Course requirements

- Submit Project1 report on time
- Submit Project2 report on time
- Oral exam:
  - Presenting Project1 and Project2
  - Answer questions on other topics from the course book

Topics for Project1

Range of topics

- NUMERICAL EXPERIMENT -> REPORT + code/notebook (not just the code!)
- Anything related to chapters 9-13 of the course book (Rubin Landau: Survey of Computational Physics, 2008 edition)
- You should work ahead of lecture topics
- Check out the “Assessment” section at the end of chapters for ideas
- Check out my notes in the annotated book
- Check out the ideas listed on the course webpage
- Search the web for ideas
- You may repeat some (simple) numerical experiment from research papers
- Your own (related) ideas are welcome, too! If you are not sure, if it is appropriate: Ask!
- Select something interesting, but doable!
- Check out the formal requirements!

Topics

- Ordinary differential equation simulations
  - Oscillations, non-linear oscillations, various potentials, friction, coupled systems, resonances, time dependent forces
  - Solution of quantum eigenvalue problem with ODE solver, combining with zero point search algorithms, various quantum potentials
  - Two and many-body problems, gravitational systems, projectile motion with drag, scattering
  - Other interesting systems …
  - Analysis of various numerical ODE methods (RK4, predictor-corrector, …), performance, accuracy analysis, test of energy conservation
- Fourier analysis
  - Fourier analysis of measured or simulated time series, oscillations.
  - Maybe combined with oscillation simulations.
  - Power spectra, spectrograms. Real data sources, like sounds, gravitational waves.
  - Digital filtering

Topics

- Wavelet analysis, compression
  - Similar to Fourier projects, same data, different analysis
  - Demonstration of compression efficiency on various signals
  - Wavelet transformation/compression of images
- Nonlinear dynamics, chaos
  - Chaotic maps, fix-point, period doubling, bifurcation analysis (you may move beyond the logistic map)
  - Measures of complexity, Lyapunov exponents, Shannon entropy
  - Coupled chaotic maps on grid
  - Coupled nonlinear oscillations, coupled pendulums with nonlinear potentials, friction, external forces (e.g. Fermi-Ulam-Pasta-Tsingou model)
  - Analysis of phase space, chaotic attractors
  - Evolutionary models, Lotka-Volterra

Topics

- Fractals and growth processes
  - Generating and analyzing fractals
  - Measuring various fractal dimensions of real or simulated data
  - Ballistic deposition, diffusion limited aggregation
  - Cellular automata pattern analysis