



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](#) ($F : \mathbb{R}^2 \rightarrow \mathbb{R}$): Plot3D, ContourPlot, DensityPlot

[Special new features for 3D Graphics in Version 6.](#)

[3D Parametric curves and surfaces](#): ParametricPlot3D and its versions

[Contoursurfaces of scalarfields](#) $V : \mathbb{R}^3 \rightarrow \mathbb{R}$

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 Version 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 and examples in 1D Calculus

[Tangent line and secant lines](#)

[Animation of the tangent lines](#)

[Animation of trigonometric series](#)

[Graphical interpretations of derivative: zooming](#)

[Investigation of functions](#)
[Taylor polynomials](#)

■ **Applications in 2D-3D Calculus**

[Calculus methods: partial derivatives, ..., maxima and minima](#)
[Tangent planes and normal vectors of surfaces](#)
[Tangent vectors and normal planes of curves](#)
[Moving points in 2D](#)
[Moving points in 3D](#)
[Maxima and minima: the numerical and visual point of view](#)
[Constrained extrema](#)

■ **Curve Fitting**

[Curve fitting](#)

■ **Complex numbers, complex functions**

[Summary and examples](#)

■ **Differential equations I.**

[ODE summary](#)
[Modeling with 1D ODE's](#)
[2D equations: vector fields, solutions, trajectories](#)
[Trajectory animation and manipulation in 2D \(using only built in functions\)](#)
[Trajectory animation in 3D \(Lorenz system\)](#)

Advanced programming in *Mathematica*

■ **List programming I: Structure operations**

[Structure operations: Apply rules to lists](#)

■ **List programming II**

[Rotating lists \(RotateLeft, RotateRight\)](#)

Examples

[The midpoint rule](#)
[Moving average of data and analogous problems](#)
[Simple image processing](#)

[ListConvolve, ListCorrelate](#)

■ **Recursion, iteration**

[Summary and basic examples](#)

Examples: recursion vs. nesting

[Factorial](#)
[Continued fractions](#)

Simple numerical algorithms

[Fixedpoints of mappings](#)

[Newton iterations](#)
[Picard iteration](#)
[Methods to approximate zeros of functions](#)
 Riemann sums

■ **Programming paradigms in Mathematica: a systematic treatment**

[Procedural programming](#)
[Functional programming](#)
[Rule- and pattern-based programming](#)

Nontrivial applications

■ **Addons' to list programming: some string manipulations**

Examples

[Morse](#)
[A coding-decoding system](#)

■ **Graphical programming I: Advanced visualization**

Transformations on graphical (Graphics and Graphics3D) objects

[Transformations on Graphics objects \(2D\)](#)
[Transformations on Graphics3D objects \(3D\)](#)
[Replace anything by anything](#)

Numerical data from graphical objects

[Points of contour lines of planar scalar fields](#)
[Normal vectors to a graphically given surface](#)

Advanced visualization problems (graphics from numerical data)

[Volume rendering, slicing; coloring the discrete space by scalar fields](#)
[Volume rendering, slicing; coloring the continuous space by scalar fields](#)
[Visualizing parametric curves given in lists](#)
[Vector field at given contour lines in 2D](#)
[Vector field at given surfaces in 3D](#)

■ **Graphical programming II: Advanced substitutions, Iterative forms**

Simple iterative constructions

[Iterate simple substitutions \(generate trees\)](#)
[Iterate the substitution of patterns](#)
[Simple selfsimilar objects](#)

Some other examples

[Iterations using the midpoint rule](#)
[Generate trees](#)
[Some more tree-like structures](#)
[Sierpinsky triangles, Koch curves](#)
[Sierpinsky attractor](#)

■ **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](#)