| UČNI NAČRT PREDMETA / COURSE SYLLABUS (leto / year 2017/18) | | | |
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| **Predmet:** | Optimizacija v financah | | |
| **Course title:** | Optimization in finance | | |

| **Študijski program in stopnja**<br>**Study programme and level** | **Študijska smer**<br>**Study field** | **Letnik**<br>**Academic year** | **Semester**<br>**Semester** |
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| Magistrski študijski program<br>Finančna matematika | ni smeri | 1 ali 2 | prvi ali drugi |
| Master's study programme<br>Financial Mathematics | none | 1 or 2 | first or second |

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| **Vrsta predmeta / Course type** | izbirni / elective |
| **Univerzitetna koda predmeta / University course code:** | M2519 |

| **Predavanja**<br>**Lectures** | **Seminar**<br>**Seminar** | **Vaje**<br>**Tutorial** | **Klinične vaje**<br>**work** | **Druge oblike**<br>**študija** | **Samost. delo**<br>**Individ. work** | **ECTS** |
|---|---|---|---|---|---|---|
| **30** | **15** | **30** | | | **105** | **6** |

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| **Nosilec predmeta / Lecturer:** | prof. dr. Janez Bernik, prof. dr. Tomaž Košir, prof. dr. Mihael Perman, prof. dr. Bor Plestenjak, prof. dr. Jaka Smrekar |

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| **Jeziki / Languages:** | **Predavanja / Lectures:** | slovenski / Slovene, angleški / English |
| | **Vaje / Tutorial:** | slovenski / Slovene, angleški / English |

| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | **Prerequisites:** |
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| Vpis v letnik študija. | Enrolment in the programme. |
| **Vsebina:** | **Content (Syllabus outline):** |

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| Linearno Programiranje:<br><br>Teorija in algoritmi, metoda simpleksov, metode notranjih točk, programski paketi za praktično reševanje. Linearni modeli v financah: osnovni izrek o vrednotenju, vrednotenje izvedenih finančnih instrumentov v odsotnosti arbitraže, uporaba linearnega programiranja pri klasifikaciji podatkov ipd<br><br>Kvadratično programiranje:<br><br>Pogoj optimalnosti, dualnost, metode notranjih točk, programska orodja za praktično reševanje. Finančni modeli: različni načini izbire in upravljanja portfelja, maksimiziranje Sharpeovega razmerja, mean-variance optimizacija idr.<br><br>Optimizacija na stožcih:<br><br>Pregled teorije in praktičnih algoritmov. Finančni modeli: arbitraža z minimalnim tveganjem, aproksimacija kovariantnih matrik idr.<br><br>Stohastično programiranje:<br><br>Uporaba stohastičnih modelov, modeliranje ob upoštevanju negotovosti, metode za reševanje. Primeri finančnih modelov: izbor in upravljanje s portfelji, optimizacija z izogibanjem tveganja ipd.<br><br>Dinamično programiranje:<br><br>Pregled teorije in osnovnih metod za reševanje, dinamično programiranje v diskretnem in zveznem času, zvezni prostor stanj, optimalno upravljanje. Primeri finančnih modelov: dinamična analiza portfelja, problem optimalnega ustavljanja idr.<br><br>Po potrebi predavatelj v tečaj vključi tudi druge aktualne teme iz novejše znanstvene periodike. | Linear programming:<br>Theory and algorithms, simplex method, interior point methods, software packages for practical problem solving. Linear models in finance: the basic theorem of asset pricing, the pricing of financial derivatives in the arbitrage-free setting, use of linear programming for data classification, etc.<br><br>Quadratic programming:<br><br>Condition for optimality, duality, interior point methods, software packages for practical problem solving. Financial models: various methods for creating and managing a portfolio, maximization of the Sharpe's ratio, mean-variance optimization, etc.<br><br>Cone programming:<br><br>Overview of the theory and of the practical algorithms.<br><br>Financial models: minimal risk arbitrage, covariant matrix approximation, etc.<br><br>Stochastic programming:<br><br>Use of stochastic models, modeling with uncertanity, methods for solving various stochastic prgramming problems. Examples in finance: portfolio building and management, risk averse optimization, etc.<br><br>Dynamic programming:<br><br>Overview of the theory and of the basic methods for problem solving, dynamic programming in discrete and continuous time, continuous state space, optimal control. Examples in financial models: dynamic portfolio analysis, optimal stopping problem, etc.<br><br>The lecturer can also include other current topics from recent scientific periodicals in the |

