UNIVERSIDAD DE MURCIA

FACULTY OF MATHEMATICS

Combinatorial Optimization

Syllabus

Course code:	6373
Number of ECTS credits:	6
Semester:	1st (September-January)
Recommended components:	Real functions of a single variable I (1568), Linear algebra (1569), Real functions of a single variable II (1573), Functions of several real variables I (1578), Linear Programming (1582), Graphs and Discrete Optimization (1592), Nonlinear Optimization (1604).
Language of instruction:	Spanish (students are allowed to ask questions and write homeworks and exams in English)

Course description

The goal of this course is to adquire enough knowledge to be able to solve problems and obtain new theoretical results in the branch of Mathematical Optimization called Combinatorial Optimization.

Of special importance is to dominate the advanced formulation of problems with linear constraints and integer variables. Also to obtain lower bounds for the minimization problems by means of the relaxation of the feasible solutions set, and the strengthening based on the partial description of the associated polyhedron. To this end it worths to deeply study the Set Packing Problem. Another aim is to develop algorithms making use of the aforementioned lower bounds, as well as to split the solutions set in subsets easier to approach.

There is a family of combinatorial problems which are specially outstanding, those which can be represented on directed graphs. In the second part of the course, theory and algorithms on these problems will be approached. Among others, network flow problems will be studied in detail.

Learning outcomes and competences

After completion of this course you will:

1. correctly formulate Integer Programming problems
2. use basic techniques for solving Integer Programming problems
3. identify real-life problems than can be approached with Discrete Optimization models
4. know the theoretical results that support the solution techniques for Combinatorial Optimization problems
5. acquire skills in Discrete Optimization software
6. know the theory of directed graphs

7. modelize problems with directed graphs
8. solve shortest paths and network flow problems on directed networks

Course contents

I. THEORY

1. Review of basic concepts
2. Lagrangian relaxation
3. Polyhedrics
4. Set packing problem
5. Review of undirected graphs
6. Shortes path problems on directed graphs
7. Network flow problems
8. Minimum cost flow in networks

II. COMPUTER PRACTISES

1. Use of Integer Programming software

References

Main texts

1. Christofides N. *Graph Theory. An Algorithmic Approach*; Academic Press, 1975.
2. Nemhauser G., Wolsey L. *Integer and Combinatorial Optimization*; Wiley, 1988.
3. Reeves C. *Modern Heuristic Techniques for Combinatorial Problems*; BlackWell Scientific Publications, 1993.
4. Wolsey L. *Integer Programming*; Wiley, 1998.

Supplementary references

1. Ahuja R.K. *Network flows: theory, algorithms and applications*; Prentice-Hall, 1993.
2. Cook W.J., Cunningham W.H., Pulleyblank W.R., Schrijver A. *Combinatorial Optimization*; Wiley Interscience, 1998.
3. Eiselt H.A., Sandblom C.L. *Integer Programming and Networks Models*; Springer, 2000.
4. Ford L.R., Fulkerson D.R. *Flows in networks*; Princenton University Press, 1974.
5. Gould R. *Graph Theory*; Dover, 2012.
6. Junger M., Naddef D. *Computational Combinatorial Optimization: Optimal or Provably Near-Optimal Solutions*; Springer-Verlag, 1998.
7. Korte B., Vygen J. *Combinatorial Optimization. Theory and Algorithms*; Springer, 2008.
8. Lee, J. *A First Course in Combinatorial Optimizaton*; Cambridge University Press, 2004.

9. Salazar González, J.J. *Programación Matemática*; Díaz de Santos, 2001.

10. Thulasiraman K, Swamy M.N.S. *Graphs: Theory and Algorithms*; John Wiley & Sons, Inc., 1992.

11. Yang X., Mees A., Fisher M., Jennings L. *Progress in Optimization*; Kluwer Academic Press, 2000.