COURSE DESCRIPTION

COURSE DETAILS

Title (of the course): **METAHEURÍSTICAS**
Code: 101425
Degree/Master: **GRADO DE INGENIERÍA INFORMÁTICA** Year:
Name of the module to which it belongs: OBLIGATORIO ESPECIALIDAD COMPUTACIÓN
Field: METAHEURÍSTICAS
Character: OBLIGATORIA Duration: SECOND TERM
ECTS Credits: 6.0 Classroom hours: 60
Face-to-face classroom percentage: 40.0% Study hours: 90
Online platform: www.uco.es/moodle

LECTURER INFORMATION

Name: GARCIA MARTÍNEZ, CARLOS (Coordinator)
Department: INFORMÁTICA Y ANÁLISIS NUMÉRICO
Area: CIENCIA DE LA COMPUTACIÓN E INTELIGENCIA ARTIFICIAL
Office location: Dpto. Informática y Análisis Numérico. Anexo C3 en Edificio Marie Curie, planta baja (X3BN090)
E-Mail: cgarcia@uco.es Phone: 957 21 26 60

Name: LUNA ARIZA, JOSÉ MARÍA
Department: INFORMÁTICA Y ANÁLISIS NUMÉRICO
Area: CIENCIA DE LA COMPUTACIÓN E INTELIGENCIA ARTIFICIAL
Office location: Dpto. Informática y Análisis Numérico. Edificio Albert Einstein, planta tercera
E-Mail: jmluna@uco.es Phone: +34957212218

PREREQUISITES AND RECOMMENDATIONS

Prerequisites established in the study plan

None

Recommendations

Students should possess basic programming skills, usually provided in first year courses, and certain practice with data structures and object oriented programming, usually taught in second year courses. Additionally, it is interesting to have some background in statistics, maths, and algorithms

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INTENDED LEARNING OUTCOMES

CTEC2 Ability to know the theoretical foundations of programming languages and associated lexical, syntactic and semantic processing techniques, and know how to apply them for the creation, design and processing of languages.

CTEC3 Ability to evaluate the computational complexity of a problem, know algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance according to the established requirements.

CTEC4 Ability to know the fundamentals, paradigms and techniques of intelligent systems and analyze, design and build systems, services and computer applications that use these techniques in any field of application.

CTEC5 Ability to acquire, obtain, formalize and represent human knowledge in a computable way to solve problems through a computer system in any field of application, particularly those related to aspects of computing, perception and performance in intelligent environments.

OBJECTIVES

- To get an idea of the concept of the complexity class of a problem and the P vs NP problem, the difference between heuristic and metaheuristic algorithms, and the No Free Lunch Theorem for optimisation problems.
- To be able to provide proper computer solution encodings for different optimisation problems in terms of the basic structures: binary, integer, ordered, floating-point and object oriented ones.
- To know and be able to implement basic local optimisation procedures, and to be aware of their limitations.
- To know and be able to implement the main single solution metaheuristics: simulated annealing, tabu search, iterated local search, greedy randomised adaptive search procedures and iterated greedy algorithms.
- To know and be able to implement the main population based metaheuristics: evolutionary algorithms, particle swarm optimisation, ant colony optimisation and artificial bee colony algorithms.
- To notice the importance of the balance between the diversification and intensification concepts that govern every metaheuristic and to detect their associated components.
- To be able to classify metaheuristics in terms of their characteristics: number of solutions, problem knowledge exploitation, explicit use of memory structures...
- To be able to analyse and compare the performance of several metaheuristics on a set of problems.
- To get in touch with other specific optimisation problems: multimodal, multiobjective, constrained, and machine learning; and to know the main approaches to solve them.

CONTENT

1. Theory contents

Lesso 1. Introduction to metaheuristics. General concepts. Solution encoding and evaluation.

Lesson 2. Local optimisation of initial solutions.

Lesson 3. Single solution metaheuristics. Simulated annealing, tabu search, iterated local search, greedy randomised adaptive search procedures, and iterated greedy algorithms.

Lesson 4. Population based metaheuristics I: Evolutionary algorithms. Diversity and premature convergence.

Lesson 5. Population based metaheuristics II: Ant colony optimisation, particle swarm optimisation and artificial bee colony algorithms.

Lesson 6. Categorisation and metaheuristics evaluation: Features, statistical analysis, graphs, and knowledge exploitation identification.

