MULTIDISCIPLINARY OPTIMAL DESIGN

ECTS: 6

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UNIVERSITY WHERE THE COORDINATOR IS: UPM

HAVE YOU GIVEN PERMISSION TO RECORD YOUR CLASSES?

No

LECTURER 1:

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UNIVERSITY WHERE THE LECTURER 1 IS:

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LECTURER 2:

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LECTURER 3:

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HAVE YOU GIVEN PERMISSION TO RECORD YOUR CLASSES?

No

LECTURER 4:

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UNIVERSITY WHERE THE LECTURER 2 IS:

UPM

HAVE YOU GIVEN PERMISSION TO RECORD YOUR CLASSES?

No

SUBJECT CONTENTS

1.- Introduction to Engineering design: objectives and technical disciplines; modelization and simulation. Design variables and parameters. Constraints and specifications. Design cycles. Multi-disciplinary optimization and multi-objective optimization.

2. Modelization and simulation. Some remarks on simulation. Construction/selection of models of the physical system. Construction/selection of simulation tools. Modular simulation. Design structure matrix and N2 diagram. Codification and preliminary tests. Simulation architectures.

3. Overview of constraint and unconstraint single-objective optimization. Gradient-like methods; Lagrange. KKT conditions. Direct search; Compass, Rosenbrock, Powell, Nelder-Mead. Heuristic methods; genetic algorithms, particle swarm, simulating annealing, neuronal networks. MATLAB optimization tools.

4. Design of experiments and post-optimality. Sampling: factorial, central composite, and random sampling. Correlations, correlation matrix, multiple linear correlations. Response surfaces and surrogate models: least squares, interpolation, Kriging, low-dimensional approximations. Post-optimality and robustness.

5. Multi-objective optimization. Introduction; single-objective vs. multiobjective. Pareto-optimality and Pareto-fronts: weighted means; constraint multiobjective; formulation in terms of KKT. Multi-objective genetic algorithms. MATLAB tools.

6. Continuous vs. discrete formulations. Calculus of Variations revisited. Sensibility and the gradient. Adjoint formulation; discrete and continuous adjoint; application to the Navier-Stokes equations. Shape and topology optimization.

7. Multidisciplinary design in various fields. Automotive engines and turbojets. Aerodynamic design. Structural design. Orbital design.

METHODOLOGY

Theory (basic ideas) and practice (using optimization tools, especially the MATLAB optimization toolbox), somehow following a project-based-learning strategy.

Students will be grouped, with individual groups of up to four members. Each group will define a project (two pages) on a system to be optimized within the first month of the course. This project will need approval from us, to ensure the project is both feasible and multi-disciplinary. Each group will have in mind its project along the course, where the various methods and tools will be provided. In order to follow this evaluation system, the maximum number of lack of attendance to the classroom is 5%. Otherwise, a traditional evaluation system (final exam, with theoretical and practical questions) will be followed.

LANGUAGE USED IN CLASS:

Spanish/English, depending on the audience

IS IT COMPULSORY TO ATTEND CLASS?

Yes, attendance can be both in the classroom where the lecture is done or in a remote classroom connected via telecom.

BIBLIOGRAPHY

1. R. Fletcher “Practical Methods of Optimization”. John Wiley & Sons, 2007.

2. P. Isasi and I. Galván "Redes de neuronas artificiales, un enfoque práctico". Pearson - Prentice Hall, Madrid, 2004.

3. M. Mitchell, “An Introduction to Genetic Algorithms”, MIT Press, 1999.

4. E. Marsopoulos and M. Vrahatis, "Particle swarm optimization and intelligence", Information Science Reference, 2010, NY.

5.- J. Nocedal and S.J. Wright, “Numerical Optimization”, Springer-Verlag, 2006.

6. P.Y. Papalambros and D.J. Wilde, “Principles of Optimal Design. Modeling and Computation”, Cambridge Univ. Press, 2000.

7. P. Salamon, P. Sibani, and R. Frost, "Facts, conjectures and improvements for simulated annealing" . SIAM, Philadelphia, PA, 2002.

8. S. Samarasinghe, "Neural networks for applied science and engineering", Auerbach Publications (Taylor and Francis Group), Boza Ratón, FL, 2007.

9. J. Spall. "Introduction to stochastic search and optimization". Wiley-Interscience, NJ, 2003

10. G.N. Vanderplaats, “Numerical Optimization Techniques for Engineering Design”, Vanderplaats Research & Development Inc., 2001.

11.- K. Willcox et al. "Multidisciplinary Design and Optimization". Lecture Notes. MIT OpenCourseWare, 2014.

SKILLS

Basic:

CG1 -Have knowledge that provides a basis or opportunity for originality when developing and/or applying ideas, often within a research context and knowing how to translate industrial needs in terms of R&D in the field of Industrial Mathematics.

CG2 – Be able to apply the acquired knowledge and abilities to solve problems in new or unfamiliar environments within broader contexts, including the ability to integrate multidisciplinary R&D in the business environments.

CG4 – Have the ability to communicate the conclusions reached together with the knowledge and reasons that support them to specialist and non-specialist audiences in a clear and unambiguous way.

CG5 – Have the appropriate learning skills to be able to continue studying in a way that will largely be self-directed or autonomous and also to be able to successfully undertake doctoral studies.

Specific:

CE1 – Acquire a basic knowledge in an area of Engineering/Applied Science, as a starting point for an adequate mathematical modelling by using well-established contexts or in new or unfamiliar environments within broader and multidisciplinary contexts.

CE2 – Model specific ingredients and make the appropriate simplifications in a model to facilitate their numerical treatment, maintaining the degree of accuracy, according to previous requirements.

CE5 – Be able to validate and interpret the obtained results, comparing them with visualizations, experimental measurements and/or functional requirements of the corresponding physical engineering system.

Specific to orientation "Modelling:

CM2 – Know how to model elements and complex systems or not very common fields which lead to well-posed formulated problems.

WILL YOU BE USING A VIRTUAL PLATFORM?

Yes, moodle at UPM platform

WILL YOU BE USING ANY SPECIFIC SOFTWARE?

No, MATLAB is recommended but any equivalent SW can be used

CRITERIA FOR THE 1ST ASSESSMENT OPPORTUNITY

Group report plus oral presentation of the project by one of the team members, followed by a maximum of fifteen minutes of questions and answers.

The project done during the subject lead the student to study different problemes and look for information for them. This allows to evaluate general skills CG1, CG2 and CG5 as well as specific skills CE1, CE2, CE5 and CM2. The presentation of the project allows to evaluate general skill CG4.

Final exam is also possible

CRITERIA FOR THE 2ND ASSESSMENT OPPORTUNITY

Same as 1st assessment opportunity