Introduction to Computational Thinking and Programming for CFD ("CFD 0")

Module 13251

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Brandenburg
University of Technology
Cottbus - Senftenberg

Organizational details

- **Contact**

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Heiko Schmidt	AZFD	Room 3.06	heiko.schmidt@b-tu.de

- **Moodle**

  https://www.b-tu.de/elearning/btu → 13251 ...

- **Dates and places**

Lecture	Tue	11:30 – 13:00	LG1A, HS 1
Exercise	Tue	13:45 – 15:15	AZFD, 2.32
or	Tue	09:15 – 10:45	LG3A, 338

- **Exams**

  Final module examination (MAP)

  Dates: Written: **4 Aug. 2025** (P1) / Oral: individual date in P1/P2

  Duration: 30 min oral / 90 min written

  oral/written mode is fixed after week 3 based on registered students

Organizational details (cont'd)

2 important points

- The **exercise** is primarily offered as **consultation**, in particular when there are more than 40 participants.
- Please **bring your laptop** with you to the lecture/exrcise.
- Please do not hesitate to ask me about **hybrid teaching** options.

Goal

Obtain professional & methods competence

- You will acquire basic **hands-on programming** skills in **Python**, but only if you *practice, practice, practice, . . . !*
- You will learn to design and write **own** computer programs for **simple** problems. On this basis, you will be put in the position to work yourself into more complex tasks in the future.
- **This is not yet a course in CFD!** The course aims to prepare you for forthcoming courses in CFD (like CFD I, II, III etc.).

Target group

Primarily Bachelor, but also Master students from . . .

- Engineering and Computer Sciences
- Natural Sciences
- Mathematics

Planned content (subject to prioritization)

- Fundamentals of scientific computing
- Data types, conversions, input, and output
- Branching and iteration
- Gridded data, interpolation/extrapolation
- Numerical differentiation and integration
- Numerical errors and their quantification
- Random sampling, distribution functions, and statistical moments
- Computational efficiency
- Functional programming and recursion
- Object-oriented programming
- Plotting and visualization

Module description 13251 via module search:
`https://www.b-tu.de/qisserver3/rds?state=user&type=0&topitem=modules`

Planned schedule

	#	CW	SW	Topics of Lecture	Topics of Exercise (preliminary)
x	1	15	B	Course overview; What is CFD?	---
	2	16	A	Introduction to Python I	Data types, control structures
	3	17	B	Introduction to Python II	Modules, functions, plotting
x	4	18	A	*Complex task (double block)*	Taylor expansion
	5	19	B	*Complex task (double block)*	Algebraic grid generation
	6	20	A	Numerical differentiation: FDM	First and second derivative
	7	21	B	Numerical integration: Quadrature rules	Newton-Cotes formulas, numerical errors
	8	22	A	*Complex task (double block)*	Lorenz attractor, ODE integration
	9	23	B	Random sampling	Random walk
x	10	24	A	Statistical analysis	Statistical moments, distribution functions
	11	25	B	Root finding	Intersection, minimum, maximum
	12	26	A	Minimization	Curve fitting based on least squares
	13	27	B	Object-oriented programming	Tracer advection
	14	28	A	*Complex task (double block)*	Tracer advection
	15	29	B	Summary and outlook	Exam preparation
		...			
		32	P1	Written exam or oral exams	
		...			
		39	P2	Alternative appointments for oral exams	

Computing facilities

Prerequisites

- We will use the programming language **Python 3.8** (or higher) `https://www.python.org/`
- Recommended comprehensive Python package: **Anaconda** (Windows, Linux, Mac) – `https://www.anaconda.com/`
- Recommended integrated development environment (IDE): **Spyder** (Windows, Linux, Mac) – `https://www.spyder-ide.org/`

