Course guide
270032 - IO - Operations Research

Last modified: 13/07/2023

Unit in charge: Barcelona School of Informatics
Teaching unit: 715 - EIO - Department of Statistics and Operations Research.

Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: ESTEVE CODINA SANCHO

Others: Primer quadrimestre:
ESTEVE CODINA SANCHO - 10
JOAN GARCIA SUBIRANA - 10

PRIOR SKILLS

Students must have sufficient knowledge of algebra to assimilate the methods exposed algoritmcs should also be able to read English at a technical level

REQUIREMENTS

- Prerequisite PE

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CCO1.3. To define, evaluate and select platforms to develop and produce hardware and software for developing computer applications and services of different complexities.
CCO2.4. To demonstrate knowledge and develop techniques about computational learning; to design and implement applications and system that use them, including these ones dedicated to the automatic extraction of information and knowledge from large data volumes.
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.
CSI2.1. To demonstrate comprehension and apply the management principles and techniques about quality and technological innovation in the organizations.
CSI2.2. To conceive, deploy, organize and manage computer systems and services, in business or institutional contexts, to improve the business processes; to take responsibility and lead the start-up and the continuous improvement; to evaluate its economic and social impact.
CSI2.6. To demonstrate knowledge and capacity to apply decision support and business intelligence systems.
CSI3.5. To propose and coordinate changes to improve the operation of the systems and the applications.

Generical:
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

TEACHING METHODOLOGY

Learning is done following the methodology of cases, from problems in the area of ☐☐Operations Research. From these problems will develop the knowledge necessary formal theory classes, classroom and exhibition, and its application in laboratory classes, so that will strengthen the assimilation of various concepts. Used software available on the UPC (AMPL,OPL/Studio Excel).

LEARNING OBJECTIVES OF THE SUBJECT

1.Knowing the basic methodology and scope of Operations Research
2.Learn simple models of O.R., and special solutions
3.Understand and identify the components of an optimization problem
4.Identification of objectives in a decision process. Learn how to express constraints, both linear and nonlinear, to meet the conditions for decision variables in the model. To formulate multiobjective programming models and goal programming models.
5.Understanding the structure and properties of linear and non-linear programming problems
6.Understand and apply the simplex method to solve linear programming problems
7.Know how to solve linear programming problems in which variables are associated to a graph. networks flow problems.
8.Understand and apply basic techniques for solving linear problems with integer variables
9.Understand and identify the inputs and outputs of Operations Research models underlying various information systems and decision support systems described in the practical sessions.
10.Being able to apply heuristic methods for integer linear programming problems
11.Know and be able to apply different kinds of metaheuristics seen in the course
12.Being able to effectively use information resources in O.R.
14.Having proper attitude and motivation towards work

STUDY LOAD

Type	Hours	Percentage
Self study	84,0	56.00
Guided activities	6,0	4.00
Hours large group	30,0	20.00
Hours medium group	15,0	10.00
Hours small group	15,0	10.00

Total learning time: 150 h

CONTENTS

Introduction to modeling decisions:

Description:
The modeling in the process of decision making. Models of Operations Research. The cycle of operations research methodology

Continuous programming. Properties and methods

Description:
Characteristics of optimization problems. Formulation of optimization problems. Techniques of mathematical programming. Formulation of problem PL. Troubleshooting PL. The geometry of the PL. The simplex method: basic feasible solutions and extreme points. Sensitivity analysis. Introduction to the presence of nonlinearities in the models.

Continuous programming models and systems to support decision making

Description:
Examples of LP problems: production planning; investment problem, transportation problems, mixture problems, inventory problems. Network flow problems. Multi-objective problems. Programming objectives. Presence of non-linearities in models.

Integer Linear Programming

Description:
Integer Linear programming problem properties. Some problems ple: the problem of scheduling workers, problems with routing problems fixed cost and location algorithms PLE: secant planes; Branch & Bound algorithm

Heuristic methods for solving ILP problems

Description:
Constructive heuristics: Greedy methods. Local search. Metaheuristics: beyond local optima. The method of simulated annealing. Tabu search. Genetic algorithms. Aplications of heuristics to routing and other problems.

Search and evaluation of information for conducting a task in O.R.

Description:
Browsers academics. Databases and electronic journals. Assessment Information

Motivation and attitude to work in O.R.

Description:
Motivation for liability, the quality of their work and professional realization. Ability to adapt to organizational changes, technological. Teamwork. Adapting the lack of information and material limitations and time

ACTIVITIES

Block 1. Presentation of the objectives of the basic models of IO and IO

Description:
Monitoring of exposures and review the material proprocionat for the corresponding session. Assimilation of the role of optimization problems as a source of modeling.

