Optimisation Methods for Processes and Systems

Classification	Module ID	Kind of Module	Number of Credits (ECTS)
		Elective	5

Location	Language	Duration of Module	Frequency of Module	Max. Number of Participants
Online	English	One Semester	Summer Semester	60

Module Convenor	Professor / Lecturer
Assoc. Prof. Dr. Tetiana Klochko	Assoc. Prof. Dr. Tetiana Klochko Assistant Lecturer Dr. Valentyn Tsapenko

Prerequisites*

Mathematical analysis, information technologies, computer engineering and intelligent and information systems.
*** Note: Please also note the prerequisites according to the examination regulations in the respective valid SPO version.**

Usability	Teaching Methods	Workload
The module is offered by the Department of Computer-Integrated Technologies of Device Production, Igor Sikorsky Kyiv Polytechnic Institute, as an elective module at Master's level for the Digital Technology and Management programme. The usability in other courses of study must be checked in each individual case.	Lecture; practical exercises (problem solving)	Contact time: 60 h Self-study: 60 h Exam preparation: 30 h Total effort: 150 h

Learning Outcomes
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After successful completion of the module, students will have acquired the following professional, methodological and personal skills and competencies:
Professional Skills:

- Students can identify typical models of optimisation problems and formalise optimisation tasks for automated processes and systems.
- Students are able to apply optimality conditions, including the Kuhn-Tucker theorem and duality, and numerical one- and multidimensional optimisation methods.
- Students can solve linear programming, transportation, assignment and combinatorial problems such as the travelling salesman and knapsack problems.
- Students are able to apply multi-criteria optimisation to technological processes, for example to find the most cost-effective machining variant.

Methodological Skills:

- Students can build mathematical models for optimisation and operations research problems and select a suitable solution algorithm.
- Students are able to choose the best variant of automating an object or process without checking all possible options.

Personal Skills (Social Competence and Self-competence):

- Students can argue and justify decisions between competing alternatives using algorithmic thinking.

Course Content

Basic concepts: formulation and formalisation of optimisation problems, classes of extremum problems, extrema of functions of one and several variables, constrained extremum. Necessary and sufficient optimality conditions, the Kuhn-Tucker theorem, duality in convex programming. Numerical methods: one-dimensional minimisation and global search; first- and second-order gradient methods (steepest descent, conjugate gradients, Newton, DFP); zero-order methods (Gauss-Seidel, Rosenbrock, simplex search, Hooke-Jeeves, random search); penalty functions and gradient projection. Linear programming: simplex method, duality, integer problems. Production models: transportation and assignment problems, travelling salesman, knapsack and bin packing problems, greedy algorithms, branch and bound, dynamic programming. Systems modelling and multi-criteria optimisation of automated technological systems.

Literature

1. Klochko T. R. (comp.). Optimisation Methods for Processes and Systems: Lecture Notes. Igor Sikorsky KPI, 2024. 194 p. (in Ukrainian)
2. Zaichenko Yu. P. Operations Research: textbook. 7th ed. Kyiv: Slovo, 2006. 816 p. (in Ukrainian)
3. Zhaldak M. I., Tryus Yu. V. Fundamentals of the Theory and Methods of Optimisation: textbook. Cherkasy: Brama-Ukraina, 2005. 608 p. (in Ukrainian)
4. Hillier F. S., Lieberman G. J. Introduction to Operations Research. McGraw-Hill, 2021.
5. Taha H. A. Operations Research: An Introduction. Pearson, 2017.
6. Rao S. S. Engineering Optimization: Theory and Practice. Wiley, 2019.

Internationality (content-related)

Optimisation and operations research methods are an internationally standardised body of knowledge; the module draws on leading international textbooks (Hillier and Lieberman, Taha, Rao, Nemirovski).

Method of Assessment (if applicable, notes on multiple choice as form of examination - APO §9a)

Form of Examination*1)	Type/Scope incl. Weighting*2)	Learning Objectives/Competencies to be Assessed
Portfolio examination	Practical classes (7): 84 % Module test: 16 % Optional written credit test: replaces the rating if the result is higher	All of the above-mentioned competencies are assessed by way of the aforementioned examination forms.

*1) Please refer to the applicable overview of the forms of examination at the OTH Amberg-Weiden
*2) Please provide additional information on the weighting (in % share) and, if applicable, explain the bonus system.