Teaching Mathematical Modeling to first-year math students: experiences of a modeling course in 2016

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Introduction

Goals of the course

- Synthesized application of the learned math theories to simple mathematical models and real world phenomena
- Students learn the concept and methods of mathematical modeling, computer tools with special respect of their computer implementations and the needed software tools
- Students work as in a company: they explore phenomena and develop models in small groups
- Non-academic approach: real world problems introduce new theoretical concepts, e.g., populations lead to differential equations

Keywords: curriculum development, modeling approach, Experimental mathematics, dynamic simulation, Wolfram Mathematica

Main point: application-based approach of the theoretical concepts at the very beginning of their studies.

Problems

- High school and univ. math courses are mainly theory oriented (definition, theorem, proof, example)
- Many math students (even some teachers) believe that they do not need sciences (Physics, …)
- They do not learn any science courses, they hardly meet real world applications and modeling
- Often missed from the theoretical courses: experimental and modeling approach of concepts and methods

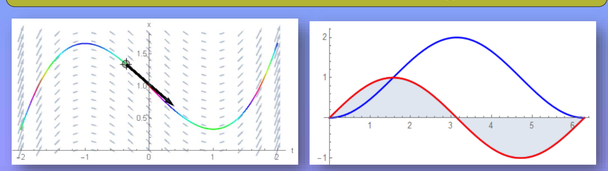
Didactic difficulties

- The very different work style is shocking: active participation, group work, nonstandard evaluation
- High school math, calculus and linear algebra are only completed
- Fine synchronization is needed with other courses.
- Some theories will be treated later; they are explored at elementary level

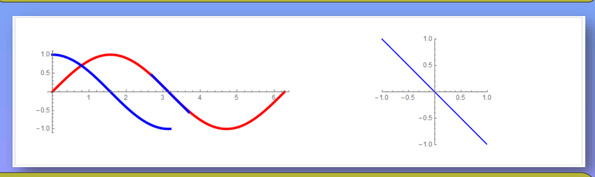
Examples of treated topics

Details: www.model.u-szeged.hu/kurzus-21-1-matematikai_modellek.html

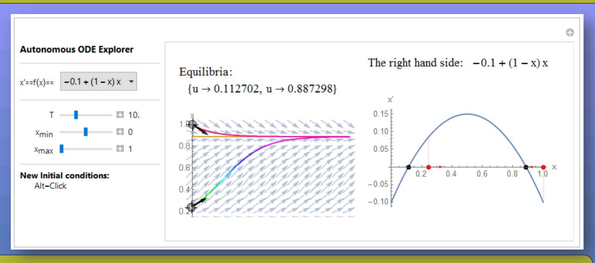
Visualization of the integral



Visualization of the derivative

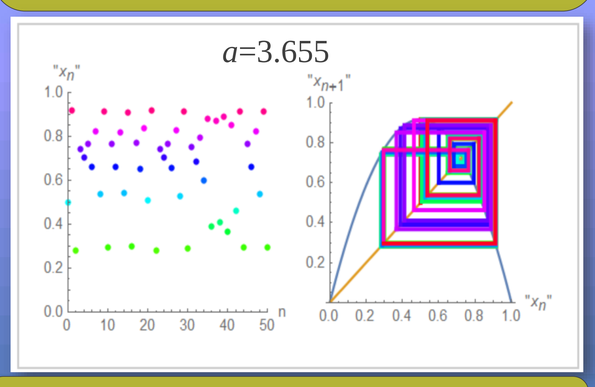


Simple continuous models, elements of differential equations

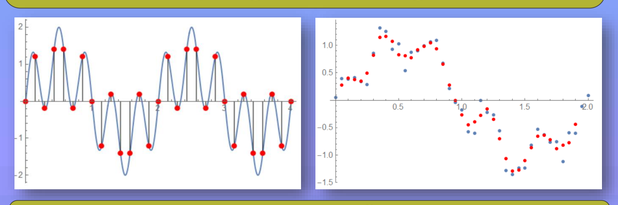


Discrete models: properties of fixed points, period doubling, chaos in logistic growth:

