M129	**Nonlinear optimization**	L	E	S	ECTS
		3	2	0	7

Course objectives. Introduce students to how to approach real-time problems of nonlinear optimization that occur in different applications. Particular consideration will be given to setting the problem, solving it and interpreting the results. Known numerical methods for solving one-dimensional and multidimensional problems of differentiable and non-differentiable nonlinear optimization will be analyzed and analyzed. The methods will be illustrated and tested in numerous examples using a computer. In this way mathematical and computer knowledge will be linked.

Prerequisites. Undergraduate study programme in mathematics, computer science and similar study programmes.

Course content.

1. Introduction and motivation. Illustrative examples.
2. Convex and quasi-convex functions. Lipschitz-continuous functions. Local and global minimum.
3. One-dimensional minimization of differentiable functions. The method of tangents. Newton's method.
4. One-dimensional minimization of non-differentiable functions. Half method. Gold cut method. Piavsky method, Shubert method, DIRECT method.
5. Multidimensional minimization of differentiable functions. The gradient method. Newton's method. Quasi-Newton methods. Conjugate Direction Method.
6. Multidimensional minimization of non-differentiable functions. The Nelder-Mead method. DIRECT method, Branching and fencing method. Population algorithms.
7. Nonlinear least squares problem. Gauss-Newton method. The Marquardt method.
8. Nonlinear problems of the smallest absolute deviations. Application of DIRECT algorithm.

LEARNING OUTCOMES

No.	**LEARNING OUTCOMES**
1.	Define the local and global extremes of nonlinear functions of one and more variables.
2.	Mathematically model a real problem that boils down to nonlinear extrema problems.
3.	Apply methods for solving one-dimensional and multidimensional problems of differentiable and non-differentiable nonlinear optimization.
4.	Recognize the opportunities offered by nonlinear optimization.
5.	Solve real problems of nonlinear optimization using the available software tool.
6.	Apply knowledge to solve problems in collaboration with other professions, ie in an interdisciplinary environment.
7.	Present and argue the results.

RELATING THE LEARNING OUTCOMES, ORGANIZATION OF THE EDUCATIONAL PROCESS AND ASSESSMENT OF THE LEARNING OUTCOMES

TEACHING ACTIVITY	ECTS	LEARNING OUTCOME **	STUDENT ACTIVITY*	EVALUATION METHOD	POINTS	
					min	max
Attending lectures and exercises	1	1-7	Lecture attendance, discussion, team work and independent work on given tasks	Attendance lists, tracking activities	0	15
Homework	1	1-7	Solving of programming tasks	Checking the correct solutions (rating)	0	35
Written exam (Mid-terms)	2	1-7	Preparing for written exam	Evaluation	25	35
Final exam	2	1-7	Revision	Oral exam	10	15
TOTAL	7				35	100

Teaching methods and student assessment. Lectures and exercises are obligatory. The exam consists of a written and an oral part. Upon completion of the course, students can take the exam. Successful midterm exam scores replace the written exam.

Can the course be taught in English: Yes

Basic literature:

1. R. Scitovski, K. Sabo, D. Grahovac, Globalna optimizacija, Sveučilište u Osijeku, Odjel za matematiku, 2017.
2. R. Scitovski, N. Truhar, Z. Tomljanović, Metode optimizacije, Sveučilište Josipa Jurja Strossmayera u Osijeku, Odjel za matematiku, Osijek, 2014.
3. Ackleh, A.S., Allen, E.J., Kearfott, R.B., Seshaiyer, P., 2010. Classical and Modern Numerical Analysis: Theory, Methods and Practice. Taylor and Francis Group, LLC.

Recommended literature:

1. Bonnans, J.F., Gilbert, J.C., Lemarechal, C., Sagastizabal, C.A., 2006. Numerical Optimization. Theoretical and Practical Aspects. Springer-Verlag, Berlin.
2. Hendrix, E.M.T., Tóth, B.G., 2010. Introduction to Nonlinear and Global Optimization. Springer.
3. Horst, R., Tuy, H., 1996. Global Optimization: Deterministic Approaches. Springer, Berlin, third edition.
4. Kincaid, D., Cheney, W., 1996. Numerical Analysis. Mathematics of Scientific Computing. Brooks/Cole Publishing. 2nd edition.
5. Liberti, L., 2008. Introduction to Global Optimization. LIX, École Polytechnique.
6. R.Plato, Concise Numerical Mathematics American Mathematical Society, Providence, 2003.
7. R. Scitovski, Numerička matematika, Sveučilište u Osijeku, Odjel za matematiku, 2015.
8. Stoer, J., Bulirsch, R., 2002. Introduction to Numerical Analysis. Springer-Verlag, New York.
9. C. T. Kelley, Iterative methods for optimization, SIAM, Philadelphia, 1999.
10. J. E. Dennis, Jr, R. B. Schnabel, Numerical Methods for Unconstrained Optimization and Nonlinear Equations, SIAM, Philadelphia, 1996.
11. Thomas Weise, Global Optimization Algorithms. Theory and Application, e-book: \url{http://www.it-weise.de/projects/book.pdf}, 2008.