The Centre for Technical Geoscience is a national research school based in Delft. It offers a curriculum of graduate courses, which are especially dedicated to the PhD students of the participating institutions but also available to external participants.

Participants within CTG are:

- TU Delft
  - Faculty of Civil Engineering and Geosciences
  - Faculty of Applied Sciences
- Utrecht University
  - Faculty of Geosciences

Detailed information can be found on the CTG website: www.ctg.tudelft.nl

GRADUATE COURSES IN TECHNICAL GEOSCIENCE

COURSE PROGRAMME
2016 – 2017
The Delft-based Centre for Technical Geoscience is a national research school with a curriculum aiming at enlargement and integration of skills and knowledge in four main geo-disciplines:

- Wave field imaging
- Applied geology
- Stress and deformation
- Flow and transport
- Geodesy, Atmospheric Science and Remote Sensing

**COURSE SCHEDULE 2016-2017**

CTG's standard curriculum comprises various courses that are programmed over a two years period. For the course year 2016-2017 the scheduled courses are presented in this brochure. Additional courses might be planned during the year, please check our website or contact us to be put on the mailing list.

**Introduction courses**

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<th>Date Range</th>
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<tr>
<td>09 Jan - 13 Jan</td>
<td>tg030</td>
<td>Introduction to transport in porous media with applications in reservoir engineering and geo-environmental engineering (Bruining)</td>
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<td>01 Feb - 23 Feb</td>
<td>tg032</td>
<td>Seismic data processing: theory and practice (Gerritsma)</td>
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<td>29 Nov - 15 Dec</td>
<td>tg038</td>
<td>Seismic data and their physical information content (Drijkening/Verschuur)</td>
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<td>Practical aspects of reservoir simulation (Voskov)</td>
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**Advanced courses**

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<td>06 Sep – 16 Sep</td>
<td>tg131</td>
<td>Advanced wave theory for geoscientists (Fokkema/Wapenaar)</td>
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<td>25 Apr – 18 May</td>
<td>tg136</td>
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Looking for interesting MSc courses? Please check the MSc programmes of CTG’s participants via www.ctg.tudelft.nl
COMPACT INTRODUCTION COURSES

tg030 Introduction to transport in porous media with applications in reservoir engineering and geo-environmental engineering
Lecturer: Prof. Dr. J. Bruining, (j.bruining@tudelft.nl)
Entrance requirements: MSc level in science or technology
Course format: 5 full days of lectures and computer exercises; homework and reading assignments will complement the lectures. We will use COMSOL 5.2 to illustrate applications of porous media flow in petroleum and environmental engineering. It is necessary to take your laptop with you with COMSOL 5.2 and Excel installed.
Course date: 9-13 January 2017
GS credits: 5
Scope: Covers the scientific and engineering principles of flow in porous media. The topics covered are single-phase flow, multi-phase flow in porous media, wetting behavior, reservoir-fluids properties, material-balance principles, and reservoir-pressure interpretation. The successful course participant will understand the concepts and methodologies that are used currently in petroleum and environmental engineering.

tg032 Seismic data processing: theory and practice
Lecturer: Drs. P.H.A. Gerritsma (www.gerritsma-geophysical.nl)
Entrance requirements: MSc level in science or technology
Course format: 8 times of 4 hours of lectures
Course date: 1, 2, 8, 9, 15, 16, 22 & 23 February 2017
GS credits: 4
Scope: Seismic data processing typically consists of a sequence of specific processes where each process has a number of alternative implementations. This course gives an overview of the processes that are common in seismic data processing and discusses for each process the theory of the different implementations together with their practicality and inherent assumptions. The course starts with those topics of "digital signal processing theory" that are relevant for seismic data processing: Fourier and Laplace transform, linear systems, sampling, z-transform, inverse filtering and least-squares filters. The topics of seismic data processing are: static corrections, velocity analysis and stacking, deconvolution, signal-to-noise enhancement techniques, multiple elimination, migration, dmo and velocity model building. The course contains many examples and exercises and there will be ample opportunities for interaction. At the end of the course the participants will have obtained a thorough understanding of the theory and practice of seismic data processing.

