the students get familiar with the strengths and weaknesses of various numerical methods and approaches. Required: Basic Programming Skills (!) and solid Math, Physics, Engineering, Informatics background.

For more information contact
S Luding | 053 489 4212 | s.luding@utwente.nl
Theory of chaos and dynamical systems

Advanced Modelling in Science (150910)

Prof.dr. EWC van Groesen, UT
For the content see : www.mastermath.nl/courses/00005/00004.
For more information contact
EWC van Groesen | 053 489 3413 | e.w.c.vangroesen@utwente.nl

Chaos (3T220)

Prof.dr.ir. W van de Water, TUE
Chaos is the disordered behavior of nonlinear systems with just a few degrees of freedom: very simple but nonlinear systems. We will see why the route to chaos is often universal. This universality is contained in a renormalization theory, which expresses the invariance of the dynamics under a change of scale. We will discuss the Feigenbaum-- Cvitanovic renormalisation equation for the route to chaos through period doublings. Next, we will walk the road to chaos along the golden mean in the case of competition of nonlinear oscillators. The emphasis will be on systems with dissipation, but we will see a simple geometric description of the route to chaos in Hamiltonian systems. A theory of scales is beautifully illustrated by the concept of fractals. It is possible to give a thermodynamic description of these strange things. We will discuss practical applications to control nonlinear systems and to influence chaos. A central theme of this course is the application of the ideas of Chaos to hydrodynamics. It will appear that an interesting theory of turbulence can be based on fractal scaling, and it will also appear that the motion of tracers in viscous fluids has a one to one correspondence with chaotic Hamiltonian dynamics. The course has two “Tutorials”: problem solving sessions, the results of which partly determine the grade for the course. In addition, the participants are asked to present an article from the recent literature (Physical Review Letters) on a subject covered in the course. Of course, adequate coaching is offered for this final presentation.
For more information contact
W van de Water | 040 247 3443 | w.v.d.water@tue.nl
Combustion

Chemically reacting flows (4BC00)

Dr.ir. JA van Oijen, TUE
Reacting flows play an important role in energy conversion systems. Chemical reactions are essential in the conversion of fuels in heat and other useable forms of energy. Some examples are heating boilers, biomass gasifiers, combustion engines, gas turbines and furnaces for steel and glass manufacturing. In order to design such conversion systems, good understanding of the fundamental physical and chemical processes that occur in chemically reacting flows is inevitable. The mathematical models that describe these processes will be presented and used to analyze simple chemical reactors and combustion systems. The use of numerical tools for the design of energy conversion systems will be trained in a practical work. These skills and knowledge are inevitable for the design of energy systems that convert future durable fuels in a clean and efficient way.

For more information contact
Dr.ir. JA van Oijen | 040 247 3133 or 2140 | j.a.v.oijen@tue.nl

Gasturbines (4P700)

Dr.ir. HC de Lange, TUE
The gasturbine is one of the most often used machines in the production of mechanical power. In this course a number of application areas (aero engines, turbochargers, industrial applications) will be discussed. Using the book by Cohen et al. the thermo- and fluidodynamics of turbomachines is studied. First, different systems (using intercooling, regeneration, etc.) are compared using simple thermodynamical theory. They show the applicability and efficiency of different processes. Second, the working principles of both radial and axial compressors are explained based on compressible flow equations (both one- and more dimensional). Using aerodynamical arguments the working of a combined compressor/turbine is discussed, both in the design-point as well as at offdesign conditions. Besides the stationary flow considerations, a number of dynamical aspects (acceleration, stall, surge, etc.) will discussed.


For more information contact
HC de Lange | 040 247 2129 | h.c.d.lange@tue.nl
Turbulent reacting flows (ME1540)

Prof.dr. DJEM Roekaerts, TUD
Models for interaction between turbulent flow and chemical reaction are treated. The main question addressed is by which method or model the mean properties of the flow can be obtained without having to solve the transport equations in full detail. Such methods are useful in the design of industrial combustion chambers, chemical reactors and in the description of reactions in the atmosphere. In the first part, basic aspects are developed (transport equations, reaction kinetics, non-dimensional numbers and regime diagrams, fundamentals of a statistical description, laminar flames). In the second part a more extensive introduction to turbulent combustion is presented. Methods for handling the closure problems arising in averaged or filtered transport equations are described and evaluated (RANS, LES, flamelet model, probability density function method). Simple application exercises are made. Depending on the specific interest of the student, additional topics can be added.

