هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

2023
TPG-153

Course Specification

(Postgraduate)

Course Title:	Calculus of Variations and Optimal control
Course Code:	Math613
Program:	Master of Science in Mathematics
Department:	Mathematics
College:	College of Science and Humanities
Institution:	Prince Sattam Bin Abdulaziz University
Version:	2
Last Revision Date:	Oct 2022

Table of Contents

A. General information about the course:

1. Course Identification:

1. Credit hours: (3 hours)				
2. Course type				
A.	☐University	☐College	☒ Department	☐Track
B.	☒ Required		☐Elective	
3. Level/year at which this course is offered: (Master)				
4. Course general Description:				
General variations of a functional constrained extrema. Euler equations. Hamilton-Jacobi equation and related topics. The second variation and sufficient conditions for an extremum. Formation of optimal control Problems, Bolza, Mayer and Lagrange Formulation, Variational Approach to Optimal Control, Pontryagin Maximum Principal, Dynamic programming.				
5. Pre-requirements for this course (if any)**: NIL**				
6. Pre-requirements for this course (if any)**: Nil**				
7. Course Main Objective(s):				
To provide various theories and concepts of Optimal Control and prepare the students solve mathematical problems using vibrational approach.				

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	3 hours a week	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning	**Elearning**: In case of suspension of regular classes due to any unforeseen eventualities	Not applicable
4	Distance learning		

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

No	Activity	Contact Hours
1.	**Lectures** (16 X 2)	32
2.	**Laboratory/Studio**	
3.	**Field**	
4.	**Tutorial (16 X 1)**	16
5.	**Others (specify)..... (Office Hours – 16 X 1)**	16
	Total	64

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

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	Acquire knowledge about historical account for the theory, standard notations and simple formulations	**K1**	1. Class Room Lectures 2.Interactive sessions 3.Exclusive Office Hours for clearing doubts in small groups	1.Homework 2.Assignments 3.Quiz 4.Mid Term and Final Exam
1.2	Able to describe modeling of simple optimal control problems such as Bolza, Mayer and Lagrange Formulation etc.	**K3**		
...				
2.0	**Skills**			
2.1	Formulate simple problems in calculus of variations.	**S1**	Application oriented exercises during lectures and tutorial session.	1.Homework 2.Assignments 3.Quiz 4.Mid Term and Final Exam
2.2	Apply theory and techniques of calculus of variations and optimal control to solve certain control problems.	**S1**		

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
2.3	Gain ability to use Analytical techniques of Calculus of variations, dynamic programming and the maximum principle etc. to solve real world problems.	**S3**		
2.4	Be able to apply Vibrational Approach to Optimal Control, Pontryagin Maximum Principle in solving mathematical problems	**S1**	Group discussion Application oriented exercises during lectures and tutorial session.	**Application oriented take home assignment**
3.0	**Values, autonomy, and responsibility**			
3.1	Work independently and in groups	**V1**	1.Group and Individual discussion 2. Interactive Session 3. Brain storming	Group and Individual Assignment Continuous Assessment

C. Course Content:

No	List of Topics	Contact Hours
1.	General variations of a functional constrained extrema	6
2.	Euler equations. Hamilton	6
	Jacobi equation and related topics	6
4.	The second variation and sufficient conditions for an extremum	6
5.	Formation of optimal control Problems, Bolza, Mayer and Lagrange Formulation	6
6.	Vibrational Approach to Optimal Control	6
7.	Pontryagin Maximum Principal	6
8.	Dynamic programming	6
Total		**48**

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Mid Term Exam I	6	15%
2.	Quiz (Atleast 2 quiz)	4 & 10	10%
3.	Mid Term Exam II	13	15%
4.	Continuous Assessment – Homework, Assignment, Attendance etc.	--	10%
5.	End Semester Exam	17	50%

*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	1- Troutman J. L., "Variational Calculus with Elementary Convexity", New York – NY: Springer– Verlag, ISBN: 9780387907710 Jacob Rubinstein. 2- Thierry Miquel. Introduction to Optimal Control. Master. Introduction to optimal control, ENAC, France. 2022, pp.188. ffhal-02987731v2f
Supportive References	Nil
Electronic Materials	**https://cel.hal.science/hal-02987731v2**
Other Learning Materials	Lecture Notes Prepared by the Department of Mathematics

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classrooms with Smartboards with seating facilities for at least 30 students
Technology equipment (Projector, smart board, software)	• Smartboard, Internet Connection for Blackboard
Other equipment (Depending on the nature of the specialty)	

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students Peer Review/Class Room Observation	Indirect
Effectiveness of students assessment	Independent member teaching staff	Check marking by an independent member teaching staff of samples of student work.
Quality of learning resources	Students	Indirect
The extent to which CLOs have been achieved	Faculty Member Quality Unit of College and department	Direct Learning outcomes assessment.
Other		

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

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	
REFERENCE NO.	
DATE	SEP 2024