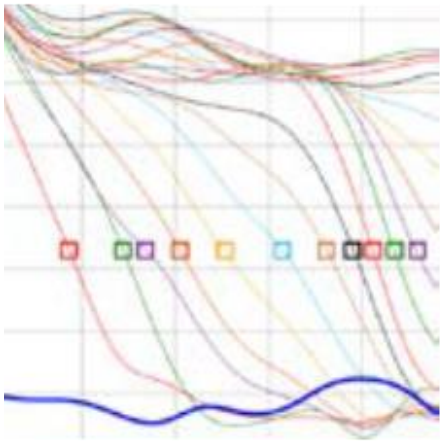
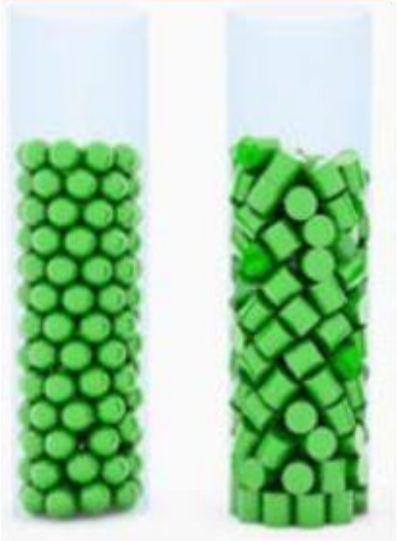
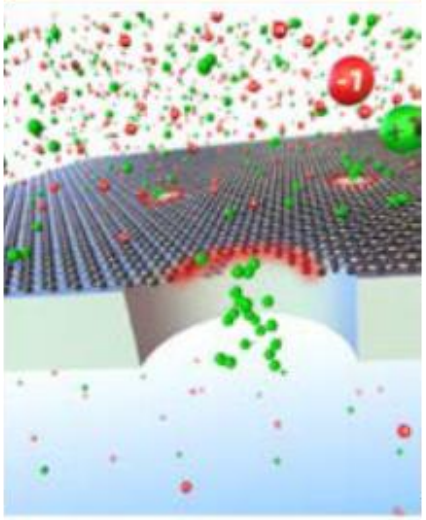


# Course Programme

2023

2024





J.M. Burgerscentrum

Research School for Fluid Mechanics

# Introduction

This guide provides an overview of the courses that are organised for the training of the PhD students of the J.M. Burgerscentrum (JMBC), the 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 PhD courses in the year 2023-2024, with information about the conditions to participate and instructions for registration. The courses are primarily organised for PhD students of the JMBC, although PhD students from other research schools and post-docs can also participate. Moreover, people from industries and technological institutes are also welcome to attend the courses.

Additional information about courses and more general information about the JM Burgerscentrum can be found on our website Burgerscentrum Courses.

Prof. dr. ir. Ruud A.W.M. Henkes

Scientific Director of the Burgerscentrum

# Structure of the PhD programme

## Purpose of the PhD programme

The purpose of the PhD programme of the J.M. Burgerscentrum is to help 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 its mathematical, physical, and numerical modelling, with experimental techniques for validation, is required. This also gives the ability to further develop this knowledge and to apply it to solve scientific and technical problems. Obviously, the main part of a PhD studies 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 consists of the participation in courses. Details of that latter part (the training programme) are given in this guide.

## Structure of the training programme

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

1. MSc courses
2. PhD courses
3. 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.

## MSc courses

The MSc degree fluid mechanics courses may be useful for PhD students (or other interested persons), who have had limited 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. Information about content, time and location of these courses can be found in the study guides of the different universities participating in the JMBC.

## 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 an MSc degree in fluid mechanics. The PhD courses of the J.M. Burgerscentrum fit this purpose. The deepening of knowledge is not restricted to the specific area of fluid mechanics, to which the research project of a PhD student belongs. After obtaining his/her PhD degree, the PhD student must be able to quickly acquaint himself/herself with a new area of fluid mechanics and solve problems in that area. Therefore, each PhD student registered within the J.M. Burgerscentrum is expected to participate in at least three PhD courses. The content of the courses is composed in such a way that the courses can be followed by all PhD students (independent of the knowledge obtained in their MSc degree programme). The different PhD courses of the J.M. Burgerscentrum are usually given once every two years, depending on the number of participants. The courses are concentrated in time, usually lasting one week or part of a week. The courses are given by senior staff members of the JMBC, but also by (internationally well-known) guest lecturers.