For more information contact
DJEM Roekaerts | 015 278 2470 | d.j.e.m.roekaerts@tudelft.nl

Non-linear differential equations (WI4019TU)

Dr.ir. WT van Horssen, TUD
1st semester, second quarter.
Pre-knowledge: an introductory course on Differential Equations e.g. Boyce and DiPrima, Chapters 2-7, 9.

For more information contact
WT van Horssen | 015 278 3524 | w.t.vanhorssen@tudelft.nl

Advanced combustion diagnostics using laser techniques (4P620)

Dr. NJ Dam, TUE
The main goal of this course is to achieve knowledge and understanding of the use and applications of various laser-optical techniques for diagnostics of fluid flow in general, and of high temperature systems (combustion) in detail. Of specific interest is to develop insight into various non-intrusive techniques for species concentration measurements, temperature measurements and methods for particle characterization in high temperature environments.

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After a brief overview of laser-optical diagnostics techniques and an introduction to basic molecular spectroscopy and optical-laser instrumentation, the course involves the following subjects:

- Diagnostics of soot characterization by scattering/extinction and Laser-Induced Incandescence (LII);
- Theory and fundamentals of Laser-Induced Fluorescence followed by thermometry and imaging applications;
- Rayleigh and Raman scattering for species concentration measurements and thermometry;
- Non-linear optical techniques, e.g. Four-Wave Mixing techniques and Polarization spectroscopy for minor species detection;
- Finally an overview of emerging techniques, e.g. Ballistic imaging for diagnostics in dense sprays and picosecond LIDAR measurements for spatially resolved measurements in environments with limited optical access.

For more information contact
NJ Dam | 040 247 2117 | n.j.dam@tue.nl

Engines: Modeling and analysis

LMT Somers, TUE
In this lecture series the student will apply the first law of thermodynamics to the general systems of reacting mixtures. The course covers aspects related to cycle simulation tools (modeling) and analysis approaches for engine experiments (analysis). Modeling: a matlab based computer program to simulate a real engine cycle using a modeled combustion progress (Wiebe-like). The oral lectures are short and only meant to give a concise introduction to the problem. A systematic approach is used to increase the complexity in a gradual way through the organization of the lectures series. Emphasis is not on numerics but on physics. Analysis: experiments performed on a Heavy-Duty diesel engine (12.4l DAF) will be analyzed. Using the same first law analysis as above, the Sankey diagram will be determined and engine parameters like thermal efficiency, BMEP etc, computed. A so-called heat-release model is developed. The course is mainly in hands-on exercise and a notebook and Matlab are required. Final term: written report and a final presentation (10-15 min).

For more information contact
LMT Somers | 040 247 2107 | l.m.t.somers@tue.nl

Fuels and Lubes (4N850)

Ir. HJ van Leeuwen, dr.ir. M Meijer, ir. PC Bakker
Geopolitical, environmental and societal factors are forcing the automotive industry to develop more efficient and cleaner burning engines. In current engine design processes, fuels and lubricants are regarded as “facts of life”. However, future requirements in terms of fuel efficiency and emissions, may be easier to meet when the chemical structure of fuels and lubricants is adjusted in a proper way.
Therefore, a lot of research is going on worldwide to characterize alternative fuels such as biofuels, synthetic fuels, oxygenated fuels, dual fuelling strategies, and so on. The same holds for lubricants research. In the course, starting from knowledge of the molecular (hydrocarbon) structure of fuels and lubricants available today (plus the likely options for the future), the student will learn to compute or estimate the relevant physical (density, saturation pressure, viscosity) and chemical properties (e.g. auto-ignition, heating value, adiabatic flame temperature). Essential engine processes such as lubrication, spray formation, evaporation, and formation of emissions (such as NOx and soot) in an engine will be discussed with emphasis on which physical, chemical and tribological properties of fuels and lubricants play a role. The ultimate goal is the ‘reverse engineering’ step: given the requirements to the engine, the student should be able to ‘design’ the proper fuel and lubricant for a given application. Near the end of the course trends in fuels and lubricants are discussed and further illustrated in guest lectures by leading experts.

