Operations Research and Logistics

Course

Decision Science 1

Course code	ORL-20306
Period	1 and 2
Contact Person	G.D.H. (Frits) Claassen
Lecturers	M.E. (Marjolein) Buisman G.D.H. (Frits) Claassen A. (Argyris) Kanellopoulos D. (Dmitry) Krushynskyi J.C. (Joke) van Lemmen
Examiner	G.D.H. (Frits) Claassen
Language of instruction	English
Assumed prerequisite knowledge	Mathematics M (MAT-12806) or Mathematics 3 (MAT-15003)
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Course Guide 2019/2020

Profile of the course

Decision Science 1 is an introductory course in the field of Operations Research (also called Decision- or Management Science). The course is included in different study programmes at Wageningen University.

Students of our university traditionally have a heterogeneous background coming from different countries all over the world with various study disciplines and varying competence in mathematical abstraction. This diversity offers a continuous challenge to exploit the added value of OR models and techniques in various study disciplines without compromising to the original purpose: i.e. *to deliver an introduction to Operations Research; to explain how, why and when OR models and the related (basic) solution techniques can be expected to work and to provide a solid basis for future study in OR topics*.

Decision Science deals with quantitative methods and techniques to support complex decision processes. The starting point is to optimise, i.e. to perform as well as possible, by making use of mathematical models. Applications of Operations Research models and techniques can be found in many different fields, e.g. economics, technology, logistics, environmental management, forestry, ecology, agriculture, health care, sports, water management and almost in every commercial company.

Global aims of the course are: getting familiar with and acquiring basic insight and understanding of mathematical programming (i.e. MP-based) models and techniques. Recognize where typical decision problems occur, develop models and apply MP-based solution techniques to solve these models. The background of the methods is discussed in the course and it is indicated how they can be applied to practical decision problems. The modelling is illustrated from many decision problems of firms, consumers, governments and other non-profit organisations.

Learning outcomes

After the course the students are expected to be able to:
- recognize situations in which typical decision problems occur
- distinguish the different classes of decision problems
- construct an optimization model based on a verbal description of a decision problem
- apply the studied algorithms to calculate a solution to minor provided problems
- demonstrate insight with respect to solution techniques
- analyse the outcome of the solution techniques for small-scale problems
- translate MP-based models in state of the art, design oriented optimization tools

Learning materials and resources
- *Decision science; Theory and applications*, G.D.H. Claassen et al., 2007. ISBN: 978-90-8686-001-02. The book can be purchased either at WURshop (Forum building) or directly from the publisher during the first lecture day (room and time slot will be announced on Blackboard).
- *Exercises and Computer Practicals*. The exercises can be downloaded from Blackboard. On the first lecture day a hardcopy is available too.

Educational activities

Five different work forms are used:
- *Tutorial/hearing sessions*. Theory is presented in tutorial/hearing sessions. Many small scale examples are given. Main goal is to support and stimulate students in acquiring knowledge, insight and understanding. A separate line includes to recognize (families of) decision problems and to formulate appropriate optimization models for these problems.
- *Supervised tutorial sessions*. Students make exercises both at home and during the tutorial sessions. Difficult aspects are explained plenary. Stimulating and supporting students in their study process is more important during supervised study/tutorials than acquiring basic skills.

- *Computer practicals*. Exercises are made using professional software. Modelling is a major topic. Moreover, these practicals have a significant added value in acquiring insight and understanding. At the beginning of each session several exercises are handed out that have to be made and handed in at the end of the session. The exercises are well linked up with the subjects of the supervised tutorial and hearing sessions. At the end of each session new exercises are available for homework. These exercises have to be handed in at the beginning of the next session. The aim of the home work exercises is to stimulate students to study the book and to be well prepared for the computer practicals. Due to both a limited capacity of computer labs and restricted availability of teaching assistance, it is necessary to enrol for the course. The final grouping will be announced. Please follow the grouping, both for the tutorial sessions and the computer practicals! Candidates that followed the computer practicals successfully, receive a bonus for the written exam (see assessment strategy). **It should be emphasized that we must exclude the possibility of following computer practicals repeatedly. The practicals can be followed only once, in a single period (i.e. the period of first enrolment for the course).**
- *Question hours*. Question hours for individual feedback are scheduled weekly. At these occasions, no plenary information is offered.
- *Self-study*. The total number of contact hours comprises only a part of the 6 credits. Experience has taught that keeping up with the subjects and studying during the lecture period is much more effective and efficient than a great study effort shortly before the exam. Practicing exercises as a main study activity to acquire skills and being able to reproduce, is strongly discouraged!

Assessment strategy (examination)

The exam is a written exam (partly multiple choice, partly open questions). A calculator and the book can be used. Notes are not allowed (also not in the book!).

Learning outcomes \ where assessed	Computer Practicals	Exam
1. recognize situations in which typical decision problems occur	x	x
2. distinguish the different classes of decision problems	x	x
3. construct optimization models based on a verbal description of a decision problem	x	x
4. apply the studied algorithms to calculate a solution to minor provided problems		x
5. demonstrate insight with respect to solution techniques		x
6. analyse the outcome of the solution techniques for small-scale problems	x	x
7. translate MP-based models in state of the art, design oriented optimization tools	x	

Candidates that have completed the computer labs successfully (which means: they attended all sessions, handed in all exercises which are approved by the lecturers), receive a bonus of 10 credits for the written exam. At our university, practical's are by default compulsory. **A bonus is at most three times valid, i.e. for <u>one</u> of the <u>regularly scheduled exam</u> immediately after the practicals are finalised successfully (either P1 or P2) <u>and</u> for the <u>two</u> officially scheduled <u>re-exams in the same academic year</u>.**

For candidates with a bonus the following rule applies:

$$\text{final mark} = \frac{\text{number of credits for the exam} + 10}{6}$$

For candidates without a bonus the following rule applies:

$$\text{final mark} = \frac{\text{number of credits for the exam}}{5}$$

The total number of credits for the written exam is 50. Passing the course implies that the score of the final mark is at least 5.5.