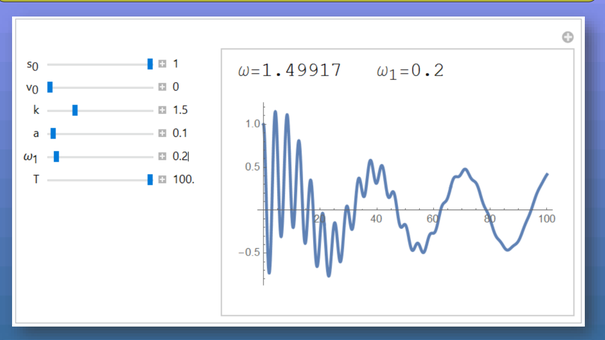
$$x_{n+1} = a \cdot x_n (1 - x_n)$$



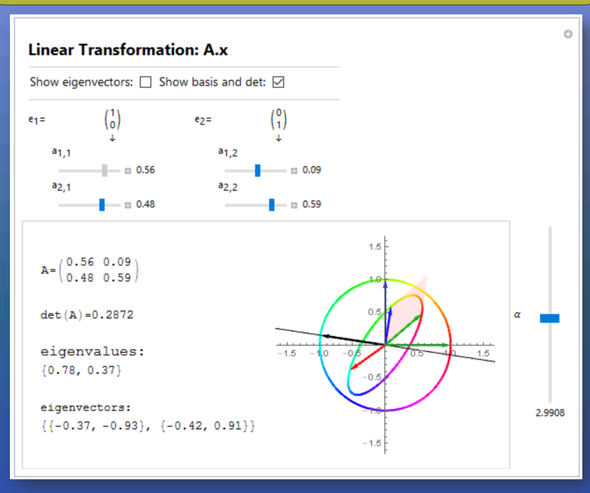
Functions given by experimental data: sampling, smoothing,…



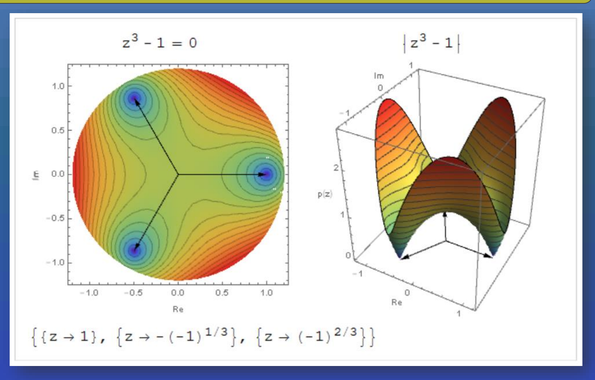
Oscillation: $s'' + a \cdot s' + k^2 \cdot s = \sin(\omega, t)$



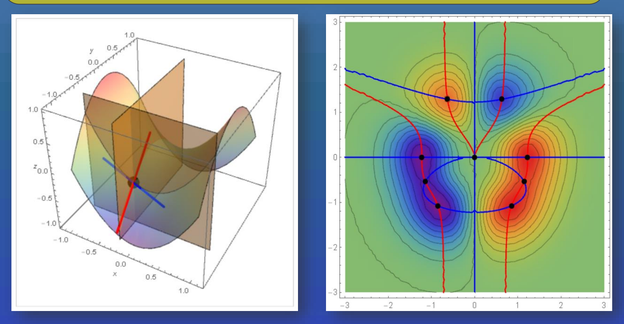
Interpretations of linear transformations: image of unit sphere, understanding the eigenvectors



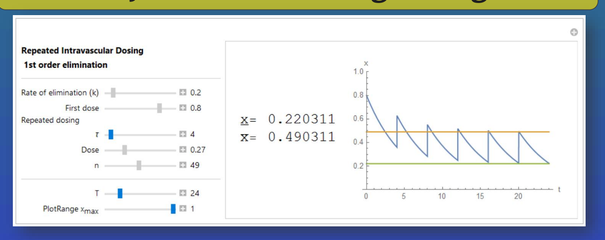
Complex numbers and functions



Properties and applications of functions of several variables:



Hybrid models: drug dosing



Student projects

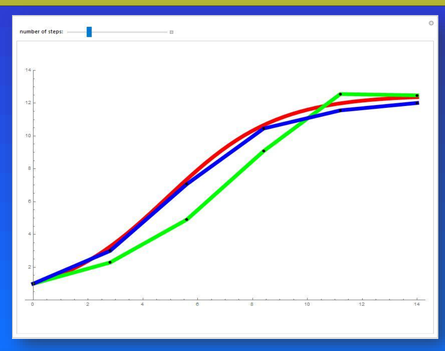
- Students develop and present their project works
- Three small and one comprehensive projects are completed
- Own developments and other resources are combined
- Students have to explore fields not learned yet

Some project topics

- Models in population dynamics
- Applications of graph theory
- Fractals
- Motions: missiles, oscillations
- Learning models
- Visualization of concepts in linear algebra
- Numerical methods

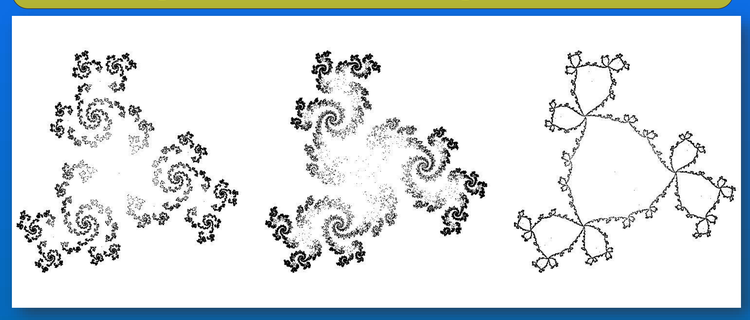
Approximations of the integral by Henrietta Hugyik

Euler method for scalar differential equations by Csilla Almási and Violetta Pavlovity



Communities in social networks by László Hajdu

Complex iterations, fractal constructions by Csenge Balázs, Patrícia Pengő, Réka Szabady



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