For more information contact  
HJ van Leeuwen | 040 247 3063 | h.j.v.leeuwen@tue.nl

**Powertrain components (4AT00)**

Dr.ir. LMT Somers, dr.ir. T Hofman
This introductory course on automotive power trains (including engine and transmission), covers the basic technology behind automotive vehicle propulsion. In the introductory lecture, basic road load forces will be discussed in order to derive the amount of torque and power a vehicle power train should deliver. Next, the principles of 4-stroke Internal Combustion Engine are discussed (components, kinematics and operating characteristics). Some elements of ICE operation (a.o. gas exchange, cycles, thermo chemistry and fuels, fuel consumption and emissions) are discussed in more depth in order to enable students to make quantitative computations. The course continues by treating the history and basic principles of the automotive drive train and its components. The aim of this part is to obtain a broad (and in some aspects deep) insight in components, systems and system designing of vehicle drive trains. Some basic powertrain modeling techniques will be treated, followed by the somewhat more detailed analysis of the Toyota Prius powertrain. This example and others will be used to explain the challenges that powertrain designers are facing nowadays. The course consists of 16 hours of lectures, approximately 12 hr’s of guided selfstudy, and some additional practicals at the laboratories of Automotive Engineering Science (2x half a day). The course runs in the first quartile of the academic year.

For more information contact  
LMT Somers | 040 247 2107 | l.m.t.somers@tue.nl
Turbulence

Turbulence in hydraulics (CIE5312)

Prof.dr.ir. WSJ Uijttewaal TUD
This course is an introduction to turbulence with applications in hydraulics. The subjects treated are: statistical description of turbulence, Reynolds equations, energy equation, turbulent boundary layers, free shear flows, turbulence models, dispersion and diffusion, experimental techniques.

For more information contact
WSJ Uijttewaal | 015 278 1371 | w.s.j.uijttewaal@tudelft.nl

Turbulence A (wb1424A)

Dr.ir. WP Breugem TUD
In this course an introduction is given to the theory of turbulence. The course starts with the treatment of the properties of turbulence and the distinction between laminar and turbulent flows. This is followed by the treatment of linear stability theory applied to Kelvin-Helmholtz instability, the inflection criterion of Rayleigh and the Orr-Sommerfeld equation. Next follows a phenomenological treatment of turbulence, a discussion of Richardson’s energy cascade and the Kolmogorov 1941 theory on the micro and macrostructure of turbulence. The statistical treatment of stochastic processes is discussed and the Reynolds-Averaged Navier-Stokes (RANS) equations are derived. This leads to a discussion of the closure problem for the Reynolds stress and the introduction of the gradient-diffusion hypothesis and K-theory for the turbulent viscosity. The RANS equations are then applied to boundary-free shear flows such as jets and wakes. For jets and wakes an analytical expression for the mean velocity profile can be derived based on an order-of-magnitude analysis and the assumption of self-similarity. Next the RANS equations are applied to wall-bounded shear flows such as channel and pipe flows. Approximate analytical expressions are derived for the mean velocity in the inner and the outer layer. The logarithmic law is derived for the mean velocity in the overlap region. The influence of wall roughness and a streamwise pressure gradient on wall-bounded turbulence is discussed. The transport equations are derived for the mean and the turbulent kinetic energy and related to Richardson’s energy cascade. The effect of buoyancy is explained by means of the flux Richardson number and the Obukhov length. Several popular models are discussed for the turbulent viscosity such as the k-epsilon model. The strengths and weaknesses of these models are demonstrated by means of simulations with a commercial Computational Fluid Dynamics (CFD) package. The concept of Direct Numerical Simulation (DNS) and Large Eddy Simulation (LES) is explained. Finally, an introduction is given to energy spectra and correlations of turbulent flows. The -5/3 law for the spectrum of turbulence in the inertial subrange is derived.

For more information contact
WP Breugem | 015 278 8663 | w.p.breugem@tudelft.nl
Advanced Physical Transport Phenomena (TN375-3)

Dr.ir. S Kenjeres, TUD
The covered subjects are: heat diffusion: stationary and instationary transport, moving boundary problems; mathematical methods: separation of variables, Laplace transformation, integral methods; momentum transport: potential flow, creeping flow, boundary layer flow; turbulence modelling; numerical methods in Computational Fluid Dynamics.

For more information contact
S Kenjeres | 015 278 3649| s.kenjeres@tudelft.nl

Turbulence (358001)

Prof.dr. D Lohse, UT
Subjects: Navier-Stokes equations, hydrodynamic instabilities, routes to chaos, transition to turbulence, Rayleigh-Benard convection, Boussinesq equation, fully developed turbulence, Kolmogorov, intermittency, phenomenological models for intermittency, cascade models, Keps model, boundary layer theory, turbulent diffusion.

