Multidisciplinary Optimal Design

ECTS: 6

COORDINATOR: José Manuel Vega (josemanuel.vega@upm.es)

UNIVERSITY WHERE THE COORDINATOR IS: UPM

HAVE YOU GIVEN PERMISSION TO RECORD YOUR CLASSES? NO

LECTURER 1: José Manuel Perales (jose.m.perales@upm.es)

UNIVERSITY WHERE THE LECTURER 1 IS:

UPM

HAVE YOU GIVEN PERMISSION TO RECORD YOUR CLASSES? No

LECTURER 2: Ángel Velázquez (angel.velazquez@upm.es)

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.

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 taking place or in a remote classroom connected via videoconferencing system.

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: To have knowledge that provide a basis or opportunity for originality in developing and / or applying ideas, often within a research context, knowing how to translate industrial needs in terms of R & D in the field of mathematics Industrial.

CG4: To have the ability to communicate the findings to specialist and non-specialist audiences in a clear and unambiguous way.

CG5: To have the appropriate learning skills to enable them to continue studying in a way that will be largely self-directed or autonomous, and also to be able to successfully undertake doctoral studies.

Specific:

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

CE3: To determine if a model of a process is well made and well mathematically formulated from a physical standpoint.

CE5: To be able to validate and interpret the results, comparing them with visualizations, experimental measurements and functional requirements of the physical engineering system.

Modelling specialization:

CM1: To be able to extract, using different analytical techniques, both qualitative and quantitative models.

CM2: To know how to model elements and complex systems leading to well-posed formulated problems.

WILL YOU BE USING A VIRTUAL PLATFORM? Yes, moodle at UPM platform

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WILL YOU BE USING ANY SPECIFIC SOFTWARE? No, MATLAB is recommended but any equivalent SW can be used.

CRITERIA FOR THE 1ST ASSESSMENT OPPORTUNITY

Each group will need to hand in a report and a member of the group selected by teachers will have to do a 15 minute presentation followed by fifteen minutes of questions (to the entire group). The final mark will be a combination of: report, presentation and questions. Students are also entitled to take a final exam if they have not passed the previous assessment.

CRITERIA FOR THE 2ND ASSESSMENT OPPORTUNITY

The same as for the 1st assessment opportunity.
