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% Study hours: 90
Online platform: www.uco.es/moodle

LECTURER INFORMATION

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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

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.

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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 encoding** 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

Lesson 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.

2. Practical contents

1. Problems, instances, solution encoding and evaluation.
2. Local optimisation.
3. Single-solution metaheuristics.
4. Population-based metaheuristics.
5. The quest for a good metaheuristic for a given problem.

METHODOLOGY

General clarifications on the methodology (optional)

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

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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.

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

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Activity	Total
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 learnig	Case Studies	Exams	Placement reports
CTEC2	X	X	X
CTEC3	X	X	X
CTEC4	X	X	X
CTEC5	X	X	X
Total (100%)	***25%***	***50%***	***25%***
Minimum grade	***5***	***4***	***5***

(*)Minimum grade necessary to pass the course

¿Valora la asistencia?:

No

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 examen with a 50% of influence on the final mark, and the critical analysis, by all the agents in the course (student, peers and teachers), of the work carried out by each student (case studies, 25% and placement reports, 25%). This latter part, case studies and placement reports, consists in the application of the concepts provided in class to solve a set of problems. On top of that, this methodology seeks the critical thinking of the students about their own work and those of their peers, together with a reasonable amount of student cooperation.

It is important to notice that, according to the following procedure, the best qualifications will not be given to those students who just gain a correct knowledge about the course and might have worked hard, but those who also show the ability to recognise and critically evaluate the work of their peers.

The methodology applies the following ordered steps:

1. At the beginning, students will be given a set of optimisation problems. The main concepts to address these

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problems with metaheuristics will be provided in theoretical classes, and doubts will be dispelled in practice sessions. Besides, teachers will decide the number of students that will work together on with each problem.

2. Students will apply the techniques covered along the course to their problems and elaborate proper analysis reports. Reports will be evaluated by peer students to get a quick feedback. The first four reports will be evaluated by three other peer groups and each group will evaluate three other reports. The last report, which will be exposed in class, will be evaluated by all the students and teachers. These evaluations will include:

- Indications about the errors and aspects that can be improved and, in case, indications of the work remarkably well done.

- A numeric qualification

- The ranking of the report according to the three reports evaluated by the group, with 1 for the best report and 3 for the worst one.

3. Once received the evaluations by the peer groups, each group will propose a self-qualification for its report. As for the last report, the self-qualification will be proposed before the associated exposition.

4. Teachers will evaluate the reports, too. Signs of copy will be contrasted with individual exams. In case the student did not pass that exam, her or his assignment will receive the fail score 0.

5. The final qualification students will receive for their reports will by provided by the teachers.

6. The final qualification students will receive for their peer assessments will be determined according to the differences between their provided grades and those provided by the teachers. This means that students will get the best qualifications for this aspect if they evaluate their peers in a way similar to the teacher, and lower marks if there are differences. On top of that, the final qualification will be proportionally reduced in case the student had not provided the corresponding evaluations for the reports assigned, or they do not follow these indications.

Special Situations:

- In evaluation calls when there were few students to carry out the described exposition and evaluation of the work, students will have to provide the evaluation for the work of the groups that participated in previous calls.

- The extraordinary call in April is for students that fulfil the corresponding requirements (article 29.2 of the RRA). They will be evaluated according to the syllabus of the previous academic year.

- The ill-intended usage of this evaluation methodology will result in a significant penalisation for the corresponding students. By way of guidance, the qualification associated to the peer evaluation would be divided by a power of 2, according to the number warnings the student had received.

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.

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

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30.3 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

P.M. Pardalos, M.G.C. Resende, "Handbook of Applied Optimization", Oxford University Press, 2002. Review Articles

2. Further reading

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

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

COORDINATION CRITERIA

Joint activities: lectures, seminars, visits ...

Clarifications

- Joint activities: It is usual that prestigious researchers visit our centre and provide seminars. In that case, students are often encouraged to attend to these seminars.
- Teachers will specifically look after a correct coordination with the corresponding Spanish course.
- Teaching innovation projects: teachers of this course usually participate in innovation projects, which promote interchanging experiences and ideas with other teachers.
- Detection of requirements and recommendations: the section for requirements and recommendations refer to knowledge concepts provided in previous courses.
- Degree coordination: teachers usually follow the indications of the coordinator of the degree.
- Student suggestions for the last practice: Students have to address a new optimisation problem in the last practice sessions. By default, students will choose one of the optimisation problems provided by the teacher. However, if students detected a possible application to a problem formulated in another course, teachers would evaluate the suitability of using this problem in the last practice sessions.

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SCHEDULE

Period	Assessment activities	Debates	Lab practice	Lectures
1# Week	0.0	1.5	0.0	1.5
2# Week	0.0	1.5	2.0	1.5
3# Week	0.0	1.5	2.0	1.5
4# Week	0.0	1.5	2.0	1.5
5# Week	0.0	1.5	2.0	1.5
6# Week	0.0	1.0	2.0	2.0
7# Week	0.0	1.5	2.0	1.5
8# Week	0.0	1.5	2.0	1.5
9# Week	0.0	1.5	2.0	1.5
10# Week	0.0	1.5	2.0	1.5
11# Week	0.0	1.5	2.0	1.5
12# Week	0.0	1.0	2.0	0.0
15# Week	4.0	0.0	0.0	0.0
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.