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| Zaradi nepostredne uporabnosti vsebin bodo pri predmetu sodelovali tudi strokovnjaki iz prakse. | course.<br><br>Since the content is of great practical importance we expect that also specialists from financial practice will present their work experience during the course. |

**Temeljni literatura in viri / Readings:**

D. P. Bertsekas, Dynamic programming and optimal control, Athena Scientific, 2005.

V. Chvátal: Linear Programming, Freeman, New York, 1983.

G. Cornuejols, R. Tütüncü: Optimization Methods in Finance, Cambridge Univ. Press, Cambridge, 2007.

A. Shapiro, D. Dentscheva, A. Ruszczynski: Lectures on Stochastic Programming:Modeling and Theory, MPS/SIAM Series on Optimization 9, SIAM, 2009.

S. Zenios: Financial Optimization, Cambridge Univ. Press, Cambridge, 1996.

| **Cilji in kompetence:** | **Objectives and competences:** |
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| Študent spozna nekatere osnovne vrste optimizacijskih problemov, še posebej tiste, s katerimi lahko modeliramo probleme s področja financ. Seznami se z osnovnimi matematičnimi prijemi za njihovo reševanje, hkrati pa za praktično reševanje uporablja tudi primerne programske pakete.<br>V okviru seminarskih/projektnih aktivnosti študentje z individualnim delom in predstavitvijo ter delom v skupinah pridobijo izobraževalno komunikacijske in socialne kompetence za prenos znanj in za vodenje (strokovnega skupinskega dela). | Students acquire knowledge on the basic types of optimization problems, the stress being on the problems suitable for modeling problems coming from the field of finance. The students get acquainted with the basic mathematical approaches for solving the above optimization problems and use suitable software packages for solving practical problems.<br><br>With individual presentations and team work interactions within seminar/project activities students acquire communication and social competences for successful team work and knowledge transfer. |

| **Predvideni študijski rezultati:** | **Intended learning outcomes:** |
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| Znanje in razumevanje: Sposobnost dobro opisati različne probleme s področja financ z matematičnim modelom. Poznavanje osnovnih prijemov in računalniških orodij za učinkovito reševanje dobljenih optimizacijskih problemov.<br><br>Uporaba: Reševanje zahtevnejših praktičnih optimizacijskih problemov s področja financ.<br><br>Refleksija:<br><br>Pomen predstavitve praktičnih problemov v formalizirani obliki, ki omogoča njihovo učinkovito in pravilno reševanje.<br><br>Prenosljive spretnosti – niso vezane le na en predmet:<br><br>Modeliranje nalog iz vsakdanjega življenja v obliki matematičnih optimizacijskih nalog, zmožnost razločevanja med računsko obvladljivimi in neobvladljivimi problemi, sposobnost samostojnega modeliranja in reševanja z računalnikom. | Knowledge and understanding:<br><br>The ability to describe various problems from the field of finance with a mathematical model. Knowledge on the basic approaches and software tools for efficient solving of the acquired optimization problems.<br><br>Application:<br><br>Solving more demanding practical optimization problems in finance.<br><br>Reflection:<br><br>The importance of presenting practical problems in formalized form which enables their efficient and correct solving.<br><br>Transferable skills:<br><br>Modeling the real-life problems in the form of a mathematical optimization problem, the ability to distinguish between computationally tractable and intractable problems, the ability to model and solve the problem on one's own using the computer. |

| **Metode poučevanja in učenja:** | **Learning and teaching methods:** |
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| predavanja, vaje, domače naloge, konzultacije, seminarske naloge | Lectures, exercises, homeworks, consultations, seminars |

| **Načini ocenjevanja:** | Delež (v %) / Weight (in %) | **Assessment:** |
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| Način (pisni izpit, ustno izpraševanje, naloge, projekt):<br><br>izpit iz vaj (pisni izpit) | 50%<br><br>50% | Type (examination, oral, coursework, project):<br><br>written exam |

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| ustni izpit<br><br>Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL) | | oral exam<br><br>Grading: 1-5 (fail), 6-10 (pass) (according to the Statute of UL) |

**Reference nosilca / Lecturer's references:**

Janez Bernik:
BERNIK, Janez, RADJAVI, Heydar. Invariant and almost-invariant subspaces for pairs of idempotents. Integral equations and operator theory, ISSN 0378-620X, 2016, vol. 84, iss. 2, str. 283-288. [COBISS.SI-ID 17449049]
BERNIK, Janez, POPOV, Alexey I. Obstructions for semigroups of partial isometries to be self-adjoint. Mathematical proceedings of the Cambridge Philosophical Society, ISSN 0305-0041, 2016, vol. 161, iss. 1, str. 107-116. [COBISS.SI-ID 17690457]
BERNIK, Janez, MARCOUX, Laurent W., POPOV, Alexey I., RADJAVI, Heydar. On selfadjoint extensions of semigroups of partial isometries. Transactions of the American Mathematical Society, ISSN 0002-9947, 2016, vol. 368, no. 11, str. 7681-7702. [COBISS.SI-ID 17801049]

Tomaž Košir:
GRUNENFELDER, Luzius, KOŠIR, Tomaž, OMLADIČ, Matjaž, RADJAVI, Heydar. Finite groups with submultiplicative spectra. Journal of Pure and Applied Algebra, ISSN 0022-4049. [Print ed.], 2012, vol. 216, iss. 5, str. 1196-1206. [COBISS.SI-ID 16183385]
BUCKLEY, Anita, KOŠIR, Tomaž. Plane curves as Pfaffians. Annali della Scuola normale superiore di Pisa, Classe di scienze, ISSN 0391-173X, 2011, vol. 10, iss. 2, str. 363-388. [COBISS.SI-ID 15928409]
KOŠIR, Tomaž, OBLAK, Polona. On pairs of commuting nilpotent matrices. Transformation groups, ISSN 1083-4362, 2009, vol. 14, no. 1, str. 175-182. [COBISS.SI-ID 15077977]

Mihael Perman:
PERMAN, Mihael. An excursion approach to Ray-Knight theorems for perturbed Brownian motion. Stochastic Processes and their Applications, ISSN 0304-4149. [Print ed.], 1996, let. 63, str. 67-74. [COBISS.SI-ID 7621465]
PERMAN, Mihael, WELLNER, Jon A. On the distribution of Brownian areas. Annals of applied probability, ISSN 1050-5164, 1996, let. 6, št. 4, str. 1091-1111. [COBISS.SI-ID 7101017]
PERMAN, Mihael, WELLNER, Jon A. An excursion approach to maxima of the Brownian bridge. Stochastic Processes and their Applications, ISSN 0304-4149. [Print ed.], 2014, vol. 124, iss. 9, str. 3106-3120. [COBISS.SI-ID 17154393]
PERMAN, Mihael. A decomposition for Markov processes at an independent exponential time. Ars mathematica contemporanea, ISSN 1855-3974. [Spletna izd.], 2017, vol. 12, no. 1, str. 51-65. [COBISS.SI-ID 17677145]

Bor Plestenjak:
PLESTENJAK, Bor. Numerical methods for nonlinear two-parameter eigenvalue problems. BIT Numerical Mathematics, ISSN 0006-3835, 2016, vol. 56, iss. 1, str. 241-262. [COBISS.SI-ID

17663321]
PLESTENJAK, Bor, HOCHSTENBACH, Michiel E. Roots of bivariate polynomial systems via determinantal representations. SIAM journal on scientific computing, ISSN 1064-8275, 2016, vol. 38, no. 2, str. A765-A788. [COBISS.SI-ID 17644377]
PLESTENJAK, Bor, GHEORGHIU, C. I., HOCHSTENBACH, Michiel E. Spectral collocation for multiparameter eigenvalue problems arising from separable boundary value problems. Journal of computational physics, ISSN 0021-9991, 2015, vol. 298, str. 585-601. [COBISS.SI-ID 17347417]
PLESTENJAK, Bor. Razširjen uvod v numerične metode, (Matematika - fizika, 52). 1. natis. Ljubljana: DMFA - založništvo, 2015. 418 str., ilustr. ISBN 978-961-212-264-5. [COBISS.SI-ID 280352000]

Jaka Smrekar:
FORSTNERIČ, Franc, SMREKAR, Jaka, SUKHOV, Alexandre. On the Hodge conjecture for q-complete manifolds. Geometry & topology, ISSN 1465-3060, 2016, vol. 20, no. 1, str. 353-388. [COBISS.SI-ID 17622361]
SMREKAR, Jaka. CW towers and mapping spaces. Topology and its Applications, ISSN 0166-8641. [Print ed.], 2015, vol. 194, str. 93-117. [COBISS.SI-ID 17413721]
SMREKAR, Jaka. Homotopy type of space of maps into a K(G,n). Homology, homotopy, and applications, ISSN 1532-0073, 2013, vol. 15, no. 1, str. 137-149. [COBISS.SI-ID 16643929]