هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

Course Specifications

Course Title:	CALCULUS OF VARIATIONS
Course Code:	**MATH 4520**
Program:	**BACHELOR OF SCIENCE IN MATHEMATICS**
Department:	**MATHEMATICS**
College:	**COLLEGE OF SCIENCE AND HUMANITIES STUDIES**
Institution:	**PRINCE SATTAM BIN ABDULAZIZ UNIVERSITY**

Table of Contents

A. Course Identification

1. Credit hours: 04
2. Course type **a.** University ☐ College ☐ Department ☒ Others ☐ **b.** Required ☐ Elective ☒
3. Level/year at which this course is offered: Elective
4. Pre-requisites for this course (if any)**: Math 3320. Math 3330**
5. Co-requisites for this course (if any)**:** NIL

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	**Traditional classroom**	Weekly 4 hrs	100%
2	**Blended**		
3	**E-learning**		
4	**Distance learning**		
5	**Other**		

7. Contact Hours (based on academic semester)

No	Activity	Contact Hours
1	**Lecture (14 x 3)**	48
2	**Laboratory/Studio**	
3	**Tutorial (14 x 2)**	00
4	**Others** (specify) - Office Hours (14 X 5)	60
	Total	108

B. Course Objectives and Learning Outcomes

1. Course Description

Review of Vector Spaces – Functional – The Geodesics Problems – Brachistochrone – Linear Functional – Properties of Functional – Local Maximum – Local Minimum – Extremum Value – Extremal with Corners – Euler's Necessary Condition – Constant End Points Problems – Minimal Time Curve Problem – Functional of Several Variables – Canonical Euler – Lagrange Equations – Hamilton's Principle – Functional of Higher Derivatives – Euler – Poisson Differential Equation – Functional with Multiple integrals – Minimal Surface Plateau's Problem and Applications – Schrödinger's Equations – Inverse Problem – Moving End Points Problems – Transversality Conditions – Hamilton– Jacobi Equation – Extremals With Corners – Reflection of Extremals – Refraction of Extremals – Corners Conditions – Necessary and Sufficient Conditions of Extremals – Legendre Condition – Jacobi Conditions – Weierstrass Condition – Optimal Control – Optimality Principle – Bellman's Equation – Maximum Principle and Its Applications

2. Course Main Objective

The aim of the course is to help the students acquire knowledge about calculus of variations, associated theories, its scope and applications.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	**Knowledge and Understanding**	
1.1	List all basic concepts of Mechanics.	K1
1.2	Describe appropriate methods to solve problems	K4
2	**Skills :**	
2.1	Analyse and solve the problems of Calculus of Variations using various theorems	S1
2.3	Sketch graph	S3

C. Course Content

No	List of Topics	Contact Hours
1	Review of Vector Spaces – Functional – The Geodesics Problems – Brachistochrone – Linear Functional – Properties of Functional – Local Maximum – Local Minimum – Extremum Value.	8
2	Extremal with Corners – Euler's Necessary Condition – Constant End Points Problems – Minimal Time Curve Problem – Functional of Several Variables.	12
3	Solution of Boundary Problems by Fourier Series Canonical Euler – Lagrange Equations – Hamilton's Principle – Functional of Higher Derivatives – Euler–Poisson Differential Equation – Functional with Multiple integrals – Minimal Surface Plateau's Problem and Applications – Schrödinger's Equations.	12
4	Inverse Problem – Moving End Points Problems – Transversality Conditions – Hamilton– Jacobi Equation – Extremals With Corners – Reflection of Extremals – Refraction of Extremals – Corners Conditions .	8
5	Necessary and Sufficient Conditions of Extremals – Legendre Condition – Jacobi Conditions – Weierstrass Condition – Optimal Control – Optimality Principle – Bellman's Equation – Maximum Principle and Its Applications.	8
TOTAL		48

D. Teaching and Assessment

1. Alignment of Course Learning Outcomes with Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.0	**Knowledge and Understanding**		
1.1	List all basic concepts of Mechanics.	1. Class Room Lectures 2.Interactive sessions 3.Exclusive Office Hours for clearing doubts in small groups	1.Two Internal Exams 2. Atleast two Quiz 3.End Semester Exam
1.2	Describe appropriate methods to solve problems		
2.0	**Skills**		
2.1	Analyse and solve the problems of Calculus of Variations using various theorems	1. Application oriented exercises during tutorial session. 2.Homework to improve the analytical skills	Specific homework to increase the students' analytical and problem solving ability
2.2	Sketch graph		

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Mid Term Exam I	6	20%
2	Quiz	4 & 10	5%
3	Mid Term Exam II	13	20%
4	Continuous Assessment – Homework, Assignment, Attendance etc.	--	5%
5	End Semester Exam (Practical 10%, Theory 40%)	15	50%

***Assessment task** (i.e., written test, oral test, oral presentation, group project, essay, etc.)

E. Student Academic Counseling and Support

Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice :

1. Exclusive Office Hours – 5 Hours per week
2. Academic Advising for Students – 1 Hour per week

F. Learning Resources and Facilities

1.Learning Resources

Required Textbooks	1- Giaquinta M. and Hilderbrandt S., "Calculus of Variations I", New York – NY: Springer, ISBN: 9780387506258. 2-Troutman J. L., "Variational Calculus with Elementary Convexity", New York – NY: Springer– Verlag, ISBN: 9780387907710 Jacob Rubinstein.
Essential References Materials	NIL
Electronic Materials	http://www.freebookcentre.net/SpecialCat/Free-Mathematics-Books-Download.html
Other Learning Materials	Lecture Notes Prepared by the Department of Mathematics

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	1. Classrooms with Smart boards with seating facilities for atleast 30 students
Technology Resources (AV, data show, Smart Board, software, etc.)	Smartboard, Internet Connection for Blackboard
Other Resources	NIL

Item	Resources
(Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Achievement of CLOs	Faculty and Quality Personnel	Direct (Tests and Quiz) and Review of Course Report
Quality of Learning Resources	Students	Course Evaluation (Indirect)
	Graduates	Program Evaluation(Indirect)
Facilities	Students / Graduates	Course and Program Evaluation (Indirect)
	Faculty	Faculty Survey (Indirect), Course Reports (Direct)

Evaluation areas (e.g., Effectiveness of teaching and assessment, Extent of achievement of course learning outcomes, Quality of learning resources, etc.)
Evaluators (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

H. Specification Approval Data

Council / Committee	
Reference No.	
Date	