

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 23, 2023	October 25, 2023

2 Contact

	M. Uhlmann	M. Scherer
Consultation:	by appointment	by appointment
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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_2197531

Zoom-link (just in case):

<https://kit-lecture.zoom.us/j/62914579242?pwd=L1l1UUZUZjMzK0lVdXc0eFZGTm1LZz09>

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)
- **Basic programming skills:**
 - Previous knowledge of MATLAB or similar numerical/scientific software.

6 Recommendations

- **Basic numerical mathematics:**

It is strongly recommended to attend the course “**Fundamental Numerical Algorithms for Engineers**” (course # [6221912](#)) which takes place during the first half of the winter term. Please check the information available on [ILIAS](#).

7 Exam

Written exam, duration 90 minutes, no calculator or written notes allowed. Next exam date is:
February 23, 2024.

Please register before the end of the lecture period (February 16, 2024). If not possible online, this must be done by contacting the secretariate ([A. Fels, angelika.fels@kit.edu](mailto:angelika.fels@kit.edu)).

8 Contents & Planning

week	Lecture		Problem session		
	topic	date	date	assignment	
43	L1	General introduction to NFM	23.10.	T1 25.10.	E1
44	L2	Conservation laws	30.10.	– 01.11.	–
45	L3	Equation types	06.11.	T2 08.11.	E2-part1
46		(skipped due to illness)	13.11.	15.11.	
47	L4		20.11.	T3 22.11.	E2-part2
48	L5	Finite difference method	27.11.	T4 29.11.	E3-part1
49	L6		04.12.	T5 06.12.	E3-part2
50	L7	Finite volume method	11.12.	T6 13.12.	E4-part1
51	L8		18.12.	T7 20.12.	E4-part2
2	L9	Numerical stability	08.01.	T8 10.01.	E5
3	L10		15.01.	T9 17.01.	”
4	L11	Temporal integration	22.01.	T10 24.01.	E6
5	L12		29.01.	T11 31.02.	”
6	L13	Linear algebra	05.02.	T12 07.02.	E7
7	L14		12.02.	T13 14.02.	”
8	Exam: February 23, 2024				

9 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.