Mode of operation

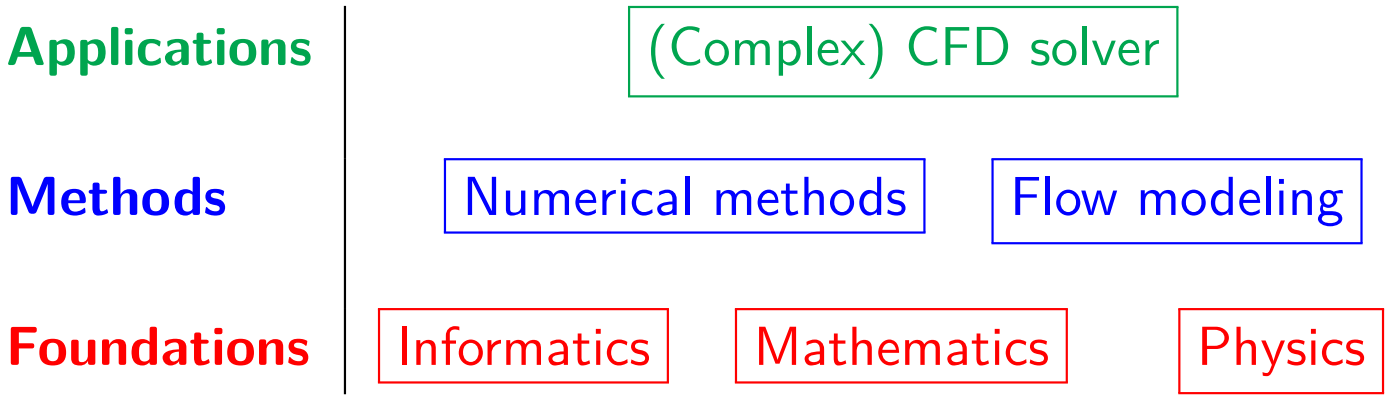
- **Own laptop:** Work anywhere. You have full control over our Python environment.
- **BTU server account (only as backup):** Work here on terminals in a predefined environment. Remote access is possible, but means notable technical overhead for beginners.