Exams are corrected by at least two assessors (i.e. lecturers). The starting point for the correction of exams is that different assessors achieve the same final mark. Individual exams between 25 and 29 credits (without bonus) or between 21 and 25 credits (with bonus) are checked twice by different assessors. Final marks are determined in the end by the examiner in consultation with all involved assessors.

Principle themes of the content

Formulating optimization models

Formulating optimization models is an important theme (i.e. a separate line) in the course. The aim is to recognize situations in which typical decision problems occur, learn to distinguish the different classes (or families) of decision problems and to develop (i.e. formulate) optimization models based on verbal descriptions of problems in different application areas. The main types of models cover continuous linear programming (Chapter 1), purely integer programming (Chapter 1 and 6), multi criteria decision making (Chapter 1 and 5) and dynamic programming (Chapter 1 and 8). Modelling needs a certain degree of ingenuity and creativity. We believe that these aspects are available in our target audience. However, they must be mined and exploited by offering structured exercises, giving (individual) feedback including the demonstration of reasoning by experienced modellers. Formulating optimization models has a prominent place in both the tutorial sessions as well as the computer practicals. Formulating general models (e.g. a prerequisite for real-life environments) requires a higher level of abstraction. Part of the hearing/tutorial sessions and the computer labs in particular, intend to lay a foundation for this way of reasoning. In Decision Science 1 we will restrict ourselves to deterministic problems.

Solving optimization problems

Solving optimization problems, i.e. the developed models of the preceding theme, is another aspect that deserves attention in an academic environment. Here we can't simply rely on well-programmed and advanced computer software. Elementary knowledge and understanding of solution techniques (e.g. algorithms) is needed to apply and interpreted the outcome of OR-models successfully in practice. Basic understanding of the logic behind the various concepts provides the desired insight and lays an indispensable foundation for the application of OR-models and a correct interpretation of the generated solutions.

The course covers a graphical introduction to linear programming (Chapter 2), The Simplex Algorithm (Chapter 3), duality (Chapter 4), an introduction to multi criteria decision making (Chapter 5), (mixed) integer programming (Chapter 6) and dynamic programming (Chapter 8).

Interpretation of generated solutions

After modelling and solving optimization problems follows the (correct) interpretation of the generated solutions. In fact, the optimal solution itself is of minor importance. More important is the robustness of solutions and sensitivity analysis. What will happen after a minor or major change in the data? Data (e.g. prices, yields, capacity limitations etc.) are usually estimations and can easily change in daily practice. Moreover, (technical) innovations may result in new activities which might alter the solutions completely. Defining new scenarios and running the model again with different data is not the ultimate way for answering all questions related to robustness and sensitivity analysis. Once we reach this phase, it becomes clear that the gained insight in previously mentioned themes is critical.

The gained insight in (a) types of solutions and the related sensitivity analysis (Chapter 2), (b) algorithms (chapter 3, 6 and 8) and (c) duality theory (Chapter 4) pays back at this phase. It prevents misinterpretations or even worse: erroneous conclusions.

Outline and schedule of the programme of the course

The global study scheme for Decision Science 1 is:

Periods 1 and 2	Topics in both the Tutorial/hearing and Supervised tutorial sessions	Book	Computer practical's
Week 1	Applications, formulating LP, linear algebra, inverting, sets of equations, graphical solution method, formulating LP-models	Ch1 Ch2 App.A	Formulating LP problems Using Xpress-IVE
Week 2	Basic solution, main theorem, basic solution = vertex = corner point, pivoting, feasible basic transition, formulating LP-models	App.A Ch 3	Formulating in Xpress-IVE, Basic concepts
Week 3	r-row, relative cost coefficients, unbounded solutions, alternative optimal solutions, two-phase method, degeneracy, formulating (integer) models, general LP-formulations	Ch 3	Formulating (general) LP models in Xpress-IVE
Week 4	Duality, dualizing, complementary slackness relations, shadow prices, right-hand-side ranges, cost coefficient ranges, sensitivity analysis. Formulating (integer) models	Ch 4	Formulating general models in Xpress-IVE
Week 5	Multi criteria decision making, decision space, objective space, Pareto optimal solutions, ideal and pessimistic solution, goal programming, integer LP, formulating (multi-objective) models.	Ch 5 Ch 6	Duality (shadow prices, right-hand-side ranges, cost coefficient ranges), sensitivity analyses
Week 6	Dynamic programming (discrete, continuous, multidimensional state vectors), General Bellman equation, formulating DP-models.	Ch 8	Goal programming, Formulating (mixed) integer LP; B&B
Week 7	Self-study and question hours		
Week 8	Exam : see www.schedule.wu.nl **Only the book and a simple (non-programmable) calculator can be used; notes are not allowed (<u>even not in the book</u>)!**		