tg038 Seismic data and their physical information content
Lecturer: Dr.ir. G. Drijkoningen and Dr.ir. E. Verschuur
Entrance requirements: This course is aimed at PhD students who are not doing research on a purely seismic/geophysical topic but still are working with seismic data and models. Basic knowledge of linear algebra and differential equations is required. Furthermore, basic knowledge on Matlab is required, because the exercises as used in this course will be done in Matlab. A Matlab primer will be made available for the newcomers to Matlab. Participants are required to prepare for this course by doing a Matlab exercise in advance that will bring them to the required starting level. A laptop with Matlab installed is necessary. If you don't have this facility, please let us know so we can try to arrange an alternative.
Course format: 8 times of 4 hours of lectures
Course date: 29 November – 15 December 2016
GS credits: 4
Scope: The aim of this course is to learn what information can be obtained from seismic data, purely from a physical perspective. This information can be data (e.g., an image) or models (e.g., the velocity model). The course covers the following issues:
* Structural information: migration and the effects on seismic imaging
* Velocity information: velocity models, obtained from tomography, migration, full-waveform inversion and log data; differences and accuracy between the different velocity models
* Impedance information: impedance inversion on post-stack data
* Angle-dependent impedance information: AVO and inversion
* Rock-physics models used for seismic interpretation, including fluid replacement
* Stress-change and saturation-change information due to production/injection: time-lapse seismic and its inversion
In all these items both forward modeling and inversion play an important role. Both are seen as necessary parts. Still, inversion theory is not seen as an objective of this course. Each lecture will be followed by a Matlab exercise. Thus, the participants learn about seismic data and their information contents (e.g., models) passively, via the lectures, and actively, via the computer exercises.

**tg047 Practical aspects of reservoir simulation**
Lecturer: Dr. D.V. Voskov (d.v.voskov@tudelft.nl)
Entrance requirements: BSc level in science or technology
Course format: 3 full days of lectures and computer exercises
Course date: 4, 5 & 6 April 2017
GS credits: 3
Scope: During this course students will learn the basics and different numerical aspects of reservoir simulation. The lecture material covers basic mechanisms of multiphase flow in porous media, the derivation of governing equations, basic numerical methods required for discretization of governing equations, different types of time approximation and the major physical models. Each student will construct a set of models for simulation of simplified reservoirs. Various aspects of reservoir engineering and simulation will be studied based on these models.
Day 1: 1D simple two-phase model
Day 2: 3D black-oil model
Day 3: Thermal-compositional model

**ADVANCED COURSES**

**tg131 Advanced wave theory for geoscientists**
Lecturers: Prof.Dr. C.P.A. Wapenaar & Prof.Dr. J.T. Fokkema (c.p.a.wapenaar@tudelft.nl)
Entrance requirements: MSc level in science or technology, with mathematical or geophysical background
Course format: 10 days of 4 hours of lectures, assignments and presentations
Course date: 6 September – 16 September 2016
GS credits: 5

**tg136 MPI Course**
Lecturer: Dr. J.W. Thorbecke (j.w.thorbecke@tudelft.nl)
Entrance requirements: programming with C or Fortran on Linux
Course format: 4 times of (2 hours of lectures + 2 hours of exercises) in total 16 hours
Course date: 25 April, 4, 11 & 18 May 2017
Scope:
+ Understand the basic functionality of MPI.
+ Compile and run MPI programs.
+ Write MPI programs with point to point communication and collective operations.
+ Learn how to set-up domain decomposition and IO within MPI.
+ Combine MPI with OpenMP and vectorised kernels to match modern compute architectures.

