Combinatorial Optimization
Overview

Prof. Dr. Norbert Trautmann

University of Bern

Fall semester 2023

(as of September 6, 2023)

Outline

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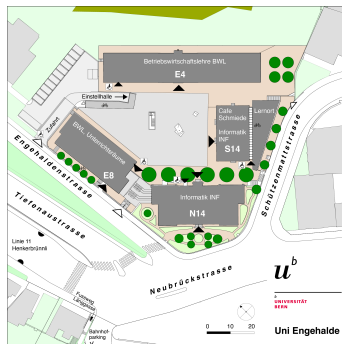
CV Norbert Trautmann

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- Born in Karlsruhe (Germany)
- 1997: MSc in Industrial Engineering (University of Karlsruhe)
  1996–1997: Université de Lausanne and EPF Lausanne
- 2000: PhD in Business Administration (Univ. of Karlsruhe)
- 2004: Habilitation (University of Karlsruhe)
- Since 2005: Professor in Quantitative Methods in Business Administration, Department of Business Administration, University of Bern
- Research:
  - Mathematical programming
  - Operations management
  - Portfolio selection

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CV Tamara Bigler

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- Born in Vinelz
- 2018: MSc in Business Administration, University of Bern and Copenhagen Business School
- 2023: PhD in Business Administration, University of Bern
- Since 2023: Scientific Staff, University of Bern
- Research:
  - Mathematical programming
  - Optimization in networks
  - Data analytics

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Contact

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UNIVERSITÄT
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- Department of Business Administration

- Chair in Quantitative Methods Engehaldenstrasse 4, 3012 Bern
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  - Office 207 (NT)

- E-Mail: tamara.bigler@unibe.ch, norbert.trautmann@unibe.ch

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Course in context of master studies

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- Course can be selected as component of[1]
    - Management Science module or
    - Elective module
- KSL registration required for participation
- Required knowledge: completion of Bachelor degree in Business Administration or Economics
    - Introduction to Mathematics
    - Quantitative Methods in Business Administration

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[1]2007 course scheme: course is part of the choice area for MSc BA and MSc B&Ec students

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Lecture: flipped-classroom concept

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- Lecture material: ILIAS
    - Slides
    - Optimization software files
    - Additional literature (textbook excerpts)
- Screencasts available every friday from 8:15am (self-study)
- In-person lectures
    - Schedule: Wednesday 9:15am–10am[2] (exception: Oct 18)
    - Location: main building, Hochschulstrasse 4, room 106
    - Discussion of screencast content and of applications
- Q&A: ILIAS forum (until Dec 13)

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[2]Sep 20: 8:15am–10am

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Exercises

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- Schedule: Wednesday 8:15–9[3] (exception: Oct 18)
- Location: main building, Hochschulstrasse 4, room 106
- Exercise material: ILIAS
  - Series available after corresponding in-person lecture
  - Solutions available after exercise session
- Types of exercises
  - Review of the lecture content
  - Formulation of combinatorial optimization problems
  - Manual application of discussed methods
  - Application of discussed methods using industrial optimization software package (AMPL)
- Q&A: ILIAS forum (until Dec 13)

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[3]starting on Sep 27

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Exercises: bonus points

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- Assignment on exercise series 2–9
- Groups of two or three students submit solution to selected exercises
- How and when to submit: last page of exercise series
- Support for forming groups: co.pqm@unibe.ch
- Grading: in total, 10 bonus points can be achieved

- For some exercises, usage of AMPL software required (download via ILIAS)
- AMPL introduction: Screencast (ILIAS), available by Oct 4

- Discussion of solutions to all exercises during exercise sessions

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Overview exam

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- 4.5 ECTS
- Written exam
- Exam will cover lecture and exercises
- Permitted aids:
    - Non-programmable hand-held calculator
    - Formulary (will be distributed with the exam)
- Grading
    - Maximal attainable score in the exam: 80 points
    - Maximal attainable score in bonus-point exercises: 10 points
    - At most 80 points required for highest grade
    - 2023 bonus points can be credited to exams in Dec 2023 and Feb 2024

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Dates for final exam

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- Dates[4] (duration of final exam is 80 minutes)
  1. Tuesday, Dec 19, 2023; begin at 10:15am
     - Registration (only via KSL) by Dec 12, 2023
     - Deregistration (only via KSL) by Dec 17, 2023
     - Access of graded exam: Dec 22, 2023 or Jan 8, 2024
  2. Wednesday, Feb 14, 2024; begin at 8:15am
     - Registration (only via KSL) by Feb 7, 2024
     - Deregistration (only via KSL) by Feb 12, 2024
     - Access of graded exam: Feb 16, 2024 or Feb 19, 2024
- Location: will be announced on ILIAS after closing date for exam deregistration
- Sample exam questions: in-person lecture Dec 6, 2023
- Q&A via ILIAS forum until Dec 13, 2023

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[4]All dates are preliminary

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Learning outcomes

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The students are able to

- efficiently model complex decision problems in finance, marketing, and management as linear programs (LP) or mixed-integer linear programs (MILP)
- implement and solve the respective programs with industrial solvers, and analyze the results obtained
- describe the structural properties of LP and of MILP
- analyze the solution procedures applied by the solvers (i.e., the simplex algorithm for LP and the branch-and-bound and the branch-and-cut-algorithm for MILP)
- select and apply basic heuristic algorithms to solve combinatorial optimization problems (CO)
- develop and implement MILP-based heuristics for solving CO
- explain basic meta-heuristic algorithms for solving CO

Structure

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1 Linear programming and the Simplex algorithm

2 Exact methods for MILP
- Branch-and-bound method
- Cutting planes
- Application: The Enchanted Journey

3 Traveling salesperson and vehicle routing problems
- MILP formulations
- Heuristics
- Applications: UPS, Coca-Cola Enterprises

4 Heuristics for CO
- MILP-based heuristics
- Metaheuristics
- Application: iHeartMedia

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Hillier Lieberman (2021): Introduction to Operations Research. McGraw-Hill

Neumann Morlock (2002): Operations Research. Hanser

Brandindu Trautmann (2014): A mixed-integer linear programming approach to the optimization of event-bus schedules: a scheduling application in the tourism sector. Journal of Scheduling 17(6), 621–629

Kant Jacks Aantjes (2008): Coca-Cola Enterprises optimizes vehicle routes for efficient product delivery. Interfaces 38(1), 40–50

Holland Levis Nuggehalli Santilli Winters (2017): UPS optimizes delivery routes. Interfaces 47(1), 8–23

Venkatachalam Wong Uyar Ward Aggarwal (2015): Media company uses analytics to schedule radio advertisement spots. Interfaces 45(6), 485–500