Course Specifications

Program(s) on which this course is given:	PhD
Department offering the program:	**Aerospace**
Department offering the course:	**Aerospace**
Academic Level:	Graduate- M. Sc.
Date	2010 – 2011
Semester (based on final exam timing)	☐ Fall ☐ Spring

A- Basic Information

1. Title:	Optimal Control			**Code:**	AER 755		
2. Units/Credit hours per week:	Lectures	2	Tutorial	-	Practical	-	Total 2

B- Professional Information

1. Course description:	**Optimal control deals with the problem of finding a control law for a given system such that a certain optimality criterion is achieved. A control problem includes a cost function that is a function of state and control variables. An optimal control is a set of differential equations describing the paths of the control variables that minimize the cost function** **The aim of this course is to give an elementary treatment of linear control theory with an Hoo optimality criterion. The systems are all linear, time invariant, and finite-dimensional and they operate in continuous time. The course has been used in a one-semester graduate course, with only a few prerequisites: classical control theory, linear systems (state-space and input-output viewpoints), and a bit of real and complex analysis. Only one problem is solved in this course: how to design a controller which minimizes the Hoo-norm of a pre-designated closed-loop transfer matrix. The Hoo-norm of a transfer matrix is the maximum over all frequencies of its largest singular value. In this problem the plant is fixed and known, although a certain robust stabilization problem can be recast in this form. The general robust performance problem - how to design a controller which is Hoo-optimal for the worst plant in a pre-specified set - is as yet unsolved. The course focuses on the mathematics of Hoo control. Generally speaking, the theory is developed in the input-output (operator) framework, while computational procedures are presented in the state-space framework..**
2. Intended Learning Outcomes of Course (ILOs):	**a) Knowledge and Understanding**
	Different sources of uncertainties.
	Different approaches of robust control.
	Some robust control techniques.
	b) Intellectual Skills
	Simulate uncertain control systems.
	Analyze uncertain control systems.
	Design uncertain control systems.
	c) Professional and Practical Skills
	Use computer software packages to design, simulate, and evaluate robust control

	systems
	d) General and Transferable Skills
	Prepare effective and informative technical reports and present results on robust control systems
	Communicate effectively with colleagues to interchange knowledge and information in robust control systems.

3. Contents

Topic	**Total hours**	**Lectures hours**	**Tutorial/ Practical hours**
1.Introduction	2	2	-
2. Background Mathematics: Function Spaces 2.1 Banach and Hilbert Space 2.2 Time-Domain Spaces 2.3 Frequency-Domain Spaces	2	2	-
3. The Standard Problem	2	2	-
4. Stability Theory 4.1 Coprime Factorization over RH_{∞} 4.2 Stability 4.3 Stabilizability	2	2	-
4.4 Parametrization 4.5 Closed-Loop Transfer Matrices	2	2	-
5. Background Mathematics: Operators 5.1 Hankel Operators 5.2 Nehari's Theorem	2	2	-
6. Model-Matching Theory: Part I 6.1 Existence of a Solution 6.2 Solution in the Scalar-Valued Case	2	2	-
6.3 A Single-Input, Single-Output Design Example	2	2	-
7. Factorization Theory 7.1 The Canonical Factorization Theorem 7.2 The Hamiltonian Matrix	2	2	-
7.3 Spectral Factorization 7.4 Inner-Outer Factorization 7.5 J-Spectral Factorization	2	2	-
8. Model-Matching Theory: Part II 8.1 Reduction to the Nehari Problem 8.2 Krein Space	2	2	-
8.3 The Nehari Problem 8.4 Summary: Solution of the Standard Problem	2	2	-
9. Performance Bounds	2	2	-
Case Study	2	2	-
4. Teaching and Learning Methods	Lectures (x)	Practical Training/ Laboratory ( )	Seminar/Workshop ( )

	Class Activity ( )	Case Study (x)	Projects ( )
	E-learning ( )	Assignments /Homework ( )	Other:

5. Student Assessment Methods

• **Assessment Schedule**	**Week**
-Assessment 1; Class test	4 and 10
-Assessment 2; Project Assignment	
-Assessment 3; Presentations	
-Assessment 3; Midterm Exam	8
-Assessment 4; Final Exam	

• **Weighting of Assessments**	
-Mid-Term Examination	10 %
-Final-term Examination	80 %
-Project	10 %
-Class Test	
-Presentation	
-Total	100 %

6. List of References

Bruce A. Francis, "Lecture Notes in Control and Information Sciences", M. Thoma and A. Wyner, 1987.

Kemin Zhou, "Essentials of Robust Control", 1999.

Journal of Guidance and Control, AIAA Journal.

7. Facilities Required for Teaching and Learning

. The necessary theory for each topic area will be presented in lectures as well as the applications, practical experiments and assignment work.

Course Coordinator:	**Prof. Gamal El-Bayoumi**
Head of Department:	**Dr. Ayman Hamdy**