ABDULLAH GÜL UNIVERSITY
GRADUATE SCHOOL OF ENGINEERING & SCIENCE
ELECTRICAL AND COMPUTER ENGINEERING PROGRAM
COURSE DESCRIPTION AND SYLLABUS

Course Title	Code	Semester	T+L Hours	Credit	ECTS
NONLINEAR CONTROL	ECE-576	FALL-SPRING	3 + 0	3	10

Prerequisite Courses	none

Type	Elective
Language	English
Coordinator	Assist. Prof. Dr. Günyaz Ablay
Instructor	Assist. Prof. Dr. Günyaz Ablay
Adjunct	none
Aim	Learning, understanding and applying nonlinear control design tools that are needed in control engineering studies.
Learning Outcomes	To give an opportunity to students for • learning the fundamentals of nonlinear systems • learning the stability theorems • learning nonlinear control design with feedback linearization • learning robust control design methods • learning integral control, gain scheduling and sliding mode control tools • learning software tools that can be used for analysis and design of nonlinear systems
Course Content	• Review of Linear Control Systems • Introduction to Nonlinear Systems • Second and Higher Order Systems • Input-State and Input-Output stability • Nonlinear Forms • Stabilization with Feedback Control • Robust Stabilization with Feedback Control • Tracking with feedback control • Observers for State-Feedback Control • Integral Control • Passivity

WEEKLY TOPICS AND PRELIMINARY STUDY

Week	Topic	Preliminary Study
1	• Review of Linear Control Systems • PID controller, State feedback control, DC motor experiment	The relevant lecture notes
2	• Introduction to Nonlinear Systems • Nonlinear models, Examples	The relevant lecture notes
3	• Second and Higher Order Systems • Phase portraits, Multiple equilibria, Limit cycles, Bifurcation	The relevant lecture notes
4	• Stability of Equilibrium Points • Basics & linearization, Lyapunov's method, Invariance principle, Exponential stability and Region of Attraction, Time varying systems, Perturbed systems	The relevant lecture notes
5	• Input-State and Input-Output stability • Ultimate boundedness, Input-to-state stability, Input-output stability, L2 gain and small gain theorem	The relevant lecture notes
6	• Nonlinear Forms • Normal form, Controller form, Observer form, Output feedback and Strict feedback forms	The relevant lecture notes
7	• Stabilization with Feedback Control • Concepts and Linearization, Feedback linearization, Cascaded systems, Backstepping, Passivity-based control, Control Lyapunov functions, Output feedback	The relevant lecture notes
8	• Midterm	
9	• Robust Stabilization with Feedback Control • Sliding-mode control, Lyapunov redesign, Backstepping	The relevant lecture notes

10	• Tracking with feedback control • Feedback linearization, Sliding Mode Control (SMC), Point-to-point transition	The relevant lecture notes
11	• Observers for State-Feedback Control • Linearization and linear observers, Extended Kalman Filter (EKF), Exact Observers, High-gain observers	The relevant lecture notes
12	• Integral Control • Linearization based integral control, Integral SMC	The relevant lecture notes
13	• Passivity • Memoryless functions and State models, Positive real transfer functions, Feedback systems, Circle and Popov Criteria	The relevant lecture notes
14	• Final Exam	

SOURCES	
Lecture Notes	Lecture notes and slides
Other Sources	**Course Textbook:** Hassan K. Khalil, Nonlinear Systems, Prentice Hall, 2013. **Additional Materials:** 1. J.J. Slotine and W. Li, Applied Nonlinear Control, Prentice Hall, 1991 2. H.J. Marquez, Nonlinear Control Systems, John Wiley & Sons, 2003

COURSE MATERIALS SHARING	
Documents	Lecture notes, slides and papers
Homework	Students will be given one homework each week
Exams	1 Midterm and 1 Final Exam

EVALUATION SYSTEM		
SEMESTER STUDY	**NUMBER**	**CONTRIBUTION**
Midterm	1	20
Homework	14	25
Quiz	14	25
SUB-TOTAL		70
Contribution of Semester Study		70
Contribution of Final Exam	1	30
TOTAL		100

Course Category	
Sciences and Mathematics	30%
Engineering	70%
Social Sciences	0%

RELATIONSHIPS BETWEEN LEARNING OUTCOMES AND PROGRAM QUALIFICATIONS							
No	Program Qualifications	Contribution Level				
		1	2	3	4	5
1	The skills of using mathematics, science and engineering information in advanced research,					**X**
2	The skills of analyzing, designing and/or implementing an original system that will be able to solve an engineering problem,					**X**
3	The skills of using the required software, hardware and modern measurement equipment in their field of research,					**X**
4	The skills of planning independent research and implementing in detail,					**X**
5	The skills of following literature, listening to and making technical presentation, writing a paper in academic level,					**X**
6	The skills of innovative and interrogative thinking and finding original solutions					**X**

*Increasing from 1 to 5.

ECTS / WORK LOAD TABLE			
Activities	Number	Duration (Hours)	Total Work Load
Course Length (includes exam weeks: 16x total course hours)	14	3	42
Out-of-class Study Time (Pre-study, practice)	14	4	56
Internet search, library work, literature search	14	5	70
Presentation	1	5	5
Homework	14	5	70
Midterm	1	27	27
Final Exam	1	30	30
Total Work Load			300
Total Work Load / 30			300/30
Course ECTS Credit			10