For more information contact
D Lohse | 053 489 8076 | d.lohse@utwente.nl
**Waves and free-surface flows**

Open channel flow (CTB3350/CIE3310-09)

Dr. ir. RJ Labeur, TUD

Subjects to be treated are: basic equations for long waves in open channels and in closed conduits; categories of long waves in open channels: translatory waves, tides, harbour oscillations, floodwaves in rivers; translatory waves of low and finite height; method of characteristics; harmonic method for sinusoidal wave propagation with linearised damping; flood waves in rivers.

For more information contact
RJ Labeur | 015 278 5069 | r.j.labeur@tudelft.nl

Stratified flows (CT5302)

Dr. JD Pietrzak, TUD


For more information contact
JD Pietrzak | 015 278 5466 | j.d.pietrzak@tudelft.nl

Ocean waves (CT5316)

Dr. ir. LH Holthuijsen, TUD

Subjects to be treated are: concepts from the theory of stochastic processes, energy-density spectrum, wind waves considered as stochastic processes in space and time, statistical properties, development and propagation of wind waves, wave climate, spectral calculations and responses.

For more information contact
LH Holthuijsen | 015 278 4803 | l.h.holthuijsen@tudelft.nl

Physical Oceanography (CT5317)

Dr. JD Pietrzak, TUD

The Free surface flow course will deal with the following topics: The physics of free surface waves; Linear wave theory, non-linear waves; Short waves, shallow water waves; Numerical methods for various wave models, e.g. Delft3D and SWAN.

For more information contact
JD Pietrzak | 015 278 9455 | j.d.pietrzak@tudelft.nl
River Systems (540021)

Dr. JJ Warmink, UT
Introductory into the physical processes in natural river systems. Phenomena in natural river system are explained and described in a qualitative way. The following processes are discussed: meandering, shifting riverbeds, bank erosion, stream roughness and sort processes. This course is a prerequisite for Shallow water flow (540041) and Transport processes and morphology (540042).

For more information contact
JJ Warmink | 053 489 2831 | j.j.warmink@utwente.nl

Shallow water flow (540041)

Dr.ir. JS Ribberink, UT
In this course steady and unsteady shallow water flows are discussed for rivers, with topics such as backwater curves, flood waves, tidal flows. Dynamic behavior and physical mathematical modeling will be discussed particularly for 1-D flows. Case studies from river management will be used to illustrate flow phenomena and the influence of human interventions. Application of a 1-d river model will be exercised in a computer class.

For more information contact
JS Ribberink | 053 4892767 | j.s.ribberink@utwente.nl

Transport processes and morphology (540042)

Dr.ir. JS Ribberink, UT
This course involves i) transport processes of dissolved substances and sediment (advection, diffusion, exchange with bottom), ii) morphologic processes, as occur in surface water systems. Understanding and modelling spreading of suspended sediment, bed load of sand or gravel, erosion or sedimentation of the bottom (morphology). Insight in characteristics and dynamic behaviour, particularly for river systems. The basis is formed by 1-D physical mathematical models. Transport processes and morphology, either or not affected by human interventions, will be analysed for practical examples. In a computer exercise, a 1-D (numerical) model will be applied to a particular morphologic river problem.

For more information contact
JS Ribberink | 053 4892767 | j.s.ribberink@utwente.nl
Marine Systems (540024)

Dr. TAGP van Dijk, UT & Deltares
Introduction to physical processes in a marine environment. The physical processes are described and explained in a qualitative way. The following processes are discussed: behaviour of waves, tide, sediment transport, beach morphology as well as the main characteristics of estuaries, river delta’s, continental shelves and shallow seas. The course Marine Systems provides knowledge for Marine Dynamics II (540081) and Seminar Morphology (540082).

For more information contact
TAGP van Dijk | 053 489 4701 | t.a.g.p.vandijk@utwente.nl

Marine Dynamics (195400800)

Dr.ir. PC Roos, BW Borsje (UT)
This course focuses on a quantitative description of marine processes, which were considered in a more qualitatively sense in the course Marine Systems (195400240). The course consists of two parts. The first part deals with tides and ocean currents, involving e.g. Kelvin waves and Ekman dynamics. The second part is about short waves and nearshore morphodynamics, covering e.g. linear wave theory, sediment transport and coastline evolution models.

