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Modelling and numerics of differential equations

1 Numerical basics

Interpolation, polynomial interpolation, splines, interpolation error

Numerical integration, rectangle rule, midpoint and trapezoidal rule, Simpson's rule, integration error, Newton-Cotes formulas and Gaussian quadrature, composite formulas

Numerical differentiation, Richardson extrapolation, unilateral and central difference quotients

Nonlinear equations, fixed-point iteration, Banach fixed-point theorem, Newton's method, convergence rate

2 Numerical solution of ordinary differential equations

One-step methods, explicit and implicit Euler method, Heun' method, Crank-Nicolson method, implementation in Matlab

Consistency and convergence, consistency rate and convergence rate

Runge-Kutta method's, Butcher tableaus, step-size control

Stiff differential equations, A-stability, stability domains

Multi-step methods, Adams-Bashforth, Adams-Moulton, backward difference formulas

3 Discretization of the heat equation

Modelling, boundary conditions, finite differences

one-dimensional case, method of lines, approximations of the eigen solutions of the Laplacian, Courant-Friedrichs-Levy condition

Discretization of the multivariate heat equation, block matrices and finite differences