

Numerical mathematics

NUMERICAL MATHEMATICS

Summer semester 2024/2025

Lectures: Thursday 12:30-14:00 (room T4:C2-438)

Tutorials: Friday 12:30-14:00 (room T4:A1-405a)

Course Schedule

Week 1

- [Introduction](#).
- Fixed point iterations: [in \$\mathbb{R}\$](#) with graphical illustration, [in \$\mathbb{R}^n\$](#) - introduction.
- Vector norms - [illustration](#).
- Matrices - what are they? [Video](#) (I recommend the whole [course on linear algebra](#)).
Graphically: [2x2 matrices as linear transformations](#)
- [Matrix properties](#). Graphically: [Spectral norm and spectral radius](#).
- Illustrations in Matlab:
 - [Fixed point iterations](#)
 - [Norms and other properties of matrices](#)
 - [Matrices as 2D transformations](#) - graphically
 - [Matrix norms](#) - graphically
- [HW](#)

Week 2

- [fixed point iterations in \$\mathbb{R}^n\$](#)
- Iterative methods for linear systems:
 - graphically: [powers of a matrix](#), [Jacobi and Gauss-Seidel iterations](#)
- [Solved problems](#)
- Illustrations in Matlab:
 - [Powers of a matrix](#) - graphically
 - [Iterative methods for linear systems](#)
- [HW](#)

Week 3

- [Newton's method, example](#).
- [Illustration in Matlab](#).
- Video: [Newton's method in \$\mathbb{R}\$ and \$\mathbb{C}\$](#) , [Newton's fractal](#)
- Recapitulation.
- [HW](#)

Week 4

- Substitution of [derivatives with finite differences](#).
- [Cauchy problem for first-order ordinary differential equation](#): explicit and implicit Euler's method, midpoint (Collatz) method.
- Existence and uniqueness of exact solution: [Example](#).
- [Illustration in Matlab](#).
- Video: [Euler's method - the basics](#)
Video: [Midpoint method - the basics](#) - first 6:30 minutes
- [HW](#)

Week 5

- [Cauchy problem for systems of ODEs](#): explicit and implicit Euler's method, midpoint (Collatz) method.
- Explicit Runge-Kutta methods - [example](#).
- One-step methods [graphically](#)
- [Illustration in Matlab](#).
- [Wiki - Runge-Kutta methods](#).
- [HW](#)

Week 6

- [One-step methods](#) - consistence, stability, convergence.
- [Behavior of errors](#).
- Stability of Euler's methods: [Illustration in Matlab](#).
- Video: [Gilbert Strang](#) (the first 25 minutes)
- Video, Gilbert Strang: [Lecture I](#), [Lecture II](#)
- Recapitulation.
- [HW](#)

Week 7

- [Boundary value problem](#) for ordinary differential equations.
- [Illustration in Matlab](#).
- Video: [Gilbert Strang, MIT](#)
- [HW](#)

Week 8

- [Classification](#) of the 2-nd order linear partial differential equations of two independent variables.
- Dirichlet problem for [Poisson equation](#), Finite difference method.
- [Illustration in Matlab](#).
- Video: [Laplacian](#)
- [HW](#)

Week 9 ... 21-st of April: Tutorial cancelled (Easter holiday)

- Mixed problem for [heat equation](#), Finite difference method.
- [Graphical illustration](#).
- [Illustration in Matlab](#).
- Video: [Heat equation](#)

Week 10

- Mixed problem for [wave equation](#), Finite difference method.
- [Illustration in Matlab](#).

- [HW](#) from week 9

Week 11 ... 1-st of May: Lecture cancelled (holiday)

- [HW](#) from week 10

Week 12 ... 8-th of May: Lecture cancelled (holiday)

- Recapitulation.

Week 13

- [Approximation by polynomials](#) - the least squares method.
- [Illustration in Matlab.](#)
- Gradient methods. [The steepest descent method.](#)
[Illustration in Matlab.](#)
- Video: [Gilbert Strang](#) (the least squares from approx. 25-th minute)
- [HW](#)
- Recapitulation.

Week 14

- **Assessment test:** Thursday 22-nd of May, 12:30 - 14:00, T4:C2-438

Exams: [Requirements](#) for exams. At exam, you should expect similar problems to those given as HWs together with theoretical questions like [these](#), see also requirements above. [Examples](#) of exam tests.

References

- T. Petersdorff: [Fixed Point Iteration and Contraction Mapping Theorem](#)
- Y. Saad: [Iterative methods for sparse linear systems \(pdf \)](#)
- J. R. Chasnov: [Numerical Methods for Engineers](#)
- G. Strang: Computational Science and Engineering, [selected chapters](#)
- C. T. Kelley: [Iterative Methods for Linear and Nonlinear Equations](#), SIAM 1995
- T. Petersdorff: [Errors for Linear Systems](#)
- M. Zeltkevic: [Forward and Backward Euler Methods](#)
- E. Cheever: [Fourth Order Runge-Kutta](#)
- I. Berg: [Comparison of RK methods](#)
- Joel Feldman: [Variable Step Size Methods](#)
- [Matlab tutorial - Clarkson University](#) - html
- * K. B. Petersen, M. S. Pedersen: [The Matrix Cookbook](#) - pdf

Video Lectures

- [Linear transformations and matrices \(video\)](#)
- 3Blue1Brown channel: [Essence of linear algebra](#)
- Gilbert Strang: Linear algebra, [Unit II: Least Squares, Determinants and Eigenvalues](#)
- Gilbert Strang: [Computational Science and Engineering I, 2008](#)
- Gilbert Strang: [Computational Science and Engineering II, 2006](#)
- 3BLUE1BROWN SERIES: [Differential equations, studying the unsolvable | DE1](#)

- Logistic equation - [Video](#)

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