GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Chaos theory, PG_00023806		
Field of study	Mathematics		
Date of commencement of studies	October 2022	Academic year of realisation of subject	2023/2024
Education level	second-cycle studies	Subject group	Optional subject group Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	blended-learning
Year of study	2	Language of instruction	Polish
Semester of study	3	ECTS credits	4.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Probability Theory and Biomathematics -> Faculty of Applied Physics and Mathematics		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Piotr Bartłomiejczyk	
	Teachers	dr hab. Piotr Bartłomiejczyk	

Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	0.0	0.0	30.0	60
	E-learning hours included: 30.0						

Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
	Number of study hours	60	5.0	35.0	100

Subject objectives

Introduction to advanced methods in studying and description of evolution of systems with trends towards chaotic behaviour. Synthesis of probabilistic, topological and analytical techniques to obtain statistical bahaviour.

Learning outcomes

Course outcome	Subject outcome	Method of verification
K7_U10	Finds fixed points, periodic points and ddense orbits.	[SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools
K7_U06	Ranks dynamical systems. Examines ergodic properties of dynamical systems. Compares the degree of chaos.	[SU2] Assessment of ability to analyse information
K7_K04	Interprets chaotic nature of data in their analysis.	[SK5] Assessment of ability to solve problems that arise in practice
K7_W03	Finds atractors. Evaluates entropy.	[SW1] Assessment of factual knowledge
K7_U09	Evaluates fractal dimension. Finds invariant measures.	[SU1] Assessment of task fulfilment

Subject contents

LECTURES Revision of selected topics from topology, measure theory and functional analysis. Abstract dynamical systems. Nonlinear contractions and fixed points. Deterministic chaos. Hypercyclicity and linear chaos in Banach spaces. Barnsley operator and attractors. Fractals. Hausdorff measure and dimension. Measurable transformations and invariant measures. Poincare recurrence theorem. Ergodicity. Mixing and weak (mild) mixing. Entropy.

SEMINARS Chaotic functions (examples). Bifurcations in the family of logistic maps . Relations between characteristics of trajectories. Sharkovski and Li-Yorke theorems. Barnsley operator. IFS systems. Chaos and Barnsley attractors. Ergodicity. Exactness. Mixing. Evolution of densities. Frobenius-Perron and Koopmann operators. Markov operators on measures. Random dynamical systems. Fractals. Hausdorff dimension. Julia sets. Chaos and fractals on a complex plain.

Prerequisites and co-requisites	Courses completed: Probability Theory (MAT1013), Functional Analysis II (MAT2003)

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Activity	51.0%	10.0%
Test	51.0%	40.0%
Research project	51.0%	50.0%

Recommended reading

Basic literature

1. S.W. Fomin, I.P. Kornfeld, J.G. Sinaj, Teoria ergodyczna, PWN, Warszawa, 1987.
2. A. Lasota and M.C. Mackey, Chaos, Fractals and Noise, Spronger, New York, 1994.
3. H.O. Peitgen, H. Jurgens, D. Saupe, Granice chaosu. Fraktale, PWN, Warszawa, 1996.
4. T.M. Sękowski, Zagadnienia matematycznej teorii chaosu, Wydawnictwo UMCS, Lublin, 2007.

Supplementary literature

1. K. Grosse-Erdmann, A.P. Manguillot, Linear Chaos, Springer, 2011.
2. W. Szlenk, Wstęp do teorii gładkich układów dynamicznych, BM tom 56, 1982.
3. Y. Pesin and V. Climenhaga, Lectures on Fractal Geometry and Dynamical Systems, AMS, Rhode Island, 2009.
4. A. Berger, Chaos and Chance, Walter de Gruyter, 2001.
5. R. Zaharopol, Invariant Probabilities of Markov-Feller Operators and their Supports, Birkhauser, 2005.
6. E.E. Peters, Teoria chaosu a rynki kapitałowe, WIG Press, 1997.
7. J. Stachursky, Economis Dynamics: theory and Computation, MIT Press, 2009.
8. T. Downarowicz, Entropy in Dynamical Systems, Cambridge University Press, 2011.

eResources addresses

Adresy na platformie eNauczanie:

Teoria chaosu 2023/2024 - Moodle ID: 32757
https://enauczanie.pg.edu.pl/moodle/course/view.php?id=32757

Example issues/ example questions/ tasks being completed

At the beginning of the term the student is provided with the list of topics to be worked out and finally to be presented as a project on a prescribed date. Theoretical components from lectures and seminars are verified on the test. Student's activity on seminars is essential.

Find the periodic structure of a dynamical system. Find chaotic featurefs of a dynamical systems. Find an attractor of a dynamical system. Evaluate Hausdorff measure and fractal dimension. Find invariant measures. Investigate ergodicity or mixing of a given transformation.

Work placement	Not applicable