The courses may contain different elements: theory, exercises with numerical simulations, numerical simulations, lab demonstrations, etc. An active role of the participants is stimulated.

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

A less-structural part of the training programme of the JM Burgerscentrum consists of workshops, summer schools and seminars. It is recommended that a PhD student registered in the JM Burgerscentrum participates in one or more (international) summer schools. Also, courses organised by organisations such as the Von Karman Institute, ERCOFTAC, EUROMECH, CISM, etc. are highly recommended.

## Individual training programme

For each PhD student an individual training programme has to be designed within the framework of the graduate school of the particular university at which the PhD student is working. These graduate schools provide training in professional and personal skills, but not in the scientific expertise area in which the PhD student is working. That type of training is ideally provided by the research schools. The JM Burgerscentrum provides this scientific training in the area of fluid dynamics. Although the specific requirements of the graduate schools differ from university to university, PhD students of the J.M. Burgers Centre are generally supposed to take at least three JMBC courses, to be selected in consultation with the supervisor. After successful course participation of the JM Burgerscentrum, the PhD student will receive a number of credit points (ECTS credits), that can be used for fulfilling the requirements in their specific graduate school programme.

## JMBC certificate

After having attended at least three JMBC courses, each PhD student will receive the JMBC certificate. This document, listing the courses attended, may be helpful when applying for a job after the PhD graduation.

## Course evaluation form

Each participant of a JMBC course is asked to fill in a course evaluation form via the website of the JMBC. The evaluation form is anonymous. The JMBC scientific director will discuss the evaluation results with the course leader.

# Schedule of JMBC courses in 2023 – 2024

| | | |
|---|---|---|
| **25 – 29 Sept 2023** | **Rheology**<br>Joshua Dijksman et al. | **WUR** |
| **6 – 9 Nov 2023** | **Turbulence**<br>Wim-Paul Breugem and René Pecnik | **TUD** |
| **13 – 14 Dec 2023** | **Solution methods in computational mechanics**<br>Jan ten Thije Boonkkamp, Martijn Anthonissen | **TU/e** |
| **29 Jan – 2 Feb 2024** | **Particle-based modelling techniques**<br>Federico Toschi | **TU/e** |
| **5 – 9 Feb 2024** | **CFD 1**<br>Marc Gerritsma et al. | **TUD** |
| **8 – 12 Apr 2024** | **Fluids and Flows**<br>Federico Toschi | **CISM** |
| **21 – 23 May 2024** | **Micro- and nanofluidics**<br>Jaap den Toonder | **TU/e** |
| **7 – 11 Oct 2024** | **Active hydrodynamics**<br>Udo Sen and Corinna Maass | **WUR** |
| **4 – 7 Nov 2024** | **Experimental techniques in fluid mechanics**<br>Alvaro Marin and Michel Versluis | **UT** |
| **11 – 15 Nov 2024** | **Technological innovation with fluid mechanics**<br>Edwin Poorte | **TUD** |

# Description JMBC courses in 2023 - 2024

## Rheology

25-29 September 2023
*Location*: WUR
*Coordinator*: Jochem Jonkman
*Lecturers*: Joshua Dijksman, Leonard Sagis, others

This course is organized by the VLAG Graduate School at WUR, in collaboration with the Burgerscentrum.

Rheology is the study of flow and deformation of materials. Rheology is important in foods like mayonnaise and artificial meat, in processing but also for their sensory perception. It is also important for the design of products such as toothpaste gels, or concrete walls, or glue on a post-it note, or protein surfactants in an emulsion. Rheology is therefore a widely used tool relevant for both applied and fundamental research. The versatility of the subject makes that a broad understanding of the underlying concepts is essential to perform experiments and interpret data. This course aims to offer such a broad view. Participants will learn how to identify typical material characteristics in rheological data (yield stress, shear thinning, fracture, etc.).

