Course Specification

(Postgraduate Programs)

Course Title:	**Nonlinear Analysis**
Course Code:	**MAