

SYLLABUS for course PHYD38, Title: Nonlinear Physics and Chaos
Winter 2014

Lectures (L) and tutorials (T) on Mondays in MW 223: 10-12 lectures, 14-15 tutorial

January	February	March	
6 [L1+2]	3 [L9+10,T4]	3 [L15+16,T6]	
13 [L3+4,T1]	10 [L11+12,T5]	10 [L17+18,T7]	
20 [L5+6,T2]	-- holiday	17 [L19+20,T8]	
27 [L7+8,T3]	24 [L13+L14,midterm]	24 [L21+22,T9]	10-26 Apr: final exam
		31 [L23+24,T10]	

* - midterm, in class

Notes:

This syllabus will evolve during the course, please download the updates from time to time. Numbers in square brackets give chapters in the Strogatz book.

0. Introduction to the course structure and requirements

INTRODUCTION - DYNAMICAL SYSTEMS AND CHAOS

1. Chaos, Fractals and Dynamics and the Importance of being nonlinear [1]
2. 1-D Flows
 - Flows on a line [2]
 - Bifurcations [3]
 - Catastrophes [3]
 - Flows on a circle [4]
3. 2-D Flows
 - Linear systems [5]
 - Phase plane portraits [6]
 - Limit cycles [7]
 - Bifurcations again [8]
4. Chaos
 - Lorenz Equations [9]
 - 1-d maps [10]
 - Fractals [11]
 - The exponential fractal
 - Strange attractors [12]

NONLINEAR WORLD - ADVANCED AND APPLIED TOPICS

Stability and bifurcations in Engineering
Euler beam theory, beam buckling as bifurcation
Nonlinear behavior of materials

Nonlinearity, chaos and complexity in Physics and Astrophysics
The three body and N-body systems
Orbits, Lagrange points, Lyapunov timescales in planetary and galactic systems

- Perturbation theory and secular interactions
- Nonlinear continuum mechanics
 - Dynamics of incompressible and compressible fluids
 - Vortices and turbulence in aerodynamics
 - Turbulent jets
- Dynamics of galactic and planetary disks
 - Linear and nonlinear stability and evolution
 - Nonlinear waves and modes
 - Fluid resonances
 - Particle resonances
- Nonlinear optics

Quantum chaos

Noise and corruption of signals in physical systems

- Noise: white, pink, black, non-power law
- Convolution, PSF

Deconvolution and denoising of signals and observations

- Wiener and Kalman filters
- Neural Networks

Chaotic stock market

Nonlinear modeling and forecasting in time series analysis

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final exam, after April 10, 3hrs