For more information contact
BW Borsje | 053 489 1094 | b.w.borsje@utwente.nl

Morphology (195410200)

Prof.dr. SJMH Hulscher, UT
In the course Morphology five topics are discussed that have a relation with morphology of rivers, estuaries, coasts and seas. Physics play an important role in this. Because understanding and predicting morphology is often necessary to support control, the link with practice often comes into play. An example is the widening of the Westerschelde, maintaining the coast line, controlling pipe lines in a dynamic seabed with sand waves. By means of recent articles these topics are studied; the articles are presented by students and the topic is discussed using the associated assignments. Moreover, every student reviews a paper, written by a researcher form the Water Engineering and Management department. This paper is ready to submit or just submitted to a peer-reviewed journal. Finally, every student focuses on a subject, individually or in pairs, which is laid down in a short report and a poster. This poster is presented and commented to other students and lecturers during a final poster session.

For more information contact
SJMH Hulscher | 053 489 4256 | s.j.m.h.hulscher@utwente.nl
Micro-scale fluid mechanics

Microfluidics (WB1429)

Prof.dr.ir. J Westerweel TUD
This course is an introduction to fluid mechanics at small scales. The subjects treated are:
Scaling laws, Navier-Stokes equations for micro-scale gas and liquid flows, for electroosmotic
flow, electrophoresis, dielectrophoresis, dispersion and diffusion, capillary effects,
experimental techniques, applications in flow control, flow sensors, valves, pumps, mixers,
filters, separators, heaters and life science applications.

For more information contact
J Westerweel | 015 278 6887 | j.Westerweel@tudelft.nl
Experimental techniques in fluid mechanics

Experimental techniques in physics of fluids (193580020)

Dr. C Sun, UT
Experimental techniques for flow measurements, like particle image velocimetry, laser-Doppler anemometry, hot-wire anemometry, and high-speed imaging, are to be included in the course. Various modern techniques, as Topographic PIV/PTV and micro/nano-PIV, will also be covered in this course. In the lectures, principles and specific advantages and limitations of the techniques will be discussed. This knowledge will be taught in lectures and deepened with research articles and homework questions. Following the lectures, hands-on experiments will be organized. In groups of two students, a specific measurement problem will be solved with one of the techniques presented in the course. The participants write a concise report and prepare a presentation on their work.

For more information contact
C Sun | 053 489 5604 | c.sun@utwente.nl
Mechanical Engineering - Mekelweg 2 - 2628 CD Delft
♦ Prof.dr.ir. J Westerweel 015 278 6887 j.westerweel@tudelft.nl
Prof.dr. DJEM Roekaerts 015 278 2470 d.j.e.m.roekaerts@tudelft.nl
Prof.dr.ir. RAWM Henkes 015 278 1323 r.a.w.m.henkes@tudelft.nl
Prof.dr. JCR Hunt 015 278 2904 jcrh@cpom.ucl.ac.uk
Prof.dr.ir. G Ooms 015 278 1176 g.ooms@tudelft.nl
Prof.dr.ir. B Eckhardt 015 278 2904 bruno.eckhardt@physik.uni-marburg.de
♦ Prof.dr.ir. BJ Boersma 015 278 7979 b.j.boersma@tudelft.nl

Maritime Engineering - Mekelweg 2 - 2628 CD Delft
♦ Prof.dr.ir. RHM Huijsmans 015 278 2889 r.h.m.huijsmans@tudelft.nl
Prof.dr.ir. TJC van Terwisga 015 278 6860 t.v.terwisga@tudelft.nl
♦ Prof.dr.ir. C van Rhee 015 278 3973 c.vanrhee@tudelft.nl

Applied Mathematics - Mekelweg 4 - 2628 CD Delft
♦ Prof.dr.ir. C Vuik 015 278 5530 c.vuik@tudelft.nl
Prof.dr.ir. P Wesseling 015 278 3631 p.wesseling@tudelft.nl
♦ Prof.dr.ir. AW Heemink 015 278 5813 a.w.heemink@tudelft.nl

Chemical Engineering - Julianalaan 136 - 2628 BW Delft
♦ Prof.dr.ir. CR Kleijn 015 278 2835 c.r.kleijn@tudelft.nl
Prof.dr. RF Mudde 015 278 2834 r.f.mudde@tudelft.nl
Prof.dr.ir. HEA van den Akker 015 278 5000 h.e.a.vandenakker@tudelft.nl
Prof.dr.ir. S Sundaresan 015 278 5000 sundar@princeton.edu
♦ Prof.dr.ir. MT Kreutzer 015 278 9084 m.t.kreutzer@tudelft.nl

