systems dynamics

Silence:

001.2.4057

Place: Campus

Room: (to be determined by the students)

Syllabus for the fall semester,

Numbers

3

3


dynamic systems interact in a variety of ways: loss of stability of a system and its development to another state through breaking of symmetry, extreme response to small perturbations, universal behaviors and many others. These systems are usually described by ordinary (ODE) or partial (PDE) differential equations.

The course aims to provide basic tools for analyzing nonlinear systems, emphasizing biological aspects.

Topics: 

- Motivation and examples of non-linear behavior in both living and non-living systems such as chemical and biological solitons,
- Concepts of non-linear dynamics and their applications to stable and unstable stationary points (equilibria),
- Hopf bifurcation, Poincaré–Bendixson theorem, Floquet theory, Poincaré sections and maps for periodic solutions, and quasi-periodic solutions,
- Strange attractors and the theory of period doubling,
- Dissipative and Hamiltonian dynamics in the presence of non-symmetry.

Textbooks:


Grading:

10% class presentations, 30% mid-term project, 60% final project
Course syllabus: Dynamical Systems  001.2.4057

Place: BGU main (Marcus) campus  
Fall semester, TBD with students  

3 credit points (3 hour lecture)

Many living and inanimate systems exhibit nonlinear dynamics expressed in various ways: loss of system state stability and its evolution to another by symmetry breaking, extreme response to small disturbances, universal behaviors and more. These systems are most often described by ordinary (non-linear) or partial (non-linear) differential equations. The course aims to provide basic, analytical and computational tools for analyzing nonlinear systems, demonstrating them with models of physical, environmental, chemical and biological systems.

Specific topic:

- Motivation and examples of nonlinear behavior in nature: resonance in forced oscillators, chemical and biological oscillations, solitons in fluids and optics, electrical discharge, neural signals and cardiac arrhythmia, and patterns in arid regions
- Basic concepts in nonlinear dynamics and their demonstration with the help of ordinary differential equations (ODEs): Stability and linear instability of stationary solutions (fixed points), phase space, and basins of attraction
- Bifurcation theory, classification and characterization of bifurcations (saddle-node, transcritical, pitchfork, etc.), supercritical and subcritical bifurcations and relation to second and first phase transitions.
- Invariance and center manifold theorem
- Hopf bifurcation and limit cycles, Poincaré – Bendixson theorem, Floquet theory, Poincaré sections and mapping, periodic and quasi-periodic solutions
- Global bifurcations, such as homoclinic and heteroclinic, introduction to Shil’nikov homoclinic theory, connection to localized waves, such as excitable pulses and fronts
- Multiplicity of unstable solutions and chaotic dynamics, strange attractors, Lyapunov exponents, and fractals
- Energy dissipation vs conservation (Leaponov functional), dynamics in the Hamiltonian vs gradient systems, i.e., chemical potential (Lagrange multipliers), meta-stable states
- Introduction to spatially extended systems described by nonlinear partial differential equations (PDEs), examples of spatial patterns such as: Wave fronts in ferromagnetism, stripes and hexagons in fluid convections, waves in the heart and cells, resonant patterns (mode-locking) in under periodic forcing

Grading: 10% submission of weekly home exercises, 30% midterm project, 60% final project

References: