

。 GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Fraktals, PG_00021049							
Mathematics							
October 2023		Academic year of realisation of subject			2023/2024		
second-cycle studies		Subject group			Optional subject group Subject group related to scientific research in the field of study		
Full-time studies		Mode of delivery					
1					Polish		
1		ECTS credits			4.0		
general academic profile		Assessment form			assessment		
Divison Of Dynamical Systems -> Institute Of Applied Mathematics -> Faculty Of Applied Physics And Mathematics -> Wydziały Politechniki Gdańskiej						vsics And	
Subject supervisor		prof. dr hab. Joanna Janczewska					
Teachers		prof. dr hab. Joanna Janczewska					
Lesson type	Lecture	Tutorial	Laboratory	Projec	t	Seminar	SUM
Number of study hours	30.0	15.0	0.0	15.0		0.0	60
E-learning hours included: 0.0							
Learning activity					Self-study		SUM
Number of study hours	60		5.0		60.0		125
The aim of the lecture topics.	e is to introduce	e the central ide	eas and concep	ots of fra	actals a	is well as ma	ny related
Course outcome		Subject outcome			Method of verification		
[K7_W05] Has enhanced knowledge of a selected branch of mathematics: knows most classical definitions and theorems and their proofs, Understands problems being examined, Knows relations between problems from particular field with other branches of mathematics, theoretical and applied		A student knows basic notions and facts of discreet and continuous dynamical systems. A student can define the space of Hausdorff type. A student is able to explain the notion of fractal by the use of examples from biology. A student can compute fractal dimension, Hausdorff's dimension and topological dimension.			[SW1] Assessment of factual knowledge		
Ievel and covering modern mathematics, to apply and present in speech and in writing the methods of at least one selected branch of mathematics: mathematical and functional analysis, theory of differential equations and dynamical systems, algebra and number theory, geometry and topology, calculus probability and statistics, discrete mathematics and graph theory, logic and set theory. [K7_U11] Can construct mathematical models used in specific advanced applications of mathematics, can use stochastic processes as a tool for modeling phenomena and		knowledge acquired at other lectures.		[SU3] Assessment of ability to use knowledge gained from the subject			
	Mathematics October 2023 Second-cycle studies Full-time studies I I general academic pro Divison Of Dynamical Mathematics -> Wydz Subject supervisor Teachers Lesson type Number of study hours E-learning hours inclu Learning activity Number of study hours The aim of the lecture topics. Course oute [K7_W05] Has enhar knowledge of a selec mathematics: knows classical definitions a and their proofs, Unc problems being exan relations between pro particular field with o of mathematics, theo applied [K7_U09] Is able, at a level and covering m mathematics, to apply and present in in writing the method one selected branch of m mathematical and fur analysis, theory of differential and fur and graph theory, log theory. [K7_U11] Can constr mathematical model seplications of mathematic stochastic proce for modeling phenoment	Mathematics October 2023 second-cycle studies Full-time studies 1 general academic profile Divison Of Dynamical Systems -> In Mathematics -> Wydziały Politechnil Subject supervisor Teachers Lesson type Lecture Number of study hours 30.0 E-learning hours included: 0.0 Learning activity Participation in classes includ plan Participation in classes includ plan Number of study hours 60 Course outcome [K7_W05] Has enhanced knowledge of a selected branch of mathematics: knows most classical definitions and theorems and their proofs, Understands problems being examined, Knows relations between problems from particular field with other branches of mathematics, theoretical and applied [K7_U09] Is able, at an advanced level and covering modern mathematics, to apply and present in speech and in writing the methods of at least one selected branch of mathematics: mathematical and functional analysis, theory of differential equations and dynamical systems, algebra and number theory, geometry and topology, calculus probability and statistics, discrete mathematics and graph theory, logic and set theory. [K7_U11] Can construct mathematical models used in specific advanced applications of mathematics, can use stochastic processes as a tool for	Mathematics October 2023 Academic y realisation second-cycle studies Subject grown is subject gro	Mathematics October 2023 Academic year of realisation of subject second-cycle studies Subject group Full-time studies Mode of delivery 1 Language of instruction 1 ECTS credits general academic profile Assessment form Divison Of Dynamical Systems -> Institute Of Applied Mathematic Mathematics -> Wydziały Politechniki Gdańskiej Subject supervisor prof. dr hab. Joanna Jancze included in study plan Number of study hours 30.0 15.0 0.0 Learning activity Participation in didactic classes included in study plan Participation in didactic classes included in study plan Number of study hours 60 5.0 Course outcome Subject outcome [K7_W05] Has enhanced knowedge of a selected branch of mathematics, theoretical and applied divent other branches and their proofs, Understands particular field with other branches and covering modern mathematics, theoretical and applied diversent problems from particular field with other branches and propised in spech and in writing the methods of at least one selected branch of mathematics: most statistics, discrete mathematics and functional analysis, theory of differential equations and theorems and theorems and syster statementics and graph theory, logic and set theory.<	Mathematics October 2023 Academic year of realisation of subject second-cycle studies Subject group Full-time studies Mode of delivery 1 Language of instruction 1 ECTS credits general academic profile Assessment form Divison Of Dynamical Systems >- Institute Of Applied Mathematics -> Fa Mathematics -> Wydziały Politechniki Gdańskiej Subject supervisor prof. dr hab. Joanna Janczewska Teachers prof. dr hab. Joanna Janczewska Lesson type Lecture Number of study 30.0 Nours Participation in didactic onsultation hours plan Learning activity Participation in didactic classcia definitions and facts of discret and concepts of fra topics. Course outcome Subject outcome K7_W05] Has enhanced knowedge of a selected branch of mathematics; theoremic and their proofs, Understands protos from biology. A student is able or of mathematics, theoremic and paptied methods of at least on discret and continuous dynamical systems. A student can compute fractal by the use of examples from biology. A student can compute fractal by the use of examples from biology. A student can apply mathematics, theoremic and number theory, geometry and topology. Calculus probability and statistics, discrete mathematics, and graph theory, logic and set theory. IK7_	Mathematics Academic year of realisation of subject 2023 Second-cycle studies Subject group Optio Subject group Optio Subject group Subject group Subject group Subject group Subject group Subject group Academic subject Full-time studies Mode of delivery at the Acage of instruction Polish 1 ECTS credits 4.0 asses Divison Of Dynamical Systems -> Institute Of Applied Mathematics -> Faculty O Mathematics -> Wydzialy Politechniki Gdańskie] Subject supervisor prof. dr hab. Joanna Janczewska Feachers Lesson type Lecture Tutorial Laboratory Project Number of study 30.0 15.0 0.0 15.0 15.0 Number of study 60 5.0 60.0 60.0 A student can define the space of Hausdorff subersend A student can compute fractals a conincuous dynamical systems. A student can com	Mathematics Academic year of realisation of subject 2023/2024 October 2023 Academic year of realisation of subject 2023/2024 Second-cycle studies Subject group Optional subject group rela research in the fiel research in the fiel Full-time studies Mode of delivery at the university 1 Language of instruction Polish 1 ECTS credits 4.0 general academic profile Assessment form assessment Divison Of Dynamical Systems -> Institute Of Applied Mathematics -> Faculty Of Applied Phy Mathematics -> Viydziay Politechniki Gdanskiej Subject supervisor prof. dr hab. Joanna Janczewska Teachers prof. dr hab. Joanna Janczewska Esson type Lecture Tutorial Laboratory Project Seminar Number of study hours 0.0 15.0 0.0 15.0 0.0 Learning activity Participation in didactic classes included in study plain Self-study Self-study Number of study hours 60 5.0 60.0 Self-study Number of study hours 63 Subject outcome Method of w

Subject contents	The Banach contraction principle. Examples of fractals. Why do so many people study fractals? Fractal spaces with the Hausdorff metric. Iterated function systems (IFS). A fractal dimension, the Hausdorff dimension and a topological dimension. The Mandelbrot definition of fractals. Julia sets. The Mandelbrot set. Discrete dynamical systems. Continuous dynamical systems. A definition and properties of the Poincare map. Attractors and repellers. The Feigenbaum cascade. The Smale horseshoe - a geometric description. Properties of the invariant set of the Smale horseshoe.						
Prerequisites and co-requisites	Mathematical analysis. Topology. Ordinary differential equations.						
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade				
	Project	100.0%	50.0%				
	A maths test	50.0%	50.0%				
Recommended reading	Basic literature	 Jacek Kudrewicz, Fraktale i Chaos, Wydawnictwa Naukowo- Techniczne, Warszawa, 2007. Lawrence Perko, Differential Equations and Dynamical Systems, Springer, New York, 2001. 					
	Supplementary literature	 J.D. Murray, Mathematical Biology. I: An Introduction, Springer- Verlag, New York, 2002. HO. Peitgen, H. Jurgens, D. Saupe, Chaos and Fractals. New Frontiers of Science, Springer-Verlag, New York, 2004. 					
	eResources addresses	Adresy na platformie eNauczanie: Fraktale rok akad. 2023/2024 - Moodle ID: 34585 https://enauczanie.pg.edu.pl/moodle/course/view.php?id=34585					
Example issues/ example questions/ tasks being completed	 Is a given subset Z in Rⁿ compact (connected, nowhere dense)? Justify the answer. Calculate the Hausdorff distance between two given subsets A and B in R². 						
	3. Calculate a fractal dimension, the Hausdorff dimension and a topological dimension of the Cantor set, the Koch curve, the Sierpiński gasket and carpet.						
	4. Let w1, w2,, wk: R ⁿ R ⁿ be given. Prove that {R ⁿ ; w1, w2,, wk} is an iterated function system. Calculate the constant of its contraction.						
	5. Solve a linear differential equation of first order x'=Ax in R ² , where A is a given square matrix 2x2.						
	6. Give a geometric description of the Smale horseshoe map.						
	7. What is it an attractor? Give a short description of the Hénon attractor, the Rössler attractor and the Lorenz attractor.						
Work placement	Not applicable						

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