Lesson 7: Other problems: Multimodal, multiobjective, constrained, and machine learning problems.

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2. Practical contents

1. Local optimisation.
2. Population-based metaheuristics.
3. Dealing with a concrete real problem.

SUSTAINABLE DEVELOPMENT GOALS RELATED TO THE CONTENT

Good health and well-being
Industry, innovation and infrastructure
Sustainable cities and communities

METHODOLOGY

General clarifications on the methodology (optional)

(**With regards to the Sustainable Development Objectives**, we shall indicate that metaheuristics are nowadays applied for many tasks of the majority of the considered objectives. The selected ones are those with a direct connection with metaheuristics)

Lectures: Students are advised to read the relevant bibliography before the theoretical classes, to lighten the lecture and promote the exposition and discussion of problem examples. Teachers will explain the connections between the concepts of the current lesson and previous ones. Main concepts will be presented, promoting the intelligent debate of the most complex aspects. **Concepts will be connected to real world problems and applications**. Teachers will formulate questions and scenarios to make students think critically. At the end, teachers will summarise the main concepts provided.

Teachers will use slide projectors for the concepts and white or blackboards for examples and exercises. Multimedia such as videos, webpages and online program executions can be used. All the materials will be on the webpage of the course. The theoretical content will be necessary for the correct development of the laboratory sessions, so this latter will help student to acquire the corresponding competences.

For theoretical classes longer than one hour, teachers will consider to have a break in the middle when students questions would be answered, but no new concepts would be introduced. If there had not been any break, a certain amount of time before the end of the class will be devoted to that purpose. Not interested students may leave the classroom in these time slots.

Laboratory sessions: The goal of laboratory sessions is to expose students to the concepts provided in theoretical ones. Teachers will provide students with practice scripts. Students are advised to work at home on these scripts and dispel their doubts with the teachers in these sessions. In general, students will work on these practice scripts in groups, whose size would have been determined at the beginning of the course. Teachers would use any available academic material to answer the questions of the students (slide presenters, blackboard...)

Individual assistance: Students will be allowed to appoint individual meetings with the teachers to dispel their doubts. However, student should know that individual assistance is not aimed at substituting the regular sessions, so no aspect or doubt apart from those in the student personal notes will be addressed.

Methodological adaptations for part-time students and students with disabilities and special educational needs

Partial time students, as full time students, do not have to attend classes to pass the course. They will be able to get the material from the webpage of the course and appoint meetings with the teachers to dispel their doubts. Nevertheless, students must know that individual assistance is not aimed at substituting the regular sessions, so no aspect or doubt apart from those in the student personal notes will be addressed.

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Face-to-face activities

Activity	Large group	Medium group	Total
Assessment activities	2	2	4
Debates	17	-	17
Lab practice	-	22	22
Lectures	17	-	17
Total hours:	***36***	***24***	***60***

Off-site activities

Activity	Total
Analysis	15
Group work	30
Reference search	15
Self-study	30
Total hours	***90***

WORK MATERIALS FOR STUDENTS

Case studies - *www.uco.es/moodle*
Coursebook - *www.uco.es/moodle*
Dossier - *www.uco.es/moodle*
Placement booklet - *www.uco.es/moodle*

EVALUATION

Intended learning	Exams	Placement reports	Project
CTEC2	X	X	X
CTEC3	X	X	X
CTEC4	X	X	X
CTEC5	X	X	X
Total (100%)	***50%***	***20%***	***30%***
Minimum grade	***5***	***5***	***5***

(*)Minimum mark (out of 10) needed for the assessment tool to be weighted in the course final mark. In any case, final mark must be 5,0 or higher to pass the course.

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Method of assessment of attendance:

The perturbation of the class, by means of activities different from those of the own class, would reduce the global score by 0.5 per reprimand.

General clarifications on instruments for evaluation:

The evaluation mainly consists in the assessment of the theoretical knowledge acquire by the student by means of an **exam** and the work carried out in laboratory assessments, **placement reports** and **project**. Besides obtaining scores greater than or equal to those minima indicated in the table, it is required that the students pass each laboratory assessment individually. The global score will be computed as the weighted sum according to the weights in the Table, in case the minimal scores are satisfied. Otherwise, the global score will be computed as the minimum between 4 and the weighted sum.

