M028	FIN - elective – Year 2 MR - elective – Year 2 IPM - obligatory – Semester 3	**Optimization Methods**	L+P+S 2+1+1	ECTS 6

Course objectives: Students will be introduced to the main methods of one-dimensional and multi-dimensional minimization with and without constraints. Special attention will be devoted to minimization methods for non-differentiable functions. During the course we will try to avoid proving oftheorems, except in cases with constructive proofs pointing to construction of methods or getting general ideas.

Course prerequisites. Undergraduate study programme in mathematics. (Functions of Several Variables, Numerical Mathematics, Mathematical Tools.)

Syllabus.

1. Introduction**.** Local and global minimum. Illustrative examples and applications. Convex functions.
2. One-dimensional minimization. Golden section search, parabolic interpolation and Brent's method. Newton's and modified Newton methods.
3. Multidimensional optimization without constrains. Gradient methods. Method of steepest descent. Newton's and modified Newton methods. Quasi-Newton methods. Conjugate gradient method. Least squares problems. Examples and applications. Graphic representation of iterative processes.
4. Constraint optimization problems. Necessity and sufficiency for optimality. Gradient method with projection. Newton’s method with projection.
5. Multidimensional optimization without constrains for non-differentiable functions (search methods). Coordinate relaxation methods. Nelder-Mead downhill simplex method. Powell's method. Random search methods.

Expected learning outcomes.

After completing the course, students are expected to be able to:

- completely understand the concept of local and global minimum of functions with one and several variables;
- completely understand and apply knowledge of solving one-dimensional optimization problems;
- apply golden section search, parabolic interpolation and Brent's methods as well as Newton's and modified Newton methods;
- completely understand and apply knowledge of multidimensional optimization without constrains. Apply and understand concepts of Newton's and modified Newton methods, Quasi-Newton methods;
- completely understand and apply knowledge of multidimensional optimization with constrains. Apply and understand concepts of Gradient method with projection, Newton method with projection;
- completely understand and apply knowledge of multidimensional optimization without constrains for non-differentiable functions. Apply and understand concepts of coordinate relaxation methods, Nelder-Mead downhill simplex method, Powell's method and random search methods;
- use mathematics literature from different sources.

Teaching methods and student assessment. Lectures will be illustrated with ready-made software and graphics using a computer and an LCD projector with the help of software packages like Mathematica or Matlab. Exercises are partially auditory and partially laboratory

supported by a computer and an LCD projector with the help of these software systems. Lectures and exercises are obligatory. The exam consists of a written and an oral part, and it will be taken after completion of lectures and exercises. Acceptable scores achieved in mid-term exams taken throughout the semester replace the written part of examination.

Can the course be taught in English: Yes.

Basic literature:

1. R. Scitovski, N. Truhar, Z. Tomljanović, Metode optimizacije, course book in preparation, Department of Mathematics, University of Osijek, Osijek.

Recommended literature:

1. C. T. Kelley, Iterative methods for optimization, SIAM, Philadelphia, 1999.
2. P. E. Gill, W.Murray and M.H.Wright, Practical Optimization, Academic Press, 1981.
3. F. Jare, J.Stoer, Optimierung, Springer-Verlag, Berlin, 2004.
4. J. E. Dennis, Jr, R. B. Schnabel, Numerical Methods for Unconstrained Optimization and Nonlinear Equations, SIAM, Philadelphia, 1996.
5. J. E. Dennis Jr., J. J. More, Quasi-Newton methods, motivation and theory, SIAM Review, 19(1977), 46-89.