*For more information, contact*:
Joshua Dijksman | j.a.dijksman@uva.nl

## Turbulence

6 – 9 November 2023
*Location*: TUD
*Coordinators*: Wim Paul Breugem, René Pecnik

This course gives an introduction to the fundamentals of turbulence. It is aimed at PhD students and other researchers from the JM Burgerscentrum. Prerequisite knowledge of turbulence is not required, though may be helpful to keep up with the pace of the lectures. Basic knowledge of fluid mechanics is assumed. The first 2 days of the course are dedicated to classical turbulence theory such as can be found in the textbooks of S.B. Pope (Turbulent Flows), P.A. Davidson (Turbulence) and Tennekes & Lumley (A First Course in Turbulence), among others. It concerns the qualitative behaviour, the statistical description, the underlying physics and the modelling of turbulence. During plenary instruction hours a few assignments will be given and discussed in order to practice the theory. On the third day of the course a demonstration will be given of the performance of several popular turbulence models with the help of a commercial CFD package (Fluent). Furthermore, an overview will be given of popular numerical and experimental methods for studying turbulent flows (such as DNS/LES, LDA/PIV). On the fourth day several guest lecturers will give an invited talk.

*For more information, contact:*
Wim Paul Breugem | 015 278 8663 | w.p.breugem@tudelft.nl
René Pecnik| 015 278 9153 | r.pecnik@tudelft.nl

## **Solution methods in computational mechanics** (EM-JMBC)

13 – 14 December 2023
*Location*: TUE
*Coordinators*: Jan ten Thije Boonkkamp, Martijn Anthonissen (TUE)

Partial differential equations (PDEs) are ubiquitous in (fluid) mechanics, describing a wide range of phenomena. This course will address some numerical methods for PDEs, and consists of two parts, first, discretization and time integration methods, and second, iterative methods for the resulting linear systems. The following topics are included:

- Classification of second order PDEs
- Finite difference methods for the Poisson equation (central differences, compact
- scheme)
- Finite volume methods for generic elliptic PDEs
- Advanced time integration methods for parabolic equations
- Discretisation methods for the wave equation (second and fourth order schemes)
- Basic iterative methods
- Krylov subspace methods
- Lanczos biorthogonalization
- Preconditioning

The discretization and time integration methods will be analysed in terms of accuracy and stability. We like to emphasize that finite element methods are not covered in this course. The course will include a number of computer sessions with MATLAB, in which the participants can put in practice the numerical methods introduced. The required prior knowledge is elementary numerical analysis.

*For more information, contact:*
Jan ten Thije Boonkkamp | 040 247 4123 | j.h.m.tenthijeboonkkamp@tue.nl

## **Particle-based modeling techniques**

29 Jan – 2 Feb 2024
*Location*: TUE
*Coordinator*: Federico Toschi
*Lecturers*: Federico Toschi, Gianluca Di Staso, Alex Lyulin, Stefan Luding, Johan Padding

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, Discrete Particle Method, Lattice Boltzmann techniques, Smoothed-particle hydrodynamics, Direct Simulation Monte Carlo.

*For more information, contact*:
Federico Toschi | 040 247 3911 f.toschi@tue.nl

## CFD 1

5 – 9 February 2024
*Location*: TUD
*Coordinator*: Marc Gerritsma
*Lecturers:* Marc Gerritsma, Barry Koren, Fred Wubs, Roel Verstappen

The course discusses the basic methods for solving the equations that describe the motion of fluids. It is organized as a series of lectures and computer exercises. The basic model problem is the convection-diffusion equation with dominating convection. A number of spatial discretization methods (non-uniform grids) will be discussed with their pros and cons (upwind/ central, lower/higher order, finite-difference/finite-volume). Also, the stability and accuracy of time-integration methods is shortly discussed. A next step is to study discontinuous solutions of the Euler equations, with focus on the numerical Riemann problem. Several numerical schemes for calculating shocks and contact-discontinuities will be presented; the concept of non-linear limiters is introduced. Finally, the incompressible Navier-Stokes equations are discussed. The positioning of the computational grid is assessed (staggered grids), as well as the treatment of boundary conditions.
Also, the use of mimetic methods for unstructured grids is explained. An application is the direct numerical simulation of turbulent flow.

