Course Specification

(Postgraduate Programs)

Course Title:	Optimal Control Theory
Course Code:	2202-551
Program:	Master in Electrical Engineering
Department:	Electrical Engineering
College:	College of Engineering
Institution:	King Faisal University
Version:	2.0
Last Revision Date:	17 April 2025

Table of Contents

A. General information about the course:

1. Course Identification:

1. Credit hours: (3)				
2. Course type				
A.	☐ University	☐ College	☒ Department	☐ Track
B.	☐ Required		☒ Elective	
3. Level/year at which this course is offered: Level 3/2nd year				
4. Course General Description:				
Introduction and performance measures; Dynamic programming and Hamilton-Jacobi theory; Calculus of variation and Pontrygin's minimum principle; Linear optimal control and the Linear-quadratic regulator (LQR) problem; Optimal filtering and the Linear-quadratic Gaussian (LQG) problem; Separation principle; Iterative numerical methods for solving optimal control problems.				
5. Pre-requirements for this course (if any)**:**				
2202-430: Analog Control Systems (or equivalent)				
6. Co-requisites for this course (if any)**:**				
None				
7. Course Main Objective(s):				
To develop a foundational understanding of optimal control and its broad relevance to many applications. Also, to gain experience in computational implementation of optimal control algorithms. More specifically: ● To give exposure to optimal control problems such as time-optimal, fuel optimal, energy optimal control problems ● To impart knowledge and skills needed to design Linear Quadratic Regulator for Time invariant and Time-varying Linear system (Continuous time and Discrete-time systems) ● To introduce concepts needed to design optimal controller using Dynamic Programming Approach and H-J-B equation.				

- To give exposure to various types of fault tolerant control schemes such as Passive and active approaches
- To introduce concepts needed to design optimal controller in the presence of state and control constraints

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100%
2	E-learning		
3	Hybrid ● Traditional classroom ● E-learning		
4	Distance learning		

3. Contact Hours: (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	45
2.	**Laboratory/Studio**	
3.	**Field**	
4.	**Tutorial**	
5.	**Others (specify)……**	
	Total	45

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods:

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	Understand dynamic programming and Hamilton-Jacobi theory	K1	Lectures	M.T. Exam HW

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
	for solving optimal control problems			
1.2	Understand advanced control theory and its application to practical engineering problems	K1	Lectures	Final Exam Project
...				
2.0	**Skills**			
2.1	Apply numerical techniques to solve optimal control problems using associated software such as Matlab	S1	Lectures	Project
2.2	Apply LQR to design optimal controllers for linear systems	S1	Lectures	Final Exam project
2.3	Apply LQG and optimal filtering to design optimal controllers for linear systems	S1	Lectures	Final Exam Project
2.4	Read and analyze research papers (journals) on optimal control and recent advances in control theory as well as implementing these new methods in collaborative teams	S2	Project	Project
3.0	**Values, autonomy, and responsibility**			
3.1	Develop ethical and professional judgment in control system design	V2	Lectures	Course project
3.2	Read and analyze research papers (journals) on optimal control and recent	V2	Project	Project

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
	advances in control theory as well as implementing these new methods in collaborative teams			
...				

C. Course Content:

No	List of Topics	Contact Hours
1.	Optimal control problems: dynamic programming, principle of optimality and linear programming, performance measure	9
2.	Performance criteria and constraint, static optimization, minimization of cost functions, computational procedure for solving control problems	7.5
3.	Calculus of variations, discrete and continuous dynamic programming, regular and singular solutions	7.5
4.	Linear-Quadratic regulators, LQ control system design, modeling LQ systems	6
5.	State estimation for continuous- time systems, state estimation (Kalman filter) for discrete time systems	6
6.	Stochastic optimal control, linear-quadratic-gaussian (LQG) control, Hamilton- Jacobi Bellman equations, H_∞ and robust control, Methods of steepest descent	9

Total		45

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	HW's	Week 1-14	5%
2.	Quiz#1	Week 3	5%
3.	Research paper presentation	Week 4 and 5	10%
4.	Quiz 2	Week 6	5%
5.	M.T. Exam	Week 8	25%
6.	Project	Week 9 and 10	10%
7.	Quiz 3	Week 12	5%
8.	Final comprehensive exam	Week 15	35%

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
...	**Total**		**100%**

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.)

E. Learning Resources and Facilities:

1. References and Learning Resources:

Essential References	Optimal Control Theory: An Introduction, Donald E. Kirk, Dover Edition 1998, ISBN 978-0486434841
Supportive References	1) S.P. Sethi and G.L. Thompson, Optimal Control Theory: Applications to Management Science and Economics, 2nd Edition, Kluwer, 2000. 2) A. Bryson, Applied Linear Optimal Control, Cambridge University Press, 2002 3) D. Naidu, Optimal Control Systems, CRC Press, 2002 4) P. Dorato, C. Abdallah, and V. Cerone, Linear Quadratic Control, Krieger Publishing, 2000 5) F. Lewis and V. Syrmos, Optimal Control, Wiley-Interscience, 1995
Electronic Materials	IEEE Xplore
Other Learning Materials	MATLAB

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classroom meeting twice a week (1 hour and half each lecture)
Technology equipment (Projector, smart board, software)	Blackboard and MATLAB
Other equipment (Depending on the nature of the specialty)	

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students	Indirect-Online Survey
Effectiveness of students' assessment	Students and Faculty	Direct and Indirect Assessment

Assessment Areas/Issues	Assessor	Assessment Methods
Quality of learning resources	Students and Faculty	Indirect-Online Survey
The extent to which CLOs have been achieved	Students and Faculty	Direct and Indirect Assessment
Other	None	None

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	**EE DEPARTMENT QUALITY COMMITTEE**
REFERENCE NO.	**MEETING# 10**
DATE	**APRIL 19, 2025**