NATIONAL UNIVERSITY OF SAN MARCOS

FACULTY OF MATHEMATICAL SCIENCES

SYLLABUS

1. GENERAL INFORMATION

1.1 Course name	:	Optimization I
1.2 Code	:	MA341
1.3 Academic Program	:	Scientific Computing
1.4 Credits	:	4
1.5 Prerrequisites	:	MA221. Numerical Analysis I. (5^{th} Sem)
1.6 Type of Course	:	Elective
1.7 Area of Studies	:	Estudios Generales
1.8 Number of Weeks	:	16
1.9 Hours per week	:	2 HT; 4 HP;
1.10 Cycle	:	I
1.11 Learning modality	:	Face to face
1.12 Academic Period	:	2026-I
1.13 Semester Start Date	:	
1.14 Semester End Date	:	

2. PROFESSORS

Meetings after coordination with the professor

3. INTRODUCTION TO THE COURSE

This course introduces the mathematical foundations of optimization, covering both unconstrained and constrained problems. Classical methods of continuous optimization, optimality conditions, numerical algorithms, and applications in various fields are studied. The course provides the theoretical and computational foundations for formulating and solving optimization problems in science, engineering, and economics, developing analytical skills to characterize and find optimal solutions.

4. GOALS

- Understand the fundamental concepts of optimization and classify different types of optimization problems.
- Apply optimality conditions to characterize solutions in continuous optimization problems.
- Implement numerical algorithms to solve unconstrained and constrained optimization problems.
- Analyze the convergence and efficiency of different optimization methods.
- Formulate and solve real-world optimization problems in various applied contexts.

5. COMPETENCES

ABET-1) An ability to identify, formulate, and solve broadly defined technical or scientific problems by applying knowledge of mathematics and science and/or technical topics to areas relevant to the discipline. (Usage)

ABET-3) An ability to develop and conduct experiments or test hypotheses, analyze and interpret data, and use scientific judgment to draw conclusions. (Usage)

6. TOPICS

Unit 1: Convex and Non-Convex Optimization (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Convex sets and functions • Optimality conditions • Gradient methods for convex optimization • Non-convex optimization challenges • Convergence analysis	• Characterize convex optimization problems [Assessment] • Apply optimality conditions to verify solutions [Usage] • Implement gradient-based methods for convex problems [Usage] • Analyze challenges in non-convex optimization [Assessment]
Readings : [**Nocedal2006**], [**Boyd2004**]	

Unit 2: Constrained Optimization (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Linear programming (simplex method) • Integer programming • Lagrange multipliers and KKT conditions • Penalty and barrier methods • Duality theory	• Solve linear programming problems [Usage] • Formulate and solve integer programming problems [Usage] • Apply KKT conditions to constrained problems [Usage] • Use penalty methods for constrained optimization [Usage]
Readings : [**Nocedal2006**], [**Boyd2004**]	

Unit 3: Optimization for Machine Learning (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Stochastic gradient descent • Momentum and adaptive methods (Adam, RMSProp) • Regularization and sparsity • Distributed optimization for ML • Second-order methods for ML	• Implement stochastic gradient descent variants [Usage] • Apply adaptive optimization methods [Usage] • Use regularization for model generalization [Usage] • Design distributed optimization strategies [Usage]
Readings : [**Nocedal2006**], [**Bertsekas2016**]	

Unit 4: Metaheuristics and Bio-Inspired Optimization (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Genetic algorithms and evolutionary strategies • Swarm intelligence (PSO, ant colony) • Simulated annealing • Tabu search • Hybrid metaheuristics	• Implement genetic algorithms [Usage] • Apply swarm intelligence methods [Usage] • Use simulated annealing for global optimization [Usage] • Design hybrid metaheuristic approaches [Usage]
Readings : [**Talbi2009**], [**Mirjalili2019**]	

7. WORKPLAN

7.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

7.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

7.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

8. EVALUATION SYSTEM

********* EVALUATION MISSING ********

9. BASIC BIBLIOGRAPHY