COURSE UNIT DESCRIPTION

Course unit title	Course unit code
Randomized Algorithms	

Lecturer(s)	Department where the course unit is delivered
Coordinator: prof. habil. dr. Mindaugas Bloznelis **Other lecturers:** -	Department of Mathematical Computer Science Faculty of Mathematics and Informatics Vilnius University

Cycle	Type of the course unit
2nd(MA)	Optional

Mode of delivery	Semester or period when the course unit is delivered	Language of instruction
Face-to-face	2nd semester	Lithuanian, English

Prerequisites
Prerequisites: -

Number of credits allocated	Student's workload	Contact hours	Individual work
5	130	48	82

Purpose of the course unit: programme competences to be developed

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ability to understand and apply various randomization techniques to analysis and development of algorithms

Generic competences:
- Scientific research *(GK1).*
- Problem solving *(GK2).*

Specific competences:
- Information management and processing *(SK4).*

Learning outcomes of the course unit: students will be able to	Teaching and learning methods	Assessment methods
Understand concepts of Las Vegas and Monte Carlo randomized algorithms, concepts of expected running time, expected number of iterations; use conditioning techniques and probabilistic recursion.	Theoretical analysis of Random Quick Sort, Find, minimal cut algorithm. Lectures, seminar discussions, problem solving	Mid-term and final exam. Evaluation of solutions to exercises.
Understand and apply probabilistic model of coupon collector problem and concept of , Poisson approximation to algorithms.	Theoretical analysis of concrete algorithms: the expected running time of the Stable Marriage algorithm and Poisson approximation to the running time. Lectures, discussions, problem solving	Mid-term and final exam. Evaluation of solutions to exercises.
Understand the concept of a random graph and to apply it in the analysis of algorithms on graphs. Example: proving existence of a Hamilton cycle using cross-over algorithm (coupon collector problem).	Lectures, seminar discussions, problem solving.	Mid-term and final exam. Evaluation of solutions to exercises.

Understand and apply Markov chain Monte-Carlo method. Example: random walks on graphs and its application to SAT problems.	Theoretical analysis of randomized 2-SAT problem and 3-SAT problem, comparison to a deterministic 2-SAT algorithm. Lectures, seminar discussions, problem solving.	Mid-term and final exam. Evaluation of solutions to exercises.
Undrestand, analyse and apply statistical paradigm to algorithms. Examples of selected sublinear algorithms: minimal spanning tree weight evaluation, facility location.	Individual work with scientific literature. Project presentation at the seminar. Seminar discussion.	Evaluation of the project presentation.
Understand, analyse and apply probabilistic counting algorithms, adaptive sampling algorithms and cuckoo hashing algorithm.	Individual work with scientific literature. Project presentation at the seminar. Seminar discussion.	Evaluation of the project presentation
Understand algorithmical problems of large social networks (community detection, etc.), apply and analyse relevant algorithms.	Individual work with scientific literature. Project presentation at the seminar. Seminar discussion	Evaluation of the project presentation

Course content: breakdown of the topics	**Contact hours**							**Individual work: time and assignments**	
	Lectures	Tutorials	Seminars	Practice	Laboratory work	Practical training	**Contact hours**	**Individual work**	**Assignments**
1. Probability, expectation, additivity of expectation, statistical interpretation of the expectation, concept of a randomized algorithm.	2						**2**	**2**	Individual work with scientific literature. Problem solving. Preparation of the project.
2. Analysis of Quick Sort and Find. Probabilistic recursion	4						**4**	**6**	
3. Conditional probability, probability product theorem, Min-cut Monte-Carlo algorithm.	4						**4**	**4**	
4. Coupon collector problem and Poisson approximation. Stable marriage algorithm.	6						**6**	**6**	
5. Random graphs. Algorithmic (cross-over) construction of a Hamilton cycle in a random graph. Chernoff bounds.	6						**6**	**6**	
6. Random walks in graphs and Markov chain Monte-Carlo.	2						**2**	**2**	
7. Randomized and deterministic algorithms for 2-SAT. Randomized 3-SAT algorithm.	6						**6**	**8**	
8. Sublinear algorithms: Minimal spanning tree weight, facility location.			6				**6**	**8**	
9. Probabilistic counting algorithms, adaptive sampling algorithms and cuckoo hashing algorithm.			6				**6**	**8**	
10. Algorithmical problems of large social networks (community detection and others).			6				**6**	**8**	
Preparation to mid-term exam, mid-term exam								**8**	
Preparation to final exam and taking exam								**16**	
Total	**30**		**18**				**48**	**82**	

Assessment strategy	Weight %	Deadline	Assessment criteria
Presentation of an individual project. Solving homework assignments	40	In the course of semester	Quality and content of the project presentation (description of the problem, explanation of the algorithm, algorithm realization by computer programme) are evaluated and credited with points. Solutions to the homework assignments are evaluated and credited with points.
Mid-term exam.	20	In the course of semester	Answers to theoretical questions and problem solving capability are credited with points.
Final exam	40	Examination session	Answers to theoretical questions and problem solving capability are credited with points.

Author	Publishing year	Title	Number or volume	Publisher or URL
Required reading				
R. Motwani, P. Raghavan	2000	Randomized Algorithms		Cambridge University Press, Cambridge
M. Mitzenmacher, E. Upfal	2005	Probability and Computing. Randomized Algorithms and Probabilistic Analysis		Cambridge University Press, Cambridge
Recommended reading				
O. Haggstrom	2003	Finite Markov Chains and Algorithms Application		Cambridge University Press, Cambridge
M. Habib, C.J. McDiarmid, J. Ramirez-Alfonsin, B. Reed	1998	Probabilistic Methods for Algorithmic Discrete Mathematics		Springer, Berlin
P. Flajolet, G. N. Martin	1985	Probabilistic Counting Algorithms for Data Base Applications	JOURNAL OF COMPUTER AND SYSTEM SCIENCES 31,182-209 (1985)	http://algo.inria.fr/flajolet/
P. Flajolet,	1990	On Adaptive Sampling	Computing 34,391400 (1990)	http://algo.inria.fr/flajolet/
R. Pagh, F, Rodler,	2001	Cuckoo hashing	*Algorithms ESA 2001*. Lecture Notes in Computer Science **2161**. pp.121-133	http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.25.4189
B. Chazelle, R. Rubinfeld, L. Trevisan	2005	Approximating the minimum spanning tree weiht in sublinear time	SIAM. J. COMPUT. 34 1370--1379	http://www.cs.princeton.edu/~chazelle/pubs/mstapprox.pdf