Computer -Aided modeling
with *Mathematica 6*

Compact course

University of Szeged - Technische Fachhochschule Berlin

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Starting out in *Mathematica*

Introduction

Introductory tour
The basic concepts of Mathematica: Front-End functions, Kernel, Help
Typesetting: cells, formula forms
Basic operations: Numeric and symbolic operations, variables, algebraic manipulations
Lists, vectors and arrays
Basic plot statements
Solving equations

Notebook operations I

Cell styles, stylesheets

Animations

Simple tools for animations

Examples

Zooming
Animating trigonometric series
Lissajous curves

Fundamentals of the structures in Mathematica

Setting, Rules, Functions
Data structures, head operations and parameter-type check

Graphics fundamentals

Steps of generating plots and graphics
Summary of plot functions

Plots in 2D

Plotting:functions
Plotting lists in 2D: ListPlot
Parametric curves: ParametricPlot

Examples

Animation of moving point in 2D
Inverse function
Animate the definition of Sin[x]
Animating a pendulum

Plots in 3D

Functions of two variables, scalarfields $(F : \mathbb{R}^2 \to \mathbb{R})$: Plot3D, ContourPlot, DensityPlot
Special new features for 3D Graphics in Version 6.
3D Parametric curves and surfaces: ParametricPlot3D and its versions
Contoursurfaces of scalarfields $V : \mathbb{R}^3 \to \mathbb{R}$

Examples

Plot functions in different coordinate systems
Visualization of moving points in 3D

Graphics summary

Graphics structures in Version 6.
Graphics Structures in Version 5
Graphics conversions in Vesrsin 5

Examples

Simple volume rendering: plot and color the points of a volume
Visualization of series expansions, spectrum animation

Basic applications in Mathematics

Data manipulations

Nonlinear transformations on planar datasets

Graphical study of 2D experimental data: transformations, special plots

Vectors, Matrices, Linear Algebra

Linear Algebra: vectors, matrices, transformations, eigenvalues, eigenvectors, etc.

Calculus

Calculus summary

Applications amd examples in 1D Calculus

Tangent line and secant lines
Animation of the tangent lines
Animation of trigonometric series
Graphical interpretations of derivative: zooming

Applications in 2D-3D Calculus

Curve Fitting

Complex numbers, complex functions

Differential equations I.

Advanced programming in *Mathematica*

List programming I: Structure operations

List programming II

Examples

Recursion, iteration

Examples: recursion vs. nesting

Simple numerical algorithms

Programming paradigms in Mathematica: a systematic treatment

Nontrivial applications

Addons' to list programming: some string manipulations

Examples

Graphical programming I: Advanced visualization

Transformations on graphical (Graphics and Graphics3D) objects

Numerical data from graphical objects

Advanced visualization problems (graphics from numerical data)

Graphical programming II: Advanced substitutions, Iterative forms

Simple iterative constructions

Some other examples

Difference equations, finite differences

Difference equations: definition, solution
Cobweb diagram
Logistic mapping, bifurcation diagram
Solve and visualize planar difference equations
Partial difference equations (a procedural way of solution)
Application of list rotation to finite differences
Disretization of PDE's: more examples

Differential equations: advanced problems

Technical tools

General solver: ODESolve
Visualization of solutions given in lists: Euler's method

Qualitative methods

Stability: Liapunov method
The phasemap method
ODE's with Dirac delta
Poincare maps

Extra

Writing Modules and Packages

Package design, a general overview

Examples

Variableless mappings from expressions: EulerDSolve
General program usig variable names: ODESolve
Handling options: Colored ParametricPlot

Additional topics. Notebook operations II

Options, option inspector, simple stylesheet development
Data export,import

Advanced style operations: automatic numbering, hyperlinks,...
Export, import: HTML, XML, MathML, TeX

Exercises

Basic exercises
1D Calculus
Data handling, fitting
Linear Algebra
3D Claculus, Lines and Surfaces
1D differential equations
Oscillator equations
Planar differential equations
Programming exercises
Advanced programming exercises