1. **Numerical Linear Algebra.**
   - **1.1** Gauss Elimination **(GEM)** and **LU** factorization. **PA=LU** factorization with partial pivoting.
   - **1.2** Least squares problem: **QR** factorization, orthogonal matrices, Householder reflectors.
   - **1.3** Conditioning: matrix norms, condition numbers and sensitivity of linear systems.
   - **1.4** Gram-Schmidt orthonormalization: numerical instability of **GS** and Reorthogonalized-**GS**.
   - **1.5** Iterative Krylov Methods: Krylov subspaces, **GMRES** and Arnoldi iteration.
2. **Systems of Nonlinear Equations.**
   - **2.1** Newton's method. Jacobian approximation.
   - **2.2** Parameter-dependent systems. Homotopy and pseudo-arclength continuation.
3. **Numerical Fourier Analysis.**
   - **3.1** Generalized Fourier Series.
   - **3.2** The Discrete Fourier Transform. Fourier Interpolant. Aliasing.
   - **3.3** Numerical Differentiation in physical and Fourier spaces.
4. **Numerical discretization of Ordinary Differential Equations.**
   - **4.1 Boundary value problems**
     - **4.1.1** Existence and uniqueness of solutions in bounded domains.
     - **4.1.2** Generalized Robin boundary conditions. Differentiation matrix modification.
     - **4.1.3** Eigenvalue and nonlinear two-point boundary value problems.
     - **4.1.4** Periodic domains: Fourier differentiation matrices (Hill-Mathieu equation).
     - **4.1.5** Unbounded domains: domain transformation maps (Schrödinger equation).
   - **4.2 Initial value problems**
     - **4.2.1** Explicit one-step formulas: Euler and Runge-Kutta methods.
     - **4.2.2** Explicit Linear Multistep Formulas: Adams-Bashforth methods.
     - **4.2.3** Implicit Linear Multistep Formulas: Curtiss-Hirschfelder methods.
     - **4.2.4** Convergence and stability of time-steppers. Dahlquist equivalence and barriers.
     - **4.2.5** A-stability of time-steppers, stiffness.

## Bibliography


1. G. Dahlquist, A. Björck, *Numerical Methods in Scientific Computing, vols. I and II*, SIAM, 2008.
2. A. Meseguer, *Fundamentals of Numerical Mathematics for Physicists and Engineers*, Wiley, 2020.
3. A. Quarteroni, R. Sacco, F. Saleri, *Numerical Mathematics*, Springer, 2007.
4. D.S. Watkins, *Fundamentals of Matrix Computations, 3rd edition*, Wiley, 2010.


## Grading

Course's grade $\mathrm{G_c}$ is obtained through the formula

$$\mathrm{G_c} = 0.8 \times \text{máx}\{0.3 \times \mathrm{G_{mt}} + 0.7 \times \mathrm{G_f}, \mathrm{G_f}\} + 0.2 \times \mathrm{G_{lab}},$$

where $\mathrm{G_{mt}}$ and $\mathrm{G_f}$ are are the grades corresponding to the mid-term and final exams, respectively, and $\mathrm{G_{lab}}$ is the average grade corresponding to the computational lab reports.