Study programmes: PhD – Mathematics

Course name: Dynamical Systems

Lecturers: Darko Milinković

Status: Optional

ECTS: 9

Attendance prerequisites: none

Course aims: Acquiring basic knowledge from the theory of dynamic systems

Course outcome: Upon completion of the course, the student is able to independently solve complex problems and use the appropriate software for simulation of dynamic systems.

Course content: **1. Topological Dynamical Systems:** Discrete Dynamical Systems. Difference equations. Population growth model. Linear dynamical systems. Maps (Arnold, Baker, circular, Henon, logistic, ...) Fixed points, periodic points. Conjugation and structural stability. Li-Yorke's theorem. Sharkovsky ordering. Sharkovsky's theorem. Examples.

2. Continuous Dynamic Systems: Overview of basic concepts. Vector fields, flow, linear systems, fixed points, stability. Floquet's theorem, logarithm of the matrix. Poincare's maps, examples. Hartman-Grobman's theorem. Poincare - Bendixson's theorem. Normal forms. Rezonance. Bifurcation of fixed points. Hopf's bifurcation Atractors, Lorenz, Rossler and Chua attractor.

3. Chaos theory: Symbolic dynamics. Conley Moser's chaos theory. Density of periodic orbits. Chaos and non-standard attractors. Connection of periodic orbits. Synchronization. Matching two dynamic systems.

Literature:

[1] V. I. Arnold, "Ordinary differential equations", various editions.

[2] S. Wiggins, Introduction to applied nonlinear dynamical systems and chaos, Springer, 2003.

[3] J. Guckenheimer, P. Holmes, Nonlinear Oscillations, Dynamical Systems, and Bifurcations
of Vector Fields, Springer, 1983.

[4] S. Lynch, Dynamical systems with applications using Mathematica, BirkhÄauser, 2007.

[5] G. Teschl, Ordinary Differential Equations and Dynamical Systems, Springer, 2009.

[6] M. Hirsh, S. Smale, R. Devaney, Differential equations, dynamical systems and an introduction to chaos, Elsevier, 2004.

[7] 2. Robert L. Devaney, An Introduction to Chaotic Dynamical Systems, 2nd edition, 2003.

[8] 3. Saber N. Elaydi, Discrete Chaos, Chapman-Hall/CRC, 2000.

[9] 4. M.R.S. Kulenovi´c, O. Merino, Discrete Dynamical Systems and Difference Equations
with Mathematica, Chapman-Hall/CRC, 2002.

[10] 5. C. Robinson, Dynamical Systems, CRC, 2nd edition, 1999.

[11] 1. K.T. Alligood, T.D. Sauer, J.A. Yorke, Chaos (An Introduction to Dynamical Systems),Springer, 1996.

Number of hours: 10	**Lectures:** 4	**Research:** 6

Teaching and learning methods: Frontal, tutorials, seminar

Assessment (maximal 100 points)

Course assignments	points	**Final exam**	points
Lectures		Written exam	
Exercises / Tutorials		Oral exam	20
Colloquia	50	Written-oral exam	
Essay / Project	30		