DeCAIR Course Syllabus Form

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WP Number & Title	Work Package 5: Improving Existing M.Sc. Programs in Jordan and Lebanon by Implementing or Including AI and Robotics Courses		
Activity Number & Title	Task 5.1: Developing syllabi and content for added/modified courses in existing master programs in universities of partner countries		
WP Leader	Peter Eberhard, University of Stuttgart		
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Revision History

Version	Date	Author	Description	Action *	Page(s)
1	1/8/2021	Clovis Francis	MSC RSI Update Course Syllabus	C	1-6
2	22/10/2021	Clovis Francis	Second version		
3					
4					

(*) Action: C = Creation, I = Insert, U = Update, R = Replace, D = Delete

Disclaimer

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<table>
<tr><td>Course title</td><td>Optimization</td></tr>
<tr><td>Course number</td><td>RSI01</td></tr>
<tr><td>Credit hours (lecture and lab)</td><td>24 contact hours</td></tr>
<tr><td>ECTS (weekly contact and self-study load)</td><td>4</td></tr>
<tr><td>Prerequisites/co-requisites</td><td>Operations research</td></tr>
<tr><td>Prerequisites by topic</td><td>Students are assumed to have good background in mathematics and operations research, particularly, calculus, linear algebra, statistics, and probability. Additionally, the students should have good programming skills, preferably, using Matlab Simulink, Python and Javascript.</td></tr>
<tr><td>Level and type (compulsory, elective)</td><td>Masters’ compulsory course</td></tr>
<tr><td>Year of study and semester</td><td>Year 2, first semester</td></tr>
<tr><td>Description</td><td>After having presented the fundamental notions and tools for solving the optimization problem, this course presents the concepts of the deterministic, stochastic and robust optimization techniques as well as optimization under constraints formalism.</td></tr>
<tr><td>Objectives</td><td>1. Introduce students to the techniques and tools used in optimization.
2. Introduce students to the different optimization approaches and formalisms: deterministic, stochastic and robust optimization techniques as well as constraint optimization.</td></tr>
<tr><td>Intended learning outcomes</td><td>Upon successful completion of this course, students will be able to:
<table>
<tr><th>No</th><th>Intended learning Outcome (ILO)</th><th>Program learning outcome (PLO)*</th></tr>
<tr><td>1</td><td>Demonstrate a sound understanding of the main areas of AIR.</td><td>1</td></tr>
<tr><td>2</td><td>Solve an AIR problem by developing an appropriate optimization approach.</td><td>3</td></tr>
<tr><td>3</td><td>Communicate the development of an optimization problem through a detailed technical report and a short presentation.</td><td>4,5</td></tr>
<tr><td>4</td><td>Use Matlab, Python and Javascript libraries to develop programs for solving optimization problems.</td><td>3</td></tr>
</table>
(*) The PLOs are listed in the appendix</td></tr>
<tr><td>Teaching and learning methods</td><td>Development of ILOs is promoted through the following teaching and learning methods:</td></tr>
</table>

- Lectures will be delivered through Microsoft Teams/ZOOM and will be recorded for later access.
- The AI Lab is open for the students to practice the practical aspects and solve the programming homework assignments.
- The student attends the class presentations and participates in the discussions.
- The student joins the related online team/group and participates in its discussions.
- The student studies the reference material, including books and videos.
- The student solves the programming assignments
- The student carries out a term project for solving a problem using optimization techniques.
- The student develops a professional report for the term report.
- The student presents the term project in class.

Learning material

Textbook, class handouts, some instructor keynotes, selected YouTube videos, and access to a personal computer and the internet.

Resources and references

Recommended book(s), material and media:

1. Lecture notes prepared by the Instructor
2. Numerical Optimization, Jorge Nocedal, Stephen J. Wright, Springer
3. Numerical Optimization, Theoretical and Practical Aspects. Bonnans, J.-F., Gilbert, J.C., Lemarechal, C., Sagastizábal, Springer
4. Metaheuristic Optimization: Nature-Inspired Algorithms Swarm and Computational Intelligence, Theory and Applications. Okwu Modestus, Tartibu Lagouge.

Topic outline and schedule

Lecture	Topic	Hours	ILO	Resources
1	Introduction and Motivation: Engineering applications of Optimization	2	1	1,2,3, 4
2	Non Linear optimization: Optimization Models	2	2,3, 4	1,2,3
3	Non-linear analytical optimization: Optimality conditions Convex Optimization, Unconstrained problems	2	2,3, 4	1,2,3
4	Non-linear analytical optimization: Numerical search, Equality, Inequality	2	2,3, 4	1,2,3
5	Non Linear Optimization: Duality	2	2,3, 4	1,2,3
6	Unconstrained Optimization methods: Direct, random search methods	2	2,3, 4	1,2,3
7	Unconstrained Optimization methods: Descent method, Line search, Gradient	2	2,3, 4	1,2,3

	descent method, Steepest descent method, Newton’s method, Conjugate gradient method, Quasi-Newton’s methods			
8	Meta-heuristic methods: Simulated Annealing, Particle Swarm Optimization	2	2,3, 4	1,4
9	Meta-heuristic methods: Artificial Bee Colony Algorithm, Ant Colony		2,3, 4	1,4
10	Genetic Algorithms	2	2,3, 4	1,4
11	Software for optimization: MatLab Optimization toolbox	2	5	1
12	Various applications: Vehicles and drones path planning optimization.	2	5	1

Evaluation tools

Opportunities to demonstrate achievement of the ILOs are provided through the following assessment tools:

Assessment tool	Mark	Topic(s)	Time
Term project report, programs and presentation	100%	Programming and use of optimization toolboxes for engineering problem solving	W14
Total	**100%**		

Student requirements

The student should have a computer and internet connection.

Course policies

A- Attendance policies:

- Attendance is required. Class attendance will be taken every class and the university polices will be enforced in this regard.

B- Absences from exams and submitting assignments on time:

- A makeup exam can be arranged for students with acceptable absence causes.
- Assignments submitted late, but before announcing or discussing the solution can be accepted with 25% penalty.
- The project report must be handed in in time.

C- Health and safety procedures:

- All health and safety procedures of the university and the school should be followed.

D- Honesty policy regarding cheating, plagiarism, misbehavior:

- Open-book exams
- All submitted work must be of the submitting student.

	• Other text or code must be properly quoted with clear source specification. • Cheating will not be tolerated. E- Available university services that support achievement in the course: • Microsoft Teams team • Control Lab for practicing the practical aspects and solving the programming assignments.
Additional information	None

Appendix

Learning Outcomes for the MSc in Artificial Intelligence and Robotics

Students who successfully complete the MSc in Artificial Intelligence and Robotics (AIR) will be able to:

1. Demonstrate a sound understanding of the main areas of AIR including artificial neural networks, machine learning, data science, industrial and service robots, and intelligent and autonomous robots.

2. Apply a critical understanding of essential concepts, principles and practices of AIR, and critically evaluate tools, techniques and results using structured arguments based on subject knowledge.

3. Apply the methods and techniques of the AIR fields in the design, analysis and deployment of AIR solutions and solving practical problems.

4. Demonstrate the ability to produce a substantial piece of research work from problem inception to implementation, documentation and presentation.

5. Demonstrate life-long learning, independent self-learning and continuous professional development skills in the AIR fields.

6. Demonstrate a sound understanding of the ethical, safety and social impact issues of AIR solutions and products.