*For more information, contact:*
Marc Gerritsma | 015 278 5903 | m.i.gerritsma@tudelft.nl

## Fluids and Flows

8 – 12 April 2024
*Location*: CISM, Udine (Italy)
*Coordinator*: Federico Toschi (TUE)
*Lecturers*: Federico Toschi (TUE), Roberto Benzi (Roma), Detlef Lohse (UT), Herman Clercx (TUE), Alessandro Corbetta (TUE), Bruno Andreotti (Université Paris Cité)
This lecture course is organised jointly with CISM, Udine (I)

The course will present a broad overview of fluids and flows ranging from the dynamics of complex fluids to the statistical description of complex flows. In particular the course will address the physics of yield stress materials, the rheology of dense fluid suspensions, the physics of laminar and turbulent flows, the turbulent transport of heat and mass. Lectures will present the phenomenology, the theoretical framework and, where appropriate, they will illustrate numerical and experimental approaches. The course addresses both the Dutch (JMBC) and the international scientific community (CISM).

*For more information, contact*:
Federico Toschi | 040 247 3911 | f.toschi@tue.nl

## Micro- and nanofluidics

21 – 23 May 2024
*Location*: TUE
*Coordinator*: Jaap den Toonder (TUE)
*Lecturers*: Jaap den Toonder (TUE), Hans Wyss (TUE), others

Micro- and nanofluidics is the science and technology of manipulating and analyzing fluid flow on length scales ranging from millimeters down to nanometers. It is the key enabling technology for many emerging applications and disciplines, especially in the fields of medicine, environmental sensing, biology, and chemistry. Also in engineering and the physical sciences microfluidic systems are employed in applications such as advanced printers, heat management, and energy generation. This course will cover a range of aspects of micro- and nanofluidics. These include (1) fundamentals of flow at small scales; (2) physical principles that play an important role in micro- and nanofluidics, and how these can be used to manipulate fluids at small scales; (3) microfluidics in nature, that can be used as an inspiration; (4) applications of micro- and nanofluidics; (5) micro- and nanofluidic device fabrication; and (6) valorization and commercialization of micro- and nanofluidics.

Note: As the lab at TUE is currently under re-construction, the practical workshop that usually is part of this course (to gain some hands-on experience with basic micro-fluidics device manufacturing and testing) has to be left out. Therefore, this time the course will only comprise lectures.

*For more information, contact*:
Jaap den Toonder | 040 247 5767 | j.m.j.d.toonder@tue.nl

## Active Hydrodynamics

7-11 October 2024
*Location:* Wageningen
*Coordinators:* Uddalok Sen (WUR) and Corinna Maass (UT)
*Lecturers:* Jacco Snoeijer, Mazi Jalaal, Hartmut Löwen, Marjolein Dijkstra, Alvaro Marin, Silke Henkes, Alexandre Morin, Matan Ben Zion, Luca Giomi, Idan Tuval, Daniel Tam, Chase Broedersz, Florian Muijres

Active matter systems are ubiquitous nonequilibrium condensed systems composed of self-driven (active) units capable of converting (stored or ambient free) energy into motion. These active units often interact with each other and/or interact with the ambient medium, which sometimes leads to the emergence of collective motion. The most-commonly observed active matter systems are observed in biology, but there have been significant advances in so-called `synthetic active matter' over the past decade as well. Active matter systems can be broadly classified into two groups: 'dry active matter' (where hydrodynamic interactions with the ambient are unimportant), and 'wet active matter' (where hydrodynamic interactions with the ambient must be taken into account). Finally, active

units at sufficiently high density can be regarded as intrinsically active fluids via continuum theories.