Special Situations:

- Extraordinary calls will be evaluated accordint to the same indications

Clarifications on the methodology for part-time students and students with disabilities and special educational needs:

Partial time students, who could not attend to classes, must consult periodically the webpage to be informed about the contents and indications provided.

Partial time students will be evaluated by the same methodology described for full time ones, except by the fact that they will be allowed to develop the reports individually and will be qualified accordingly

Clarifications on the evaluation of the extraordinary call and extra-ordinary call for completion studies:

Standard indications apply.

Qualifying criteria for obtaining honors:

Students with the best final scores, given that they are greater than or equal to 9, and according to the article 80.3 of the Reglamento del Régimen Académico. In case of tie, individual score would be considered.

BIBLIOGRAPHY

1. Basic Bibliography

Michel Gendreau, Jean-Yves Potvin. Handbook of Metaheuristics 2o Edition. Springer 2010

El-Ghazali Talbi. Metaheuristics. From Design to Implementation. John Wiley & Sons. 2009

F. Glover, G.A. Kochenberger (eds.) "Handbook of Metaheuristics", Kluwer Academic Press, 2003

Sean Luke. Essentials of Metaheuristics, 2o Edition. Lulu.com 2013

Sebastián Ventura, José María Luna: Pattern Mining with Evolutionary Algorithms. Springer 2016, ISBN 978-3-319-33857-6, pp. 1-190

CC2020: Computing Curricula 2020: Paradigms for Global Computing Education.

2. Further reading

Karl F. Doener, Michel Gendreau, Peter Greistorfer. Metaheuristics: Progress in Complex Systems Optimization. Springer 2007

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D. Corne, M. Dorigo, F. Glover (eds.) "New Ideas in Optmization", McGraw-Hill, 1999

A.E. Eiben, J.E. Smith, "Introduction to Evolutionary Computing", Springer, 2003

H.H. Hoos, T. Stüzle, "Stochastic Local Search", Morgan Kaufmann, 2004

M. Laguna, R. Martí, "Scatter Search", Springer, 2003
P.M. Pardalos, M.G.C. Resende, "Handbook of Applied Optimization", Oxford University Press, 2002. Review Articles

COORDINATION CRITERIA

Common evaluation criteria
Joint activities: lectures, seminars, visits ...

Clarifications

- Joint activities: in case that pretigious researchers came to our facilities and provided seminars, we usually suggest our students to attending to these ones.
- Common evaluation criteria: The evaluation activities and associated percentages are checked with the associated document of the Computer Science Degree of the University of Córdoba.
- Other activities: In case the School proposes particular activities, they are usually applied
- Detection of requirements and recomendations: these elements of the syllabus present the competences provided in previous courses.
- Teaching innovation projects: teachers often collaborate with other teachers in such kind of projects.

SCHEDULE

Period	Assessment activities	Debates	Lab practice	Lectures	Comment
1# Week	0.0	1.5	2.0	1.5	Lesson 1 / Lab 1
2# Week	0.0	1.5	2.0	1.5	Lesson 2 / Lab 1
3# Week	0.0	1.5	2.0	1.5	Lesson 3 / Lab 2
4# Week	0.0	1.5	2.0	1.5	Lesson 3 / Lab 2
5# Week	0.0	1.5	2.0	1.5	Lesson 4 / Lab 2
6# Week	0.0	1.0	2.0	2.0	Lesson 4 and 5 / Lab 2
7# Week	0.0	1.5	2.0	1.5	Lesson 5 / Lab 3
8# Week	0.0	1.5	2.0	1.5	Lesson 6 / Lab 3
9# Week	0.0	1.5	2.0	1.5	Lesson 7 / Lab 3
10# Week	0.0	1.5	2.0	1.5	Lesson 7 / Lab 3
11# Week	0.0	1.5	2.0	1.5	Lesson 7 / Lab 3
12# Week	0.0	1.0	0.0	0.0	Recap and doubts

COURSE DESCRIPTION

Period	Assessment activities	Debates	Lab practice	Lectures	Comment
14# Week	4.0	0.0	0.0	0.0	Assessment
Total hours:	***4.0***	***17.0***	***22.0***	***17.0***	

The methodological strategies and the evaluation system contemplated in this Course Description will be adapted according to the needs presented by students with disabilities and special educational needs in the cases that are required.