Univerza v Mariboru
University of Maribor

Fakulteta za naravoslovje in matematiko / Faculty of Natural Sciences and Mathematics

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Operacijske raziskave
Course title:	Operations research

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Izobraževalna matematika – enopredmetna, 2. stopnja		**2.**	**3.**
Educational mathematics single-major, 2nd cycle		**2.**	**3.**

Vrsta predmeta / Course type Izbirni / Elective

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
45	**15**	**30**			**90**	**6**

Nosilec predmeta / Lecturer: Drago Bokal

Jeziki / Languages:	**Predavanja / Lectures:**	slovensko/slovene ali angleško/english
	Vaje / Tutorial:	slovensko/slovene ali angleško/english

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Poznavanje enostavnih algoritmov. Poznavanje osnov linearne algebre in vektorske analize.	Knowledge of simple algorithms. Knowledge of basic linear algebra and calculus.

Vsebina: **Content (Syllabus outline):**

Obvezna vsebina, ki pri študentih vzpostavi temeljni nabor znanj s področja operacijskih raziskav:

- Proces matematičnega modeliranja. Modeliranje odločitev, odločitveno drevo, razveji in omeji, dinamično programiranje.
- Optimizacijski modeli s centraliziranim odločanjem, modeli teorije iger s porazdeljenim odločanjem. Deterministični, stohastični, robustni problemi.
- Nevezani ekstrem, Newtonova metoda.
- Linearno programiranje. Dokaz Farkasove alternative in krepke dualnosti. Simpleksna metoda. Senčna cena, analiza občutljivosti in parametrično programiranje.
- Večkriterijalna linearna optimizacija. Ciljno programiranje. Celoštevilsko programiranje.
- Uvod v teorijo iger. Igre z ničelno vsoto in linearno programiranje.
- Stohastično linearno programiranje (diskretna spremenljivka).

V okviru obvezne vsebine študentje izberejo tri manjše projekte, katerih rezultat so krajše seminarske naloge. Projekti so povezani z njihovo bodočo kariero (praktični problemi iz gospodarstva, teoretični problemi iz teorije optimizacije, algoritmov, modeliranja). Preostala predavanja se prilagodijo projektom, ki so jih izbrali študentje, in obsegajo izbrane vsebine z naslednjega seznama:

- Deterministični in stohastični problemi optimizacije portfelja.
- Optimalni portfelj celoštevilskih lotov in celoštevilsko programiranje.
- Imunizacija portfelja in stohastično programiranje.
- Optimizacija zalog.
- Problem prehrane.
- Aplikacije teorije iger: optimalna strategija na tržišču z dvema konkurentoma.
- Čakalne vrste.
- Druge vsebine s področja operacijskih raziskav in matematičnega modeliranja, povezane s študentskimi projekti.

V okviru seminarskih nalog se študentje srečajo tudi s programsko opremo za matematično modeliranje, komercialno (Excel, Lindo, Matlab) oz.
prostodostopno in odprtokodno (Python, NEOS, R).

Mandatory content that familiarizes the students with fundamentals of operations research:

- The process of mathematical modelling. Modelling decisions, decision tree, branch and bound search for solutions. Dynamic programing.
- Optimization models with centralized decision making. Deterministic, stohastic, robust problems.
- Unconstrained optimization. Newton's method.
- Linear programming. Farkas alternative and strong duality. Simplex method. Shadow prices, sensitivity analysis, parametric programming.
- Multicriteria linear optimization. Goal programming. Integer programming.
- Introduction to game theory. Zero sum games and linear programming.
- Stohastic linear programming with discrete variables.

Within the coursework, the students select smaller problems whose result are coursework reports. The problems are related to their future career (practical problems from industry and business, theoretical problems from the areas of optimization, algorithms, modelling). The content of the remaining lectures is selected according to these projects from the following list:

- deterministic and stochastic problems of optimal portfolio,
- Optimal portfolio of integer lots and integer programming.
- Portfolioimmunization and stohastic programming.
- Stock control.
- Diet problem.
- Applications of game theory: optimal strategy on a market with two competitors.
- Queues.
- Other operations research and mathematical modelling topics related to students' projects.

Within their coursework and exercisces, the students familiarize themselves with software for mathematical modelling, either commercial (Excel, Lindo, Matlab) or freely avaliable open source (Python, Neos, R).

Temeljni literatura in viri / Readings:

J. Franklin, Methods of Mathematical Economics: Linear and Nonlinear Programming, Fixed-Point Theorems. Classics in Applied Mathematics 37, SIAM, 2002.
R. Rardin. Optimization in Operations Research. Prentice Hall, Inc., Upper Saddle River, New Jersey, 2000.
J. Curwin, R. Slater. Quantitive Methods for Business Decisions. Third Edition. Chapman & Hall, London, 1991.
L. Neralić, Uvod u matematičko programiranje 1. Udžbenici Sveučilišta u Zagrebu, Zagreb, 2001.
S. A. Zenios, Financial Optimization. Cambridge University Press, Cambridge, 1993.

