Complete Overview of the ‚Mathematics for CES‘ Courses taught at ACoM

(dated: Oct 2025)

Course	Part	Content	total hours (1h = 45min)
Mathematical Foundations for CES, # 1 (total 70h, 5 SWS)	basics	set, relation, mapping, algebraic structures	0.5 SWS
	calculus	real/complex numbers, sequences, series, real-valued functions in one dimension, derivatives, Taylor expansion, integrals, fundamental theorem	2 SWS ≈ 34h
	linear algebra	vector space, linear mapping, matrices, linear systems of equations, determinants, eigenvalues, spectral theory for matrices	2.5 SWS ≈ 26h
Mathematical Foundations for CES, # 2 (total 65h, 5 SWS)	calculus	multi-dimensional functions, partial derivatives, Jacobian, implicit function theorem, multi-dimensional Taylor, ordinary differential equations, theorem of Picard-Lindelöf, linear systems of ODEs	2 SWS ≈ 26h
	numerical methods	interpolation, quadrature, linear systems and LU-decomposition, matrix norms, error-analysis, condition, nonlinear equations, Newton method in multi dimensions, linear regression, least squares, QR decomposition, Householder	3 SWS ≈ 39h
Mathematical Foundations for CES, # 3 (total 56h, 4 SWS)	calculus	variational calculus, first variation, Euler-Lagrange, basic measure theory, Lebesgue-measure, Lebesgue-integral, multi-dimensional integrals, Lp-spaces/norms, integrals on curves, potential, integrals on surfaces, Gauss-theorem, Stokes-theorem	2 SWS ≈ 28h
	numerical methods	numerical methods for ODEs, consistency, convergence, Runge-Kutta method, multi-step methods, stability, stiffness, implicit methods, SVP, eigenvalue stability, vector itertion, QR-algorithm, optimization, descent algorithms, trust region, constraints, penalty methods	2 SWS ≈ 28h
Mathematical Foundations for CES, # 4 (total 52h, 4 SWS)	calculus	classical partial differential equations, Poisson-, diffusion-, wave-, transport-equation, classical solution strategies, basic functional analysis, spectral theory for Laplace operator, distributions, fundamental solution, convolution, Fourier transform	2 SWS ≈ 26h
	numerical methods	trigonometric interpolation, discrete Fourier transform, fast Fourier transform, finite difference formulas, discretization of Poisson equation, convergence of FD, convection-diffusion, method of lines, Jacobi/ Gauss-Seidel algorithm, conjugate gradients	2 SWS ≈ 26h
Numerical Methods for Partial Differential Equations for CES (total 56h, 4 SWS)	elliptic PDES	discussion Poisson problem, weak derivatives, Sobolev-spaces, theory of weak solution, Lax-Milgram, Ritz-Galerkin, Finite-Element method, linear elements, convergence, a-posteriori error estimation, Stokes problem, mixed formulation, LBB condition	2 SWS ≈ 28h
	hyperbolic PDEs	conservation laws, weak solution, entropy, Riemann problem, time step methods, stability, CFL, Finite-Volume method, Lax-Wendroff theorem, Godunov method, Roe solver, high resolution methods, total variation, convergence, limiters, splitting approaches	2 SWS ≈ 28h

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