Chair of Numerical Fluid and Gas Dynamics

Prof. Dr.-Ing. Heiko Schmidt

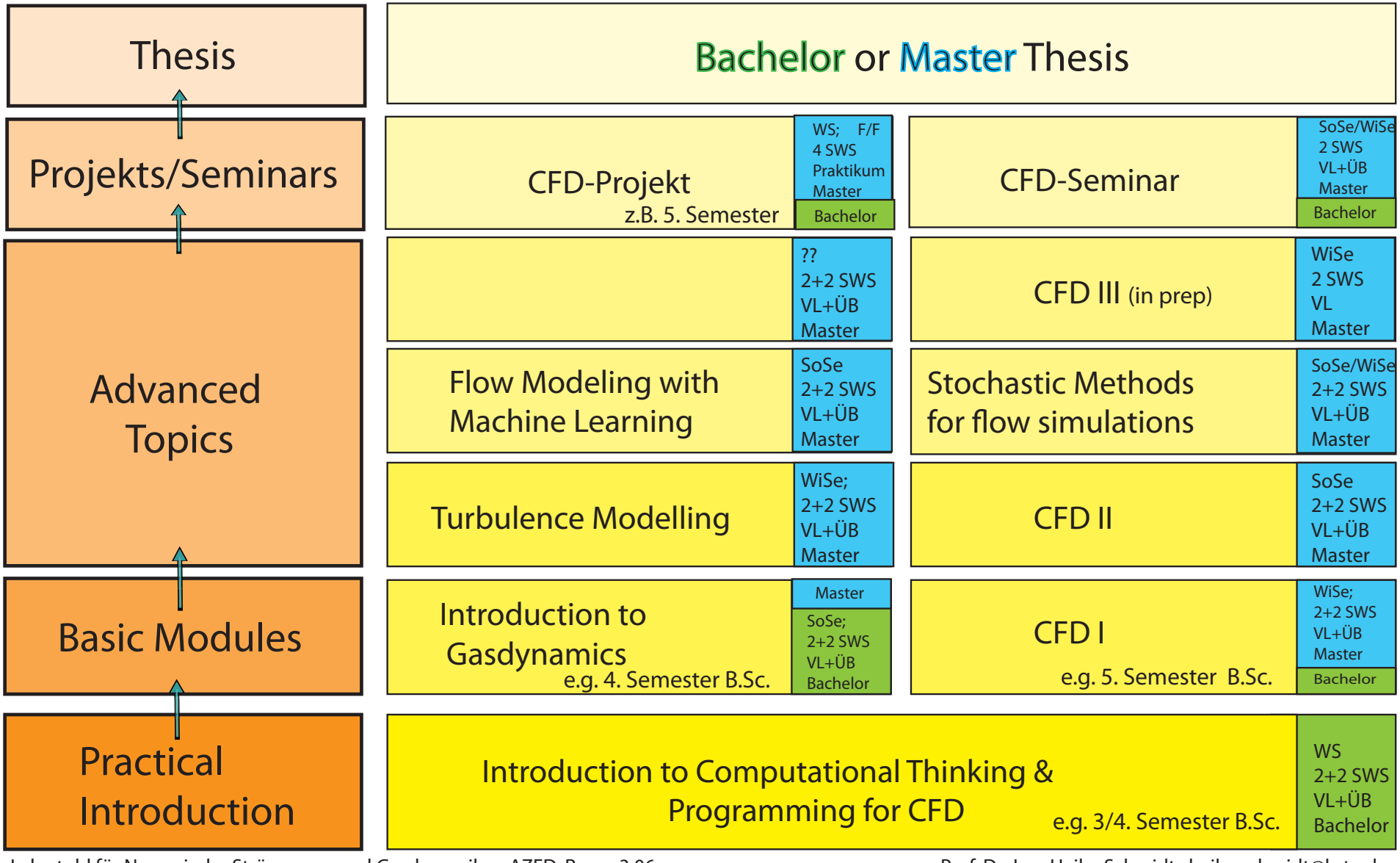
https://www.b-tu.de/en/fg-stroemungsmodellierung

Subject areas of numerical fluid and gas dynamics



Interest in Computational Fluid Mechanics (CFD)?

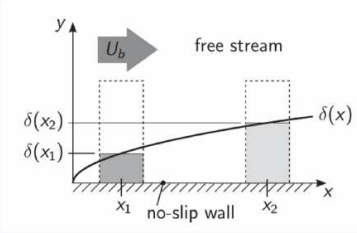
(Traffic, Motors, Gasturbines, Climate, Renewable Energies, Pollution, Hydrology, Energy Storage)

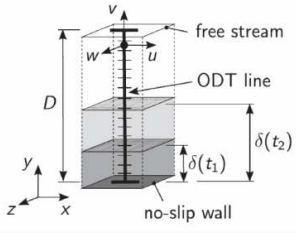


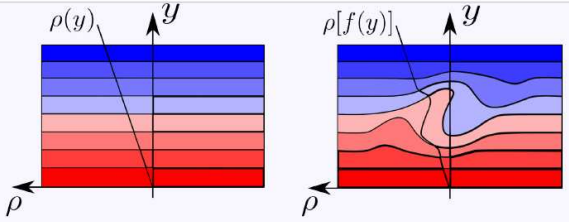
Lehrstuhl für Numerische Strömungs- und Gasdynamik AZFD, Raum 3.06 Prof. Dr.-Ing. Heiko Schmidt heiko.schmidt@b-tu.de