Specific objectives:
1, 2, 3

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.
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Full-or-part-time: 2h
Theory classes: 1h
Self study: 1h

Analysis of information sources

Description:
Analysis and evaluation of information provided by certain references (software packages / references that can provide solutions to coursework.

Specific objectives:
12

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 6h 30m
Theory classes: 0h 30m
Self study: 6h

Block 2. Continuous optimization models and systems to aid decision making

Description:
Follow the models exhibited in the theory sessions. Resolution of monitored and modeling exercises. In the lab sessions, training in the use of algebraic representation languages.

Specific objectives:
1, 3, 4

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 12h
Theory classes: 4h
Practical classes: 2h
Self study: 6h

Using search engines referrals, BD and Electronic

Description:
Search for publications of certain writers in relation to coursework. Viewing videos http://bibliotecnica.upc.edu/habilitats/eines-de-cerca-dinformacio http://bibliotecnica.upc.edu/habilitats/l039estrategia-de-cerca # 4

Specific objectives:
12

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 4h 30m
Theory classes: 0h 30m
Self study: 4h

Evaluation of the search for references in relation to course work

Description:
Delivery report with the 5 most significant references and details of the search tools used to find them

Specific objectives:
12

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Block 3. Continuous programming problems

Description:
Tracking theory classes with the support of teaching materials produced specifically. Assimilation of basic concepts feasible optimal basis, optimal local and global. Ability to perform the steps of the simplex algorithm. Individual and monitored resolution of problems. Ability to define linear and non linear models using algebraic lenguages in the lab sessions

Specific objectives:
5, 6

Related competencies :
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 16h
Theory classes: 5h
Practical classes: 3h
Self study: 8h

Attitude and motivation toward work. A1

Description:
Students discuss laboratory exercises delivered according to guidelines contained in a section.

Specific objectives:
14

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Full-or-part-time: 4h
Laboratory classes: 1h
Self study: 3h

Evaluation of information sources

Description:
Delivery of a report of the evaluation

Specific objectives:
12

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Assessing motivation and attitude towards work. A1

Description:
Using rubrics

Specific objectives:
14

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Block 4. Network Flow Problems

Description:
Make simplex iterations for the problem of min-cost. application of minimal paths algorithms. implementation of the max-flow algorithm min.cut

Specific objectives:
1, 7

Related competencies :
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CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 15h
Theory classes: 3h
Practical classes: 4h
Self study: 8h

Evaluation of a lab 1

Description:
Handed a questionnaire completed by the end of the session. This questionnaire will go.

Specific objectives:
2, 3, 4, 5, 6, 7

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.
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Part 1

Description:
Test problems for units of 1,2,3 and 4 of the course and the corresponding block 8-related objectives associated blocks 1,2,3 and 4.

Specific objectives:
1, 2, 3, 4, 5, 6, 7

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 6h
Guided activities: 2h
Self study: 4h

Block 5. Integer linear programming modeling

Description:
Acquire the ability to model using binary variables of type logical conditions. Taking as reference the models presented in the theory sessions in order to undertake their own development and modeling

Specific objectives:
1, 9

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 12h
Theory classes: 2h
Practical classes: 2h
Self study: 8h

Attitude and motivation toward work. A2

Description:
Analysis of the changes proposed by the teacher at Work Course and proposed changes to be made in a limited time. Discussion with other working groups of the adequacy of the solutions adopted

Specific objectives:
14

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Full-or-part-time: 7h
Laboratory classes: 2h
Self study: 5h

Assessing motivation and attitude towards work. A2

Description:
Delivery of final report to the collaborative session parenentatge

Specific objectives:
14

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Block 6. Integer Linear Programming Problems

Description:
Assimilation of the concepts of branching and quoting. Make iterations of the Branch and Bound algorithm with small problems.

Specific objectives:
8

Full-or-part-time: 8h
Theory classes: 2h
Practical classes: 2h
Self study: 4h

Attitude and motivation toward work. A3

Description:
Oral presentation of course work in a limited time (10min to the working group)

Specific objectives:
14

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Full-or-part-time: 7h
Laboratory classes: 2h
Self study: 5h

Assessing motivation and attitude towards work. A3

Description:
Oral presentation

Specific objectives:
14

Related competencies :
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.

Block 7. Heuristic methods for integer linear programming problems. Metaheuristics

Description:
Understand the main principles of construction heuristic solutions. Learn to build algorithms based on metaheuristics described. Simulated annealing method, tabu search, greedy search.

Specific objectives:
9

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 12h
Theory classes: 4h
Practical classes: 2h
Self study: 6h

Evaluation of lab 2

Description:
Handed a questionnaire completed by the end of the session. This questionnaire will go.

