Course Specification

(Postgraduate Programs)

Course Title:	**Integral Equations**
Course Code:	**MAT 7236**
Program:	**Doctor of Philosophy in Mathematics**
Department:	**Mathematics and Statistics**
College:	**Science**
Institution:	**Imam Mohammad Ibn Saud Islamic University**
Version:	**2024 – V1**
Last Revision Date:	**None**

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours:					
4 (4 Lectures, 0 Lab, 0 Tutorial)					
2. Course type					
A.	☐ University	☐ College	☒ Program	☐ Track	☐ Others
B.	☐ Required		☒ Elective		
3. Level/Year at which this course is offered: Level 3 / Year 2					
4. Course general Description:					
In this course, the classification of integral equations is given; then several solvability methods are discussed: basic theoretical kernel techniques as well as numerical methods.					
5. Pre-requirements for this course (if any)**:**					
None.					
6. Co-requisites for this course (if any)**:**					
None.					
7. Course Main Objective(s):					
Integral equations are important in many applications such that problems stem from radiative energy transfer, string or membrane oscillation, ... The main objective of this course is to study Fredholm and Volterra integral equations and related equations, and learn how to solve linear and nonlinear integral equations by different methods.					

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	60	100%
2	E-learning	0	0%
3	Hybrid • Traditional classroom • E-learning	0	0%
4	Distance learning	0	0%

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	60
2.	**Laboratory/Studio**	0
3.	**Field**	0
4.	**Tutorial**	0
5.	**Others (specify)**	0

Total	60

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	To name some new tools that are useful in answering deep questions in integral equations.	K1, K2	4 lecture hours\week	Direct: Regular Exams
1.2	To list problems that are can be treated by classical methods and specific techniques.	K1, K2	• 4 lecture hours\week • Self-study	Direct: Short Quizzes
2.0	**Skills**			
2.1	To develop techniques of proof of solvability of linear equations.	S1, S2	Self-study	Direct: • Participations • Short Quizzes
2.2	To develop oral communication and technical writing skills through transformation of ODEs in integral equations.	S4	Real-life problems	Direct: Homework and Mini projects
2.3	To use Internet in searching for classification of integral equations.	S3	Real-life problems	Direct: Short Quizzes
2.4	To carry out deep proofs of existence of solutions to integral equations.	S1, S2	Self-study	Direct: Participations
3.0	**Values, autonomy, and responsibility**			
3.1	To work with independence and responsibility.	V1, V2	Personal questions	Direct: Participation
3.2	To work in groups.	V1, V3	Teamwork and class discussions.	Direct: Homework and Mini projects

C. Course Content

No	List of Topics	Contact Hours
1.	Introductory Concepts: Classification of Linear Integral Equations, Fredholm and Volterra Linear Equations, Singular Equations, Volterra-Fredholm	6

	Integro - Differential Equations, Converting Volterra Equation to an ODE and Vice-Versa, Converting BVP to Fredholm Equation.	
2.	Fredholm Integral Equations: Fredholm Integral Equations of The First Kind, Various types of Fredholm integral equations. Adomian Decomposition Method, Direct Computation Method, Successive Approximation Method, Method of Regularization.	10
3.	Volterra Integral Equations: Volterra Integral Equations of The First Kind, Conversion of First Kind to Second Kind, Successive Approximations Method, Adomian Decomposition Method, Series Solution Method - The method of Laplace transform - The method of successive substitutions - Integral equations of the Faltung type.	10
4.	Singular Integral Equations: Abel's problem of the second kind integral equation- Weakly-Singular Fredholm and Volterra Integral Equations - Equations with Cauchy's principal value of an integral and Hilbert's transformation - Use of Hilbert transforms in signal processing - The Fourier transform The Hilbert transform via Fourier transform- The Hilbert transform via the $\pm\pi/2$ phase shift- Properties of the Hilbert transform - Linearity Multiple Hilbert transforms and their inverses - Derivatives of the Hilbert transform - Orthogonality properties - Energy aspects of the Hilbert transform- Analytic signal in time domain - Hermitian polynomials - The finite Hilbert transform.	10
5.	Nonlinear Integral Equations: Nonlinear Fredholm Integral Equations, Method of Regularization, Nonlinear Weakly-Singular Integral Equations, Nonlinear Volterra Integral Equations of The Second Kind, Conversion to a Volterra Equation of the second Kind. The method of successive approximations - Picard's method of successive approximations - Existence theorem of Picard's method.	10
6.	Integro-differential equations: Introduction - Volterra integro-differential equations - The series solution method-The decomposition method - Converting to Volterra integral equations.- Converting to initial value problems - Fredholm integro-differential equations - The direct computation method - The decomposition method - Converting to Fredholm integral equations. The Laplace transform method	10
7.	Applications: Volterra Integral Form of Lane-Emden Equation, First and Second Kind, Schlömilch's Integral Equation, Bratu-Type Problems, Systems of Fredholm and Volterra Integral Equations.	4
Total		60

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	HomeWorks, Quizzes, Mini projects	During the semester	30%
2.	Midterm	Week 9-10	30%
3.	Final Exam	Week 15-16	40%

*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	• A.J. Jerri, *Introduction to Integral Equations with Applications*, John Wiley and Sons, 2nd Edition, 1999. • M. Rahman, *Integral Equations and Their Applications*, WIT Press, 2007.
Supportive References	A.M. Wazwaz, *Linear and Nonlinear Integral Equations*, Springer-Verlag Berlin Heidelberg, 2011.
Electronic Materials	None
Other Learning Materials	None

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology equipment (projector, smart board, software)	The rooms should be equipped with data show and Smart Board.
Other equipment (depending on the nature of the specialty)	None

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students	During the semester and at the end of the course each student will complete two evaluation forms.
Effectiveness of Students assessment	Instructor	At the end of each semester the course instructor should complete the course report, including a summary of student questionnaire responses appraising progress and identifying changes that need to be made if necessary.
Quality of learning resources	Students	During the semester and at the end of the course each student will complete two evaluation forms.

Assessment Areas/Issues	Assessor	Assessment Methods
The extent to which CLOs have been achieved	**Instructor**	**At the end of each semester the course instructor should complete the course report, including a summary of student questionnaire responses appraising progress and identifying changes that need to be made if necessary.**
Other	**None**	

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

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	**MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL**
REFERENCE NO.	**8/1446**
DATE	**05/04/1446 (08/10/2024)**