Radiation Science and Technology - Mekelweg 15 - 2629 JB Delft
♦ Prof.dr.ir. THJJ van der Hagen/Rohde 015 278 2105 t.h.j.j.vanderhagen@tudelft.nl
Aerospace Engineering - Kluyverweg 2 - 2600 GB Delft
♦ Prof.dr.ir. H Bijl 015 278 5373 h.bijl@tudelft.nl
Prof.dr.ir. F Scarano 015 278 9111 f.scaranoo@tudelft.nl
Prof.dr.ir. PG Bakker 015 278 5907 p.g.bakker@tudelft.nl

Civil Engineering and Geosciences - Stevinweg 1 - 2628 CN Delft
♦ Prof.dr.ir. GS Stelling 015 278 5426 g.s.stelling@tudelft.nl
Prof.dr.ir. WSJ Uijttewaal 015 278 1371 w.s.j.uittewaal@tudelft.nl
♦ Prof.dr. HJJ Jonker 015 278 6157 h.j.j.jonker@tudelft.nl
Prof.dr. AP Siebesma 015 278 4720 a.p.siebesma@tudelft.nl

TUE | 040 247 9111 | PO Box 513 - 5600 MB Eindhoven

Applied Physics
♦ Prof.dr.ir. AA Darhuber 040 247 4499 a.a.darhuber@tue.nl
Prof.dr.ir. JH Snoeijer 040 247 9111 j.h.snoeijer@tue.nl
Prof.dr.ir. MEH van Dongen 040 247 3194 m.e.h.v.dongen@tue.nl
♦ Prof.dr. HJH Clercx 040 247 2680 h.j.h.clercx@tue.nl
Prof.dr. GJF van Heijst 040 247 2722 g.j.f.v.heijst@tue.nl
Prof.dr. F Toschi 040 247 3911 f.toschi@tue.nl
Prof.dr. BJ Geurts 040 247 4285 b.j.geurts@tue.nl
♦ Prof.dr.ir. K Kopinga 040 247 4303 k.kopinga@tue.nl
Prof.dr.ir. OCG Adan 040 247 3398 o.c.g.adan@tue.nl
♦ Prof.dr.ir. GMW Kroesen 040 247 4357 g.m.w.kroesen@tue.nl

Mechanical Engineering
♦ Prof.dr. LPH de Goey/Bastiaans 040 247 2938 l.p.h.d.goey@tue.nl
Prof.dr. B Johansson 040 247 3731 b.johansson@tue.nl
♦ Prof.dr.ir. JJH Brouwers 040 247 5397 j.j.h.brouwers@tue.nl
Prof.dr. Golombek 040 247 3664 m.golombek@tue.nl
♦ Prof.dr.ir. DMJ Smeulders 040 247 2140 d.m.j.smeulders@tue.nl
Prof.dr.ir. AA van Steenhoven 040 247 2140 a.a.v.steenhoven@tue.nl
Prof.dr. HA Zondag 040 247 2719 h.a.zondag@tue.nl
♦ Prof.dr.ir. JMJ den Toonder 040 247 5706 j.m.j.d.toonder@tue.nl
♦ Prof.dr.ir. EH van Brummelen 040 247 5470 e.h.v.brummelen@tue.nl

Biomedical Engineering
♦ Prof.dr.ir. FN van de Vosse 040 247 4218 f.n.v.d.vosse@tue.nl
Mathematics and Computer Science

♦ Prof.dr.ir. B Koren 040 247 2080 b.koren@tue.nl
Prof.dr. WHA Schilders 040 247 5518 w.h.a.schilders@tue.nl
Prof.dr. F Toschi 040 247 3911 f.toschi@tue.nl
Prof.dr.ir. CJ van Duijn 040 247 2855 c.j.v.duijn@tue.nl
Prof.dr. MA Peletier 040 247 2628 m.a.peletier@tue.nl
Prof.dr. IS Pop 040 247 5516 i.s.pop@tue.nl
Prof.dr. JJM Slot 040 247 2184 j.j.m.slot@tue.nl

Chemical Engineering and Chemistry

♦ Prof.dr.ir. JAM Kuipers 040 247 4158 j.a.m.kuipers@tue.nl
Prof.dr.ir. M van Sint Annaland 040 247 2241 m.v.sintannaland@tue.nl