The course will focus on 'wet active matter', and will offer a fundamental introduction into activity at primarily low Reynolds numbers, hydrodynamic interactions of active agents with each other and their environment, and the implications for their dynamics and emergent behaviour. To familiarize course participants from the fluid dynamics community with general concepts in active matter, there will also be one introductory lecture on what is active matter, followed by one on 'dry active matter' (where hydrodynamic interactions are not important). These will be followed by lectures on the essential theoretical, modeling, and experimental techniques, before delving deeper into the details of specific cases of hydrodynamics in both synthetic and biological active matter systems. As part of the course, the participants will also have to perform a mini-project/case study on topics at the frontier of this rapidly evolving field. Finally, there will also be a panel discussion focusing on scenarios where one can ignore hydrodynamics and where it is absolutely crucial.

*For more information, contact:*
Uddalok Sen | uddalok.sen@wur.nl

## Experimental techniques in fluid mechanics

4 – 7 November 2024
*Location*: UT
*Coordinators*: Alvaro Marin (UT), Michel Versluis (UT)
*Lecturers*: Nico Dam (TU/e), Fulvio Scarano (TUD), Jan van Dijk (TU/e), Michel Versluis (UT), Alvaro Marin (UT), Christian Poelma (TUD), Willem van de Water (TUD), Rudie Kunnen (TU/e)

This course for JMBC PhD students gives a general overview of concepts of experimental methods for flow, pressure, concentration and temperature measurements. The course will discuss various classic techniques (thermocouples, Pitot tubes, hot-wire anemometry) and optical techniques such as shadowgraphy and Schlieren. The course will also focus on modern non-intrusive laser techniques (Laser Doppler and Phase Doppler Anemometry, Particle Imaging and Particle Tracking Velocimetry and Laser-Induced Fluorescence). We will discuss methods for flow visualization and high-speed imaging and we have special presentations on experimental methods used in two-phase flows, in rheology and in industrial applications.

*For more information, contact*:
Michel Versluis | 053 489 6824 | m.versluis@utwente.nl
Alvaro Marin | 053 489 2379 | a.marin@utwente.nl

## Technological innovation with fluid mechanics

11-15 November 2024
*Location*: TUD

*Coordinator*: Edwin Poorte
*Lecturer*: Edwin Poorte

This JMBC course is centred around technological innovation. You learn to develop a new technology, based on sound fluid mechanics principles. To succeed both technically and commercially, many challenges must be overcome. The objective is to take a wild innovative idea (for example an ocean drone, an electric plane, or a brilliant idea for the energy transition) and convert this into a technically feasible technology concept, that must also become commercially viable. Many interdisciplinary issues must be overcome to succeed: technical, economical, commercial, organisational, political and related to society. Close collaboration in an empowered and motivated innovation team is required to overcome blockers of progress.

Some 30% of this course is 'lecturing style format', where all relevant aspects of technological innovation will be covered. Some 40% of the course is in 'workshop format', where teams of participants will grasp the topic just covered in a lecture, by applying it to their technological innovation concept. Learning-by-doing requires close collaboration. The course instructor will facilitate each team such that creative and valuable ideas are included into the technology concept. The remaining about 30% of the course is 'interactive sessions', where participants openly exchange views on several aspects of technological innovation. This interaction allows to make the course highly relevant for the ongoing PhD project of a participant, or for future innovation endeavours as part of an aspired industrial career.

The various skills acquired in this course will be highly valuable for:

- PhD students that are working on an experimental topic in fluid mechanics (which requires to be innovative to develop the best possible experimental set-up);
- PhD students that have an ambition for an industrial career based on fluid mechanics and innovation;
- Industry participants that want to develop professionalism in technological innovation.

*For more information, contact:*
Edwin Poorte | 0638342806| Edwin@troyka-innovation.com

# Registration for JMBC courses

## Conditions

The PhD courses organised by the J.M. Burgerscentrum are primarily organised for the PhD students of the J.M. Burgerscentrum. They have priority with respect to registration for these courses. However, also PhD students from other research schools, post-docs and staff members from industries and technological institutes can participate.