**tg501 Stably stratified atmospheric boundary layers: State-of-the-Art & future perspectives**
Lecturer: 8 invited speakers from abroad (definite list will be published in February 2017); course leaders: dr. Van de Wiel, dr. Basu and dr. Baas (dept. GRS) (b.j.h.vandewiel@tudelft.nl)
Enterance requirements: MSc level in science or technology
Course format: Introductionary talks followed by 4 x 2 invited lectures with historical overview; discussions in subgroups 8 x 1 ½ hour
Course date: March 27th-30th (Four days full-time)
GS credits: 4
Scope: Our daily weather has always intrigued many of us. From day to day we experience how the continuously changing weather patterns affect our ongoing activities and plans. On a sunny moment we may decide to go for a nice walk in the park, while a few hours later after a heavy thunderstorm we have to repair our roof. In any case,
we like to stay informed about the upcoming weather, be it via social media, television news or other information channels. Although we are familiar with weather phenomena that occur during the day – such as the appearance of fair weather clouds –, most of us will not have realized that ‘night-time’ weather can be as fascinating and relevant as its day time counterpart.

This graduate school course/workshop is about ‘cold weather meteorology’. With ‘cold weather’ we refer either to nighttime conditions or to winter/polar conditions. Those share the fact that the atmosphere is stably stratified. This implies that density decreases with height with coldest temperatures occurring near the ground. This effect is beautifully visualized in cases when ‘radiation fog’ is present and a thin, cold layer appears to ‘stick’ at the surface.

About the course set-up:
The course is combined with an international workshop. After a session of two invited talks on ‘hot topics’ in this field of science, a few solid statements will be made by the speakers. Next, PhD-students will join sub-groups of scientist and together discuss about those statements, followed by a plenary discussion on the outcomes.

About learning goals:
Apart from specific knowledge about cold weather physics (e.g. about turbulent transport in the atmosphere, longwave radiative transport, land-atmosphere interactions, dynamics of internal gravity waves, etc.), the student will also have a unique opportunity to have a close view ‘in the kitchen of the forefront of atmospheric science’. To see how top-scientists interact with each other and discuss their ideas and opinions in an informal setting. Besides adding to the discussions, students are asked to contribute by preparing a scientific poster. The posters will receive specific feedback from the course leaders and the one with the most challenging research topic will be elected as a subject for discussion on the last day.
GENERAL INFORMATION FOR COURSE PARTICIPANTS

Application
Six weeks before start of a course an announcement with further information and the possibility to register will be sent to all CTG members and interested colleagues. Registered persons will receive a confirmation two weeks before the start of the course. After the course, the participants are requested to fill in an evaluation form. Successful participation will be confirmed by a certificate. All external course participants should complete the application form which is available on request and on our website and send this at least two weeks before the starting date of the course.

Costs
For PhD students of CTG and related MSc students, the courses are free of charge. For PhD and MSc students from other groups, we charge €50,- per GS point (1 point = 8hr work load) + €50,- administration costs. For course participants from institutes or firms we charge a fee of €1000,-. Discounts can be discussed for external course participants who are affiliated to CTG.

Graduate School and/or CTG Certificate
Since 1 January 2012, each new PhD candidate of Delft University of Technology automatically becomes a member of the TU Delft Graduate School (GS; http://www.graduateschool.tudelft.nl/). The GS’ Doctoral Education programme consists of three categories: 1. Discipline-related skills; 2. Research skills; 3. Transferable skills. All CTG courses can be added as a discipline related course. The minimum number of GS credits for discipline-related courses you should receive is 15. We strongly advise you to take most courses within the first two years of your PhD study, thus benefitting most of it.

PhD students of TU Delft who are enrolled in the GS will obtain a Doctoral Education certificate stating all courses they followed. PhD students who are not enrolled in the GS (because they started before 2012 or because they are an external candidate) may take GS courses as well.

After finalizing a course, all participants receive a CTG certificate. If you are a member of the GS, you can add this to your GS account.

Location
If not otherwise stated, all courses are scheduled at the Department of Geoscience & Engineering in Delft. A route description can be obtained from our website.

Accommodation
Individual hotel accommodation during a course can be arranged by the secretary. The costs of such accommodation are for the course participant.

Contact
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Faculty of Civil Engineering and Geosciences
Department of Geoscience & Engineering
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