AEEE434 - Introduction to Optimization Methods and Applications

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<tr><td>Course Title</td><td colspan="5">Introduction to Optimization Methods and Applications</td></tr>
<tr><td>Course Code</td><td colspan="5">AEEE434</td></tr>
<tr><td>Course Type</td><td colspan="5">Technical Elective</td></tr>
<tr><td>Level</td><td colspan="5">BSc (Level 1)</td></tr>
<tr><td>Year / Semester</td><td colspan="5">4th</td></tr>
<tr><td>Teacher's Name</td><td colspan="5">Assoc. Prof. Marios Lestas</td></tr>
<tr><td>ECTS</td><td>6</td><td>Lectures / week</td><td>3</td><td>Laboratories/week</td><td>0</td></tr>
<tr><td>Course Purpose</td><td colspan="5">The aim of the course is to familiarize students with the basic concepts of optimization, formulating practical engineering problems in the standard forms of linear (primal and dual) and nonlinear programming and solving them using the simplex method and the gradient method.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">By the end of the course, students must be able to:
1. Formulate practical engineering problems into standard form linear programming problems with reference to the manufacturing problem, the transportation problem, routing problems and the scheduling problem.
2. Identify slack variables, extreme points, vertices, basic solutions, basic feasible solutions and degeneracy and state the fundamental theorem of linear programming.
3. Solve linear programming problems in standard form using the simplex method. Describe the full tableau implementation of the simplex method. Implement the simplex method on Matlab.
4. Transform the primal linear programming problem into the dual problem. State the duality theorem and identify the concepts of simplex multipliers, sensitivity and complementary slackness.
5. Describe the dual simplex method and implement it on Matlab.
6. Identify the standard form of the unconstrained non-linear programming problem. Identify the existence and uniqueness of optimal solutions and state necessary and sufficient conditions for optimality.
7. Introduce the gradient methods with particular emphasis on the steepest descent method and the Newton's method.
8. Formulate the least squares problem of characteristic examples: curve fitting, dynamic system identification, neural networks, pattern recognition, adaptive control. Use iterative methods to solve the least squares problem.</td></tr>
<tr><td>Prerequisites</td><td colspan="2">AEEE319</td><td>Corequisites</td><td colspan="2">None</td></tr>
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Course Content	**Linear Programming:** The standard form of the linear programming problem, slack variables, the manufacturing problem, the transportation problem, routing problems, the scheduling problem, revision on linear algebra, linear dependence, Gaussian elimination, existence and uniqueness of optimal solutions, extreme points, vertices, basic solutions, basic feasible solutions and degeneracy, the fundamental theorem of linear programming. **The Simplex Method:** The full tableau implementation of the simplex method. **Duality:** Transformation of primal linear programming problems into the dual problems. The duality theorem, simplex multipliers, sensitivity and complementary slackness. The dual simplex method. **Unconstrained Non-Linear Programming:** The standard form of the nonlinear programming problem, convexity, existence and uniqueness of optimal solutions, necessary and sufficient conditions for optimality, gradient methods, steepest descent method, Newton's method, least squares problem, curve fitting, adaptive control, neural networks.
Teaching Methodology	Students are taught the course through lectures (3 hours per week) in classrooms or lectures theatres, by means of traditional tools or using computer demonstration. Auditory exercises, where examples regarding matter represented at the lectures, are solved and further, questions related to particular open-ended topic issues are compiled by the students and answered, during the lecture or assigned as homework. Topic notes are compiled by students, during the lecture which serve to cover the main issues under consideration and can also be downloaded from the e-learning platform or the lecturer's webpage. Students are also advised to use the subject's textbook or reference books for further reading and practice in solving related exercises. Tutorial problems are also submitted as homework and these are solved during lectures or privately during lecturer's office hours. Furthermore, design projects may be assigned to the students, where literature search is encouraged to identify a specific problem related to some issue, gather relevant scientific information about how others have addressed the problem, implement to implement the design and report the results in written or orally. Where appropriate, taught material as well as examples and design problems are drawn from the recent research activities of the lecturer or other faculty members.
Bibliography	**(a) <u>Textbooks:</u>** • David. G. Luenberger, **Linear and Nonlinear Programming**, Addison-Wesley, 1984 **(b) <u>References:</u>** • D. P. Bertsekas, **Nonlinear Programming**, Athena Scientific, 1999 • D. Bertsimas, J.N. Tsitsiklis, **Introduction to Linear Optimization**, Athena Scientific, 1997
Assessment	The Students are assessed via continuous assessment throughout the duration of the Semester, which forms the Coursework grade and the final

	written exam. The coursework and the final exam grades are weighted 40% and 60%, respectively, and compose the final grade of the course. Various approaches are used for the continuous assessment of the students, such as mid-term written exam, oral exam, quizzes, design assignments and design projects. The assessment weight, date and time of each type of continuous assessment is being set at the beginning of the semester via the course outline. An indicative weighted continuous assessment of the course is shown below: • Assignments 10% • Homework 10% • Mid-Term written exams 40% • Design Project 20% • Quizzes 20% Students are prepared for final exam, by revision on the matter taught, problem solving and concept testing and are also trained to be able to deal with time constrains and revision timetable. The criteria considered for the assessment of each type of the continuous assessment and the final exam of the course are: (i) the comprehension of the fundamental concepts and theory of each topic, (ii) the application of the theory in solving related problems and (iii) the ability to apply the above knowledge in more complex design problems. The above criteria are weighted 30%, 40% and 30%, respectively. The final assessment of the students is formative and summative and is assured to comply with the subject’s expected learning outcomes and the quality of the course
Language	**English**