Mathematical Programming I

BSc in Applied Mathematics for Economics and Management (MAEG)

ISEG - Lisbon School of Economics & Management
Universidade de Lisboa

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  - Student support: contact me (in class or by email) to arrange a meeting.

Syllabus

1. Introduction to Linear Programming

2. The Simplex Method

3. Duality

4. Post-Optimization and Sensitivity Analysis

5. Transportation and Assignment Problems

Objectives

1. Understand the basic concepts of Linear Programming.

2. Formulate different types of problems.

3. Solve problems using appropriate methods.

4. Interpret solutions and evaluate the impact of changes in model parameters.

Bibliography

1 H.A. Taha. *Operations Research: An Introduction.* Pearson Education Limited. 2017.

2 F.S. Hillier & G.J. Lieberman. *Introduction to Operations Research.* McGraw-Hill Education. 2024.

3 P. Goodwin & P.G. Wright. *Decision Analysis for Management Judgement.* John Wiley & Sons, Inc. 2014.

4 P.A. Jensen & J.F. Bard. *Operations Research: Models and methods.* John Wiley and Sons. 2002.

and many others

Assessment

The assessment comprises an individual written examination.

Dates:

Regular Exam	May 18	18h00
Resit Exam	June 05	12h00
Special Exam	July 01	15h00

The grades range from 0 to 20.
To obtain approval, the grade must be greater than or equal to 9.5.

Operational Research

- Did not originate in a laboratory;

- Emerged from operational needs during the Second World War;

- Developed to support decision-making and the organization of military activities of the Allied Forces;

see `https://www.theorsociety.com/ORS/About-OR/The-history-of-OR.aspx`

What is `Operational Research` ?

- An interdisciplinary field of applied mathematics;

- Uses a scientific approach based on:
  - mathematical and statistical models;
  - algorithms;

- Aims to support decision-making in management;

- Typically seeks to improve or optimize the performance of a system;

- Based on mathematics, computer science, and social sciences (economics and management).

see `https://www.youtube.com/watch?v=0oMVVx81kCs`

see several case-studies here `https://www.theorsociety.com/ORS/About-OR/Business-case-studies.aspx`
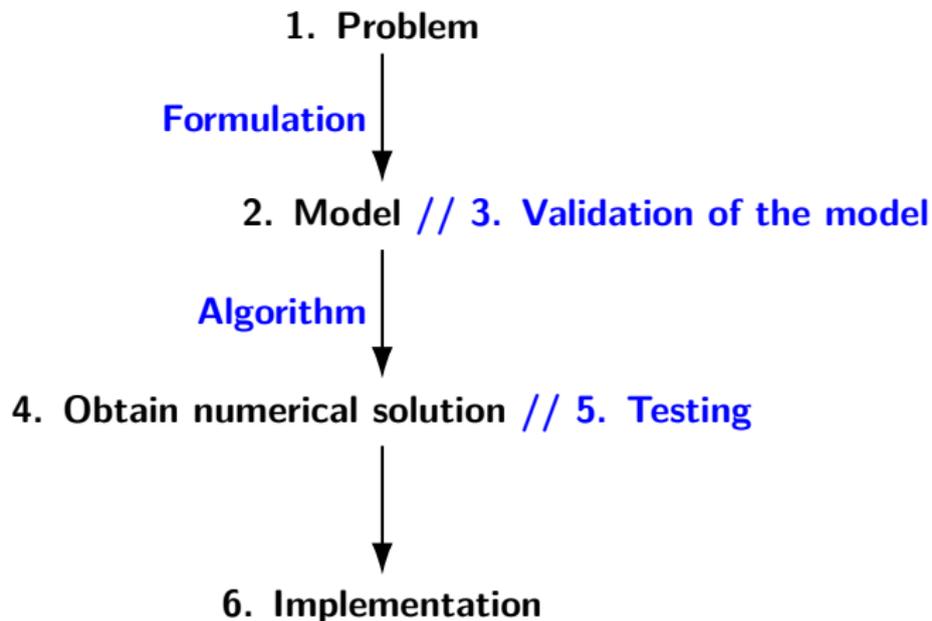
General methodology

Several authors (e.g. W. Winston, Operations Research: Applications and Algorithm, 3rd ed. Duxbury Press, 1994) suggest that the methodology of problem solving must include the following steps

1. Identification and study of the problem;
2. Formulation and construction of a mathematical programming model;
3. Validation of the model;
4. Obtaining the solution of the model;
5. Testing the solution (and validation of the model);
6. Implementation of the solution.

- models improve the organization of operations

Steps of an OR project

1. **Problem**

Formulation

2. **Model // 3. Validation of the model**

Algorithm

4. **Obtain numerical solution // 5. Testing**

6. **Implementation**

Some Operations Research (OR) models

- Mathematical Programming Models:
  - Linear Programming (LP),
  - Integer Linear Programming (ILP),
  - Non-Linear Programming (NLP),
  - Network Optimization (NO),
  - Multi-criteria Optimization (MCO),
  - Robust Optimization (RO),
  - Stochastic Optimization (SO), etc
- Probabilistic Models:
  - Markov Chains,
  - Queues,
  - Prediction, etc
- Decision models:
  - Comparison Process,
  - Decision Trees,
  - Simulation,
  - Game Theory, etc

Challenge

The organic market *From Orchard to Basket* prepares weekly fruit baskets for its customers. There are two types of baskets:

- **Premium Basket (A)** – designed for juices and fruit salads.
- **Smart Basket (B)** – an economical option for daily snacks.

The warehouse has limited fruit stock:

- **Apples:** 10 units available.
- **Oranges:** 14 units available.

Each basket requires the following resources:

- Premium Basket (A): 1 apple and 2 oranges.
- Smart Basket (B): 1 apple and 1 orange.

The profits are:

- Premium Basket (A): 5 € per unit.
- Smart Basket (B): 3 € per unit.

Decide how many baskets A and B to prepare in order to maximize profit without exceeding the stock of fruit.