## Fees

€ 250 | Officially registered JMBC PhD students and JMBC Postdocs.
Registration fee includes: course material, lunches, a joint dinner, and (if necessary) hotel accommodation. The hotel (if necessary) will be booked and paid for by the JMBC.

€ 400 | All other national and international PhD students, scientific staff, postdocs, post-graduate students. Registration fee includes: course material, lunches, and a joint dinner. Participants have to book their own hotel accommodation; no reimbursement is provided by the JMBC.

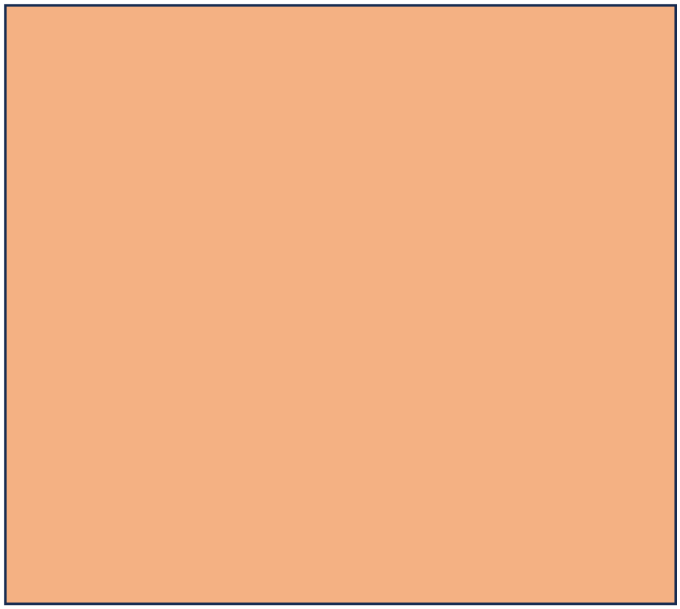
€ 1000 | Staff members from industries, technological institutes or other participants.
The registration fee includes: course material, lunches, and a joint dinner. Participants have to book their own hotel accommodation; no reimbursement is provided by the JMBC.

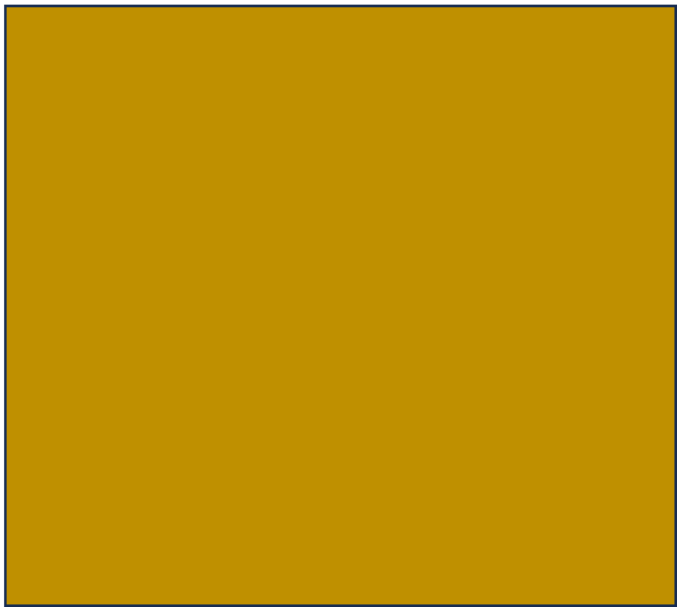
## Registration

Registration for the JMBC PhD courses is possible by filling in the online registration form on the website of the Burgerscentrum:
PhD courses for JMBC members
PhD courses for non-JMBC members

## Certificate of attendance

Directly after completing the course, each participant in a JMBC course will receive from the JMBC secretariat a “certificate of attendance” confirming his/her participation. Note that the full “JMBC certificate” is only obtained after having attended at least three JMBC courses.



# JMBC Course Programme

# 2023 - 2024