Applied Physics

♦ Prof.dr. WJ Briels 053 489 2947 w.j.briels@utwente.nl
♦ Prof.dr. D Lohse 053 489 8076 d.lohse@utwente.nl
Prof.dr.ir. D van de Meer 053 489 2387 d.vandermeer@utwente.nl
Prof.dr.ir. M Versluis 053 489 6824 m.versluis@utwente.nl
Prof.dr. A Prosperetti 053 489 9111 prosperetti@jhu.edu
Prof.dr.ir. JF Dijksman 06 2334 1331 j.f.dijksman@ziggo.nl
Prof.dr.ir. L van Wijngaarden 053 489 3086 l.vanwijngaarden@tnw.utwente.nl
Prof.dr. R Verzicco 053 489 2470 r.verzicco@utwente.nl
♦ Prof.dr. F Mugele 053 489 3094 f.mugele@utwente.nl

Chemical Engineering

♦ Prof.dr.ir. RGH Lammertink 053 489 2063 r.g.h.lammertink@utwente.nl

Mathematical Sciences

♦ Prof.dr.ir. EWC van Groesen 053 489 3413 e.w.c.vangroesen@utwente.nl
♦ Prof.dr.ir. JWW van der Vegt 053 489 5628 j.j.w.vandervegt@utwente.nl
♦ Prof.dr.ir. BJ Geurts 053 489 4125 b.j.geurts@utwente.nl
Prof.dr. JGM Kuerten 053 489 3408 j.g.m.kuerten@utwente.nl
Prof.dr. HJH Clercx 053 489 3408 h.j.h.clercx@utwente.nl

Mechanical Engineering

♦ Prof.dr.ir. HWM Hoeijmakers 053 489 4838 h.w.m.hoeijmakers@utwente.nl
Prof.dr.ir. A Hirschberg 040 247 2163 a.hirschberg@tue.nl
♦ Prof.dr.ir. ThH van der Meer 053 489 2562 t.h.vandermeer@utwente.nl
♦ Prof.dr. S Luding 053 489 4212 s.luding@utwente.nl
Water Engineering and Management
♦ Prof.dr. SJMH Hulscher 053 489 4256  s.j.m.h.hulscher@utwente.nl

RUG | 050 363 9111 | PO Box 800 - 9700 AV Groningen

Mathematics
♦ Prof.dr. AEP Veldman 050 363 3988 veldman@math.rug.nl

WUR | 0317 477 477 | PO Box 9101 - 6701 BH Wageningen

Experimental Zoology
♦ Prof.dr.ir. JL van Leeuwen 0317 482267 johan.vanleeuwen@wur.nl

UU | 030 253 9111 | PO Box 80125 - 3508 TC Utrecht

Physics and Astronomy
♦ Prof.dr. LRM Maas 0222 369 419 maas@nioz.nl
♦ Prof.dr.ir. HA Dijkstra 030 253 5441 h.a.dijkstra@uu.nl

Board of Directors
Prof.dr.ir. G Lodewijks (TUD, Chairman) 015 278 9111 g.lodewijks@tudelft.nl
Ir. AJ Dalhuijsen (VSL) 015 269 1500 adalhuijsen@vsl.nl
Prof.dr.ir. CR Kleijn (TUD) 015 278 2835 c.r.kleijn@tudelft.nl
Prof.dr.ir. JJW van der Vegt (UT) 053 489 5628 j.j.w.vandervegt@utwente.nl
Prof.dr.ir. GMW Kroesen (TUE) 040 247 4357 g.m.w.kroesen@tue.nl

