MATH6324: Applied Dynamical Systems

Fall 2016

Times & Location: Tuesday & Thursday, 5:30pm-6:45pm, SLC 2.202
Instructor: Dr. Dmitry (Dima) Rachinskiy
Office: FA 2.602D
Office hours: Tuesday & Thursday, 1:00pm – 2:00pm, or by appointment
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Students MUST be registered for the exam section. Instructor consent required.

Recommended books

1. Steven H. Strogatz, Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, and Engineering. (Available online)
2. Robert L. Devaney, An Introduction to Chaotic Dynamical Systems. (Available online)
3. Ali H. Nayfeh, Introduction to Perturbation Techniques. (Available online)

Course description

Topics from the theory of discrete time dynamical systems including symbolic dynamics, chaos, box counting dimension and fractals, bifurcations, period doubling route to chaos, Sharkovsky's theorem, Lyapunov exponents, maps of the circle and synchronization, area preserving maps, invariant curves, and strange attractors. Topics selected from the singularity theory and the theory of continuous time dynamical systems. Examples of models from ecology, epidemiology, economics, and engineering are presented.

Student Learning Objectives

1. Students will master a set of methods for analysis of dynamics of discrete and continuous time dynamical systems (maps and differential equations) and will be able to identify different dynamical scenarios.

2. Students will be able to find approximate solutions of nonlinear problems using a set of perturbation methods and numerical methods.

3. Students will familiarize themselves with important concepts of dynamics and control: stability and stabilization, bifurcations, synchronization, chaos.

Assignments and exams

Assignments: There will 3 home work assignments, one in the form of a project. All the assignments should be completed independently by the students. Each assignment is due within one week unless otherwise indicated in the assignment. **Late assignments will NOT be accepted**.

Exams: There will be two common examinations. Calculators or other electronic devises won't be allowed during examination. No exams and assignment may be dropped except in extraordinary circumstances. Missed exams and assignments are a zero. The midterms and final examinations have been scheduled as follows:

	Date	**Time**	**Room**
Midterm Exam	October 13, 2016	5:30pm-6:45pm	SLC 2.202
Final Exam	December, 2014	Please check Course Book	Please check Course Book

UTD Course Book: http://coursebook.utdallas.edu/math6390.002.14f

Grading policy

Graded assignments: 45%
Midterm exam: 25%
Final exam: 30%.

Important Dates

August 22, 2016: Classes begin
September 5, 2016: University Closing: Labor Day
September 7, 2016: Census Day

September 7, 2016: Last Day to drop a class without a "W"
October 13, 2016: **Midterm Exam**
November 21-26, 2016: University Closing, Fall break/Thanksgiving holidays
December 7, 2016: Last Day of Full-Term Session (not including exams)
December, 2016: **Final Exam** (Please check Course Book for the exact date).

UTD Course Book: http://coursebook.utdallas.edu/math6390.002.14f

Further important dates:
http://www.utdallas.edu/academiccalendar/

Course program

1. One-dimensional flows. Equilibria and stability analysis. Impossibility of oscillations. Potentials.

2. Bifurcations of equilibrium points. Tangent bifurcations: saddle-node (fold), transcritical, and pitchfork bifurcations. Catastrophes.

3. Flows on the circle. Examples of pendulums.

4. Two dimensional flows. Revision of phase portrait; linear systems; linearization. Index theory.

5. Limit cycles. Elements of Poincaré-Bendixon theory. Poincaré maps. Relaxation oscillations. Hysteresis. Weakly nonlinear oscillators.

6. Bifurcations revisited. Bifurcations of equilibria. Hopf bifurcation. Examples.

7. Global bifurcations. Homoclinic bifurcation.

8. Coupled oscillators and quasiperiodicity.

9. Higher dimensional continuous time systems. Examples of complex dynamics. Strange attractors.

10. One-dimensional maps. Fixed points, periodic orbits. Cobweb diagrams. Stability. Lyapunov exponents.

11. Chaos in the logistic model. Symbolic dynamics. Chopping map as a model of chaos. Cantor set. Order in chaos: cumulative distribution. Definition of deterministic chaos.

12. Fractals. Box counting dimension.

13. Bifurcations revisited. Bifurcations of fixed and periodic points. Sharkovsky's theorem. Period doubling bifurcation. Period doubling route to chaos (Feigenbaum diagram). Periodic windows. Universality.

14. Quasiperiodic dynamics revisited. Maps of the circle as a model of synchronization. Poincaré rotation number. Periodic and quasiperiodic dynamics. Arnold tongues. Cantor function (Devil's staircase).

15. Models of chaos in two dimensions. The Horseshoe map. Strange attractor and the Henon map. Hopf bifurcation for maps and quasiperiodic dynamics on invariant curves. Neimark-Sacker (torus) bifurcation for continuous flow. Invariant tori.

16. Examples of strange attractors. Forced Van-der-Pol oscillator. Shilnikov's chaos.

UT Dallas Syllabus Policies and Procedures

The information contained in the following link constitutes the University's policies and procedures segment of the course syllabus. For these policies, please go to: http://go.utdallas.edu/syllabus-policies

These descriptions and timelines are subject to change at the discretion of the Professor.