1 Time and location

	Lecture	**Problem session**
Time:	Mon 9:45 – 11:15 h	Wed 14:00 – 15:30 h
Location:	kl. HS, Bldg. 10.50	HS 102, Bldg. 10.50
Start date:	October 21, 2024	October 30, 2024

2 Contact

	M. Uhlmann	**M. Scherer**
Consultation:	by appointment	by appointment
Phone:	0721-608 44106	0721-608 47789
Email:	`markus.uhlmann@kit.edu`	`markus.scherer@kit.edu`

3 Aim and scope of the course

- Introduction to the numerical computation of fluid flow problems
- Techniques for analyzing numerical methods for the basic equation types (precision, stability, efficiency)
- Design of solution methods (finite differences, finite volumes)
- Supervised practical realisation of algorithms in MATLAB (or similar software)

4 Supporting material

In order to access the lecture material, including detailed lecture notes and slides as well as the problem sheets, please register with the e-learning system "ILIAS" under the following URL:
https://ilias.studium.kit.edu/goto.php?target=crs_2489422

5 Prerequisites

- **Basic fluid mechanics:**
  - Advection vs. diffusion processes
  - Practice in manipulating the Navier-Stokes equations
- **Basic mathematical background:**
  (the chapter/section data listed in the following refers to the course by M. Neher at KIT)
  - Analysis
    - Complex numbers (HMI, § 6.2)
    - Taylor series (HMI, § 15)
    - Fourier series (HMIII, § 7)
  - Linear algebra:
    - vectors (HMI, § 3)
    - matrices and determinants (HMI, § 5)
    - eigenvalue analysis (HMI, § 6)

  - Integral calculus:
    * Riemann integrals (HMII, § 1-2)
    * numerical integration (HMII, § 3)
  - Differential equations:
    * ODEs (HMIII, § 1-6,8)
    * PDEs (HMIII, § 10)

- **Fundamentals of numerical mathematics**:
  - Finite-precision arithmetic, rounding, basic algorithms, ...
- **Basic programming skills**:
  - Previous knowledge of MATLAB or similar numerical/scientific software.

6 Exam

Written exam, duration 90 minutes, no calculator or written notes allowed. Next exam date is:

February 21, 2025.

Please register before the end of the lecture period (February 14, 2025). If not possible online, this must be done by contacting the secretariate (A. Fels, `angelika.fels@kit.edu`).

7 Contents & Planning

	Lecture			**Problem session**		
week #		topic	date		date	assignment
43	L1	General introduction to NFM	21.10.	—	~~23.10.~~	—
44	L2	Conservation laws	28.10.	T1	30.10.	E1
45	L3	Equation types	04.11.	T2	06.11.	E2-part1
46	L4		11.11.	T3	13.11.	E2-part2
47	L5	Finite difference method	18.11.	T4	20.11.	E3-part1
48	L6		25.11.	T5	27.11.	E3-part2
49	L7	Finite volume method	02.12.	T6	04.12.	E4-part1
50	L8		09.12.	T7	11.12.	E4-part2
51	L9	Numerical stability	16.12.	T8	18.12.	E5
2	—		~~06.01.~~	—	~~08.01.~~	
3	L10		13.01.	T9	15.01.	”
4	L11	Temporal integration	20.01.	T10	22.01.	E6
5	L12		27.01.	T11	29.01.	”
6	L13	Linear algebra	03.02.	T12	05.02.	E7
7	L14		10.02.	T13	12.02.	”
8	**Exam: February 21, 2025**					

8 Other resources

- MATLAB campus license: http://www.scc.kit.edu/produkte/3841.php
- If possible, please **bring your own laptop** to the problem sessions.

References

[1] C. Hirsch. *Numerical computation of internal and external flows.* Butterworth-Heinemann, 2nd edition, 2007.
[2] C.A.J. Fletcher. *Computational techniques for fluid dynamics.* Springer, 2nd edition, 1991.
[3] R. Peyret and T.D. Taylor. *Computational methods for fluid flow.* Springer, 1983.
[4] R.J. LeVeque. *Finite volume methods for hyperbolic problems.* Cambridge Univ. Press, 2002.
[5] R.J. LeVeque. *Finite difference methods for ordinary and partial differential equations.* Society for Industrial and Applied Mathematics, 2007.
[6] W.H. Press, S.A. Teukolsky, W.H. Vetterling, and B.P. Flannery. *Numerical recipes in Fortran 77.* Cambridge U. Press, second edition, 1986.
[7] U.M. Ascher and C. Greif. *A first course on numerical methods.* SIAM, 2011.
[8] P.K. Kundu and I.M. Cohen. *Fluid mechanics.* Academic Press, 2nd edition, 2002.