Management Team
Prof.dr.ir. GJ van Heijst (TUE) 040 247 2722 g.j.f.v.heijst@tue.nl
Prof.dr. D Lohse (UT) 053 489 8076 d.lohse@utwente.nl
Prof.dr.ir. J Westerweel (TUD) 015 278 6887 j.westerweel@tudelft.nl
Industrial Board
Dr. ir. J Baltussen (AKZO-Nobel) 026 366 1479 joop.baltussen@akzonobel-chemicals.com
Ir. A van Berkel (TNO Science & Industry) 055 549 3759 arij.vanberkel@tno.nl
Ir. AJ Dalhuijsen (VSL) 015 269 1500 adalhuijsen@vsl.nl
Dr. E Pelssers (Philips Research) 06 40326208 eduard.pelssers@philips.com
Dr. RPJ Duursma (Tata Steel) 0251 492 363 rene.duursma@tatasteel.com
Ir. A van Garrel (ECN) 0224 564170 vangarrel@ecn.nl
Ir. J Gonzalez del Amo (ESA/ESTEC) 071 565 4781 jose.gonzalez.del.amo@esa.int
Ir. G Hommersom (Dow Benelux) 0115 67 4102 ghommersom@dow.com
Dr. ir. J Janssen (Unilever) 010 460 6324 jo.janssen@unilever.com
Dr. ir. M Veenman (DSM) 046 476 1240 maurice.veenman@dsm.com
Ir. JJ Meerman (Teijin Aramid) 088 268 9367 hans.meerman@teijinaramid.com
Prof. dr. ir. AE Mynett (WL) 015 285 8580 a.mynett@unesco-ihe.org
Dr. B Oskam (NLR) 020 511 3357 oskam@nlr.nl
Dr. ir. HJ Prins (Marin) 0317 493 405 h.j.prins@marin.nl
Ir. H Reinten (Oce) 077 359 4061 hans.reinten@oce.com
Ir. M Riepen (ASML) 040 268 3000 michiel.riepen@asml.nl
Ir. G Saccoccia (ESA/ESTEC) 071 565 4781 giorgio.saccoccia@esa.int
Ir. P Veenstra (Shell) 020 630 3384 peter.veenstra@shell.com
Ir. R Verraar (TNO Defence and Safety) 015 284 3395 ronald.verraar@tno.nl
Dr. ir. FC Visser (Flowserve) 076 502 8311 fvisser@flowserve.com
Ir. H Vos (TNO Science & Industry) 015 269 2311 hugo.vos@tno.nl
Dr. ir. B Vreman (AKZO-Nobel) 026 366 9440 bert.vreman@akzonobel.com
Dr. J Longo (ESA/ESTEC) 071 565 6662 jose.longo@esa.int
Dr. ir. J van ‘t Westeinde (Deltares) 015 278 3210 jos.vantwesteinde@deltares.nl
Ir. M Roest (VORTECH) 015 285 0127 mark.roest@vortech.nl

PhD Students Contact Group

TUD
AJ Greidanus 015 278 9111 a.j.greidanus@tudelft.nl
M Olivero 015 278 9479 m.olivero@tudelft.nl
JSB van Zwieten 015 278 9111 j.s.b.vanzwieten@tudelft.nl
PB Smit 015 278 9111 p.b.smit@tudelft.nl
X Yang 015 278 9111 xiaogang.yang@tudelft.nl
D Violato 015 278 5902 d.violato@tudelft.nl

TUE
HM Slagter 040 247 3685 h.m.slagter@tue.nl
RPC Zegers 040 247 5689 r.p.c.zegers@tue.nl
CWJ Berendsen 040 247 9111 c.w.j.berendsen@tue.nl
UT
B Bera 053 489 9111 b.bera@utwente.nl
H Gelderblom 053 489 9111 h.gelderblom@tnw.utwente.nl
HJJ Staat 053 489 9111 h.j.j.staat@utwente.nl
W Kranenburg 053 489 2959 w.m.kranenburg@ctw.utwente.nl
BJ Konijn 053 489 9111 b.j.konijn@utwente.nl
AA Verbeek 053 489 2507 a.a.verbeek@utwente.nl

RUG
HJL van der Heiden 050 363 3970 h.j.l.van.der.heiden@rug.nl

JM Burgerscentrum (the Netherlands)
Prof.dr.ir. G Ooms, scientific director 015 278 1176 g.ooms@tudelft.nl
(until 1 July 2014)
Prof.dr.ir. GJF van Heijst, scientific director 040 247 2722 g.j.f.v.heijst@tue.nl
(as per 1 July 2014)

I Hoekstein-Philips, management assistent 015 278 3216 jmburgerscentrum@tudelft.nl
Mekelweg 2
2628 CD Delft

Burgers Program Maryland
James M Wallace, Professor, Dept. of Mechanical Engineering
www.eng.umd.edu/~wallace
Gemstone Program Director
www.gemstone.umd.edu/
Chair, Burgers Program for Fluid Dynamics
www.burgers.umd.edu/
T 301 314 6695
F 301 314 8469
E wallace@eng.umd.edu
Computed fluid temperature distributions in a random array of bidisperse particles

JAM Kuipers
Eindhoven University of Technology

Snapshots from the ultra high-speed recordings taken at a frame rate of 20 million frames per second display the focusing effect with excellent spatial and temporal agreement with the numerical predictions

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University of Twente

Non-zero entry pattern of a block-structured matrix

B Carpentieri
University of Groningen

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CH Venner, HWM Hoeijmakers
University of Twente