Specific objectives:
2, 4, 8, 9, 10, 11

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.
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Laboratory 1 and 2

Description:
Reading the previous questionnaire and preparation of practice. Execution of the exercise and delivery of completed questionnaire

Specific objectives:
3, 5, 6, 7, 8, 10

Related competencies :
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 8h
Laboratory classes: 4h
Self study: 4h

Block 8. Course work.

Description:
Assimilating the different stages of formulation, analysis and testing of an optimization model as part of a system to support decision making. Analysis of performance and computational tools used in the performance of the developed model. Development of skills associated to this subject.
Students will make up work groups (2 students)

Specific objectives:
1, 3, 4, 7, 9, 10, 11

Related competencies :
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G8. APPROPIATE ATTITUDE TOWARDS WORK: to have motivation to be professional and to face new challenges, have a width vision of the possibilities of the career in the field of informatics engineering. To feel motivated for the quality and the continuous improvement, and behave rigorously in the professional development. Capacity to adapt oneself to organizational or technological changes. Capacity to work in situations with information shortage and/or time and/or resources restrictions.
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 16h
Theory classes: 2h
Laboratory classes: 6h
Self study: 8h

Assessment Course work

Description:
A model will be proposed to the students for its developement along the course.
Specific lab sessions will be used for monitoring this activity.

Specific objectives:
- Development of a model based on optimization problems as part of a system to aid decision making.
- Analyze the performance of the computational model developed for use in the environment of proper systems to aid decision making

Specific objectives:
1, 3, 4

Related competencies :
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Part 2

Description:
It consists of test problems for blocks 5,6 and 7 of the subject and the corresponding block 8 related blocks 5.6 and 7.

Specific objectives:
8, 9, 10, 11

Related competencies :
G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.
CSI1. To demonstrate comprehension and apply the principles and practices of the organization, in a way that they could link the technical and management communities of an organization, and participate actively in the user training.

Full-or-part-time: 6h
Guided activities: 2h
Self study: 4h

Final Exam

Description:
It covers all blocs of the subject

Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Related competencies :
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Full-or-part-time: 8h
Guided activities: 2h
Self study: 6h

GRADING SYSTEM

See Addenda for the academic year 2020-21

NT = Mark for Theory
NL = Mark for Laboratory sessions. This mark will consist of the marks obtained in the two lab exercises, each one of them weighting 50% of NL
NTC = Mark for Laboratory Labour Course
NC = Mark for skills

N= 0.45*NT + 0.2*NL + 0.25 * NTC + 0.1*NC

If 0.5* NExP1 + 0.5*NExP2 > = 5 then no need to submit the final exam

NT = Max (NExF, 0.5 * NExP1 + 0.5N*ExP2)

NExF Note of the final exam,

NExP1, NExP2 Notes of partial exams 1 and 2.

Mark NC will depend on the degree reached at the skills assigned to the subject and the mark will be an average of the marks obtained at each of the skills. (There are two skills, C1, C2. Then
mark NC will obtained as NC = 0.5*NC1 + 0.5*NC2

For a given skill i there is the following matching between the level obtained at that skill and the mark NC1, NC2 involved in the final mark

A level A is equivalent to a mark NC1 (or NC2) that will be between 8,5 and 10
A level B is equivalent to a mark NC1 (or NC2) that will be between 6.5 and A level C is equivalent to a mark NC1 (or NC2) that will be between 5 and A level D is equivalent to a mark NC1 (or NC2) that will be between 0 and
Marks for skills are obtained through activities carried out in bloc 8 (Laboratory Labour Course) and Lab sessions.

Marks NC1, NC2 for skills assigned to this subject will obey to the following expression:

NCi = 0.25 * NTC + 0.10*NL + Specific Activities for the skill; i=1,2

BIBLIOGRAPHY

Basic:
- Winston W.L; Venkataramanan, M. Mathematical Programming: operations research. 4th ed. Brooks/Cole, 2003. ISBN 0534359647.
- Fourer, R.; Gay, D.M.; Kernighan, B.W. AMPL a modeling language for mathematical programming. 2nd ed. Thomson/Brooks/Cole, 2003. ISBN 0534388094.
- Williams, H.P. Model building in mathematical programming. 5th ed. John Wiley and Sons, 2013. ISBN 9781118443330.
- Hillier, F.S.; Lieberman, G.J. Introduction to operations research. 2010. New York [etc.]: McGraw Hill, 2010. ISBN 9780073523453.

Complementary:
- Sierksma, G. Linear and integer programming: theory and practice. 2nd ed. CRC, 2002. ISBN 0824706730.

RESOURCES

Hyperlink:
- http://ifors.org/web/- http://people.brunel.ac.uk/~mastjjb/jeb/or/contents.html- http://www-01.ibm.com/software/integration/optimization/cplex-optimization-studi- http://www.ampl.com/- http://www.hsor.org/