Winter 2021

Discrete Optimisation and Mineral Reserves

1. **Objectives**

This course is an introduction to

- deterministic discrete optimisation: linear programming, integer linear programming, network flows
- stochastic integer programming
- decomposition
- metaheuristics
- application in mineral resource development

It includes some of the basic mathematical principles required to understand different solution techniques introduced in the lectures. No prerequisites are required to follow the course, but we assume that the students have some mathematical maturity, and that they know basically linear algebra and analysis. Course examples and project are focussed on aspects of mineral reserve development/production planning.

2. **Course content**

**Week 1 (Introduction)**
- Introduction
- Introduction to discrete optimization (Components of a mathematical model, linear programming models, integer programming models, MIPs..)
- Classical problems in discrete optimization (knapsack, assignment problem, …)

**Week 2 (A review of linear programming)**
- The simplex method (the algorithm, outcomes, cycling and degeneracy)

**Week 3 (Duality)**
- Duality (Dual formulation, Duality theorems, some uses of duality)
- Dual simplex method

**Week 4 (Integer programming)**
- Relaxations (motivation, definition, linear relaxation)
- Gomory’s cutting plane methods

**Week 5 (Integer programming)**
- Branch and Bound (the algorithm, branching strategies, node selection)

**Week 6 (Stochastic programming)**
- Stochastic integer programming

**Week 7 (Stochastic programming)**
- Stochastic integer programming
- Initial project presentation
Week 8 (Network flows)
- Simplex method for problems with bounded variables
- Minimum cost flow problem solved by the simplex method

Week 9 (Network flows, Decomposition)
- Minimum cost flow problem solved by the simplex method
- Restriction approach
- Dantzid-Wolfe decomposition method and column generation

Week 10 (Decomposition)
- Relaxation approach
- Benders decomposition

Week 11 (Metaheuristics: local search and Genetic algorithm)
- Metaheuristics: Local search methods (Descent, Tabu search, Simulated annealing, Variable Neighborhood Search)
- Genetic algorithm

Week 12 (Final exam)
- Final Exam

Week 13
- Final Project Presentations

3. **Course grade**

   Homework: 20%
   Final Exam (3 hours): 40%
   Project: 40%

4. **Schedule**

   Tuesday 10:00 – 11:30 a.m.
   Thursday 10:00 – 11:30 a.m.

5. **Course slides available in the following website:**
   http://www.iro.umontreal.ca/~ferland/COMP/index.html

6. **Project - Case study (40% of final grade)**

   - Application of stochastic integer programming in mineral resources problems (Not a toy problem. *Formulation and solution*).
   - Five parts:
     1. Initial description of problems (oral and by each individual student + written, maximum 1 page; presentation 5 minutes): 5%
     2. Make up of the teams (1 or 2 students each): each student joins a consultant team for one of the problems presented (proposals) and a management team for a different problem (data, comments).
3. Proposals by consultant teams (oral and by each consultant team): 10%
4. Preliminary findings and progress report (oral and by each consultant team): 10%
5. Final written case study report (written): 15%

More about the case study (examples)

- Examples of initial proposals for case studies
- Examples of final case study presentations
  http://cgm.cs.mcgill.ca/%7Ecmeagh1/CS567/presentations.htm

Due dates

- Initial description of the problems (oral and by each individual student + written, maximum 1 page): Week 4
- Proposals by consultants (oral and by each consultant(s), 15 minutes): Week 8
- Preliminary findings and progress report (oral and by each consultant): Week 13
- Final written case study report (written): Due to the week after the class ends

Textbooks:

- Linear and nonlinear programming, D.G. Luenberger, Y. Ye, 2008
- Linear programming, V. Chvatal, 1983
- Introduction to Stochastic Programming, Birge and Louveaux, 2011
- Linear Programming and Extensions, Dantzig, Princeton University Press (1963)
- Perspectives on Optimization, Geoffrion, Addison-Wesley (1972)

IMPORTANT:

- McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see www.mcgill.ca/students/srr/honest/ for more information).
- In accord with McGill University’s Charter of Students’ Rights, students in this course have the right to submit in English or in French any written work that is to be graded.