Research focus – Numerical Fluid and Gas Dynamics

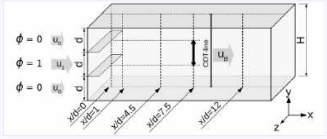
Boundary layers

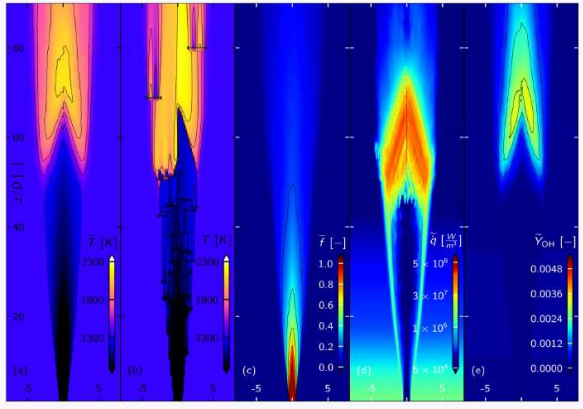


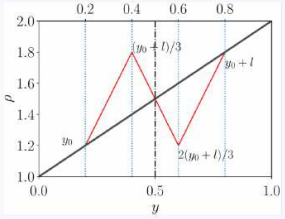




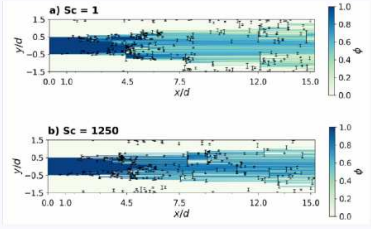
Combustion



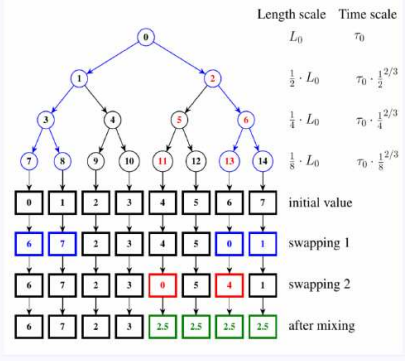




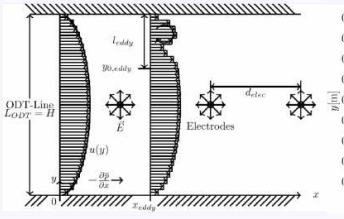
Stochastic Turbulence Models

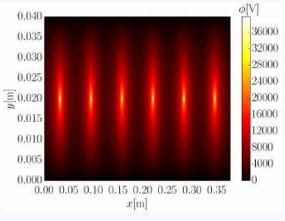


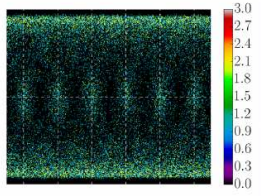
Jets

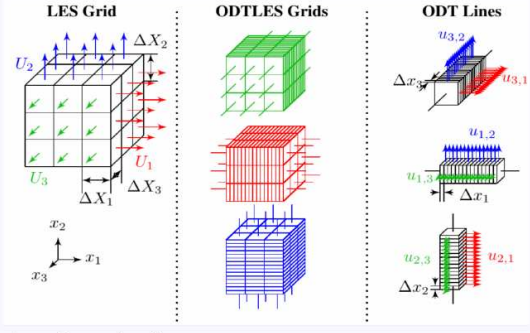


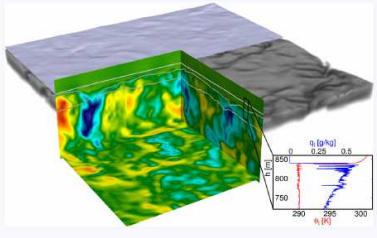
EHD flows



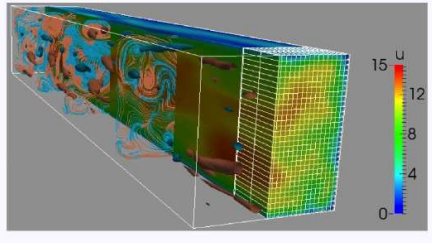








Meteorology



HPC, Multi-scale simulations

And now to you ...

- What is your motivation & expectation for this course?
- What is your field of study? Bachelor/Master?
- Do you already have knowledge of numerics, fluid mechanics, CFD?