Cilji in kompetence:

Usvojiti proces matematičnega modeliranja.

Razviti kompetenco samostojnega apliciranja matematičnih metod na probleme iz finančne optimizacije, ekonomije, ter širše iz gospodarstva.

Spoznati tehnološka orodja, s katerimi se srečujemo pri reševanju optimizacijskih problemov in problemov matematičnega modeliranja.

Objectives and competences:

Familiarize the students with the process of mathematical modelling.

Develop competent skills of independent application of mathematical methods to the problems from financial optimization, economics, and broader from industry.

Familiarize the students with technological tools that assist solving optimization problems and problems related to mathematical modelling.

Predvideni študijski rezultati:

Znanje in razumevanje:

Študent pridobi pregledno znanje v predmetu obravnavanih konceptov, kar utrjuje s smiselnim pogovorom o navedenih temah na predavanjih, vajah in konzultacijah. Naučene pojme, njihove zakonitosti in razmerja pojasni s pogovorom o obravnavanih temah na ustnem izpitu. Izbrano od obravnavanih vsebin študent prouči poglobljeno, kar izkaže z uporabo relevantnih konceptov v izdelku, seminarski nalogi, kjer z uporabo konceptov izbrane teme razreši konkreten problem, ki je aktualen ali splošno v izobraževanju, ali v povezavi s snovjo, ki jo bo poučeval, ali s problemom potencialnega delodajalca, ki izhaja iz okolja, v katerem bo izobraževal.

Prenesljive/ključne spretnosti in drugi atributi:

Direktne aplikacije v finančni matematiki, ekonomiji, poslovnih vedah, inženirstvu, kemiji in številnih drugih družboslovnih in naravoslovnih vedah. Obenem principi linearne optimizacije tvorijo osnovo za matematično programiranje.

Intended learning outcomes:

Knowledge and Understanding:

The student gains a comprehensive understanding of the concepts covered in the subject, which is reinforced through meaningful discussions on these topics during lectures, exercises, and consultations. They articulate the learned terms, their principles, and relationships by engaging in an oral exam focused on the subject matter. The student conducts in-depth research on selected content from the course, demonstrating their mastery by applying relevant concepts in a project. In the project, they address a specific issue relevant to education, their future teaching materials, or a potential workplace problem derived from the educational environment in which they will be teaching.

Transferable/Key Skills and other attributes:

Direct applications in finacial mathematics, economy, business, engineering, chemistry, and numerous other social and natural sciences. Also, principles of linear optimization are foundations for mathematical optimization.

Metode poučevanja in učenja:

Learning and teaching methods:

Na predavanjih študentje spoznajo predpisano snov predmeta. V okviru seminarskih vaj študentje razumevanje snovi utrjujejo na projektih, povezanih z njihovo bodočo kariero. Razporejeni so v manjše skupine, ki po metodah projektnega učenja delajo na izbranih projektih. V okviru seminarja študentje predstavijo rezultate projektov, s čimer se priučijo suverenega javnega nastopanja in zagovarjanja svojih rezultatov.	At the lectures the students are familiarized with the required contents of the course. Within the coursework, the students deepen their understanding of the material on projects, related to their future careers. They are organized in smaller groups who apply the principles of project based learning on three smaller projects. At the seminar, the students present the results of their projects, thus acquiring confidence with public presentation and defending their results.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt) Projekt, 90 ur samostojnega dela. Ustni izpit Vsaka izmed naštetih obveznosti mora biti opravljena s pozitivno oceno. Pozitivna ocena pri seminarskih nalogah je pogoj za pristop k izpitu.	 75% 25%	Type (examination, oral, coursework, project): Project, approx. 90 hours of individual work Oral exam Each of the mentioned commitments must be assessed with a passing grade. Passing grade of the coursework reports is required for taking the exam.

Reference nosilca / Lecturer's references:

1. Smole, A., Jagrič, T., & Bokal, D. (2021). Principal/Two-Agent model with internal signal. *Central European Journal of Operations Research*, *29*(3), 791-808.
2. Bokal, D., & Steinbacher, M. (2019). Phases of psychologically optimal learning experience: task-based time allocation model. *Central European Journal of Operations Research*, *27*(3), 863-885.
3. JEREBIC, Janja, KAJZER, Špela, VOGRINEC, Monika, BOKAL, Drago. (2021). Longitudinal dynamics between linearly ordered classes. V: DROBNE, Samo (ur.), et al. *SOR '21 proceedings : the 16th International Symposium on Operational Research in Slovenia : September 22 - 24, 2021, online*. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 221-226.
4. BOKAL, Drago, CHIMANI, Markus, VEGI KALAMAR, Alen. (2021). On the didactic value of crossing critical graphs. V: DROBNE, Samo (ur.), et al. *SOR '21 proceedings : the 16th International Symposium on Operational Research in Slovenia : September 22 - 24, 2021, online*. Ljubljana: Slovenian Society Informatika, Section for Operational Research, Str. 203-208