COURSE UNIT DESCRIPTION

Course unit title	Course unit code
Fundamentals of Category Theory	**KKPS3124**

Lecturer(s)	Department where the course unit is delivered
Coordinator: Ramūnas Garunkštis	Faculty of Mathematics and Informatics Department of Probability Theory and Number Theory Naugarduko St. 24 LT-03225 Vilnius Lithuania

Cycle	Level of course unit	Type of the course unit
1st (BA)	1 out of 1	Compulsory

Mode of delivery	Semester or period when the course unit is delivered	Language of instruction
face-to-face	Second year of study Spring semester	English

Prerequisites and corequisites	
Prerequisites: Calculus	**Corequisites (if any):** -

Number of ECTS credits allocated	Student's workload	Number of contact work hours	Number of stand-alone working hours
5	130	48	82

Purpose of the course unit: programme competences to be developed

Not very long ago (1926) David Hilbert said "No one shall expel us from the paradise which Cantor has created for us". This is about the powerful Set Theory, which we all use in our everyday mathematics. Fundamental terms of the set theory language are "element" and "function", "element" being the more fundamental of the two, while "function" can be understand as a certain construction of the elements (subset of Cartesian product). The world does not stand still. With Category Theory (CT) we can forget "elements" and construct everything from "functions" (arrows, in the category language). CT proposes a new impressive view to mathematics, rather different from Set Theory. The paradigm of CT described by ncatlab.org: "As opposed to set theory, category theory focuses not on elements [of sets] x,y,⋯ – called objects – but on the relations between these objects: the (homo)morphisms between them f : x->y." "Category theory takes a bird's eye view of mathematics. From high in the sky, details become invisible, but we can spot patterns that were impossible to detect from ground level." would be a felicitous phrase from the Introduction of "Basic Category Theory" by Tom Leister (University of Edinburg). From other side there is an academic discipline Applied Category Theory in which methods from category theory are used to study other fields including but not limited to computer science, physics, control theory, natural language processing, probability theory and causality (see wiki, Applied category theory). The purpose of this course is to introduce the basic concepts of Category Theory.

Learning outcomes of the course unit: students will be able to	Teaching and learning methods	Assessment methods
The student abstract thinking ability will be developed. The students will learn to employ mathematical reasoning, that is, to proceed from assumptions to conclusions following the patterns of logical inference, to present mathematical statements, their proofs, problems, and their solutions for others.	Lecture. Practice. Individual reading.	Tests (written). Exam (written).
Define and illustrate main concepts related to Category theory.	Lecture. Practice. Individual reading.	Tests (written). Exam (written).

Formulate and prove basic propositions (statements) related to Category theory. The students will learn to rigorously construct their mathematical arguments.	Lecture. Practice. Individual reading.	Tests (written). Exam (written).
Apply basic propositions (statements) related to Category theory.	Lecture. Practice. Individual reading.	Tests (written). Exam (written).

Course content: breakdown of the topics	**Individual work: time and assignments**						
	Lectures	Tutorials	Seminars	Practice	**Contact hours**	**Individual work**	**Assignments**
1. Set theory. Subsets. Russell's Paradox. NBG and ZF set axiom systems. Functions as product sets. Definition of Category, first examples: Set, Finset, Poset, Finord, product categories, arrow categories.	18				**18**	**30**	Individual reading. Problem solving.
2. Basic properties of Categories. Iso arrows, initial and terminal objects, products and co-products, limits and co-limits, equalizers and co-equalizers, pullback, pushouts, exponentiation.	24				**24**	**50**	Individual reading. Problem solving.
3. Functors and Natural transformations. Yoneda lemma.	6				**6**	**2**	Individual reading.
Consultations							
Exam		2					
Tests (written)		4					
Iš viso	**48**	**6**		**16**	**48**	**82**	

Assessment strategy	**Weight(%)**	**Assessment time**	**Assessment criteria**
Tests (written) during lectures.	Aprox 50	During semester	There is a short test during the lecture. It is possible to collect up to 10 points.
Exam (written)	Aprox 50	Exam after the semester	Exam consists of theory questions and exercises (of diverse difficulty). During the exam it is possible to collect up to 10 points.

Author	**Year**	**Title**	**Number or volume**	**Publisher or URL**
Reading				
R. Goldblatt	1984	Topoi. The categorial analysis of logic. Second edition. Chapters 3 and 9.		North-Holland Publishing Co. Aviable online https://projecteuclid.org/euclid.bia/1403013939#toc
P. Smith (University of Cambridge)	2018	Category Theory: A Gentle Introduction		https://www.logicmatters.net/resources/pdfs/GentleIntro.pdf
Additional reading				
Brendan Fong, David I. Spivak	2019	Seven Sketches in Compositionality: An		Cambridge University Press, https://doi.org/10.1017/978110

		Invitation to Applied Category Theory		8668804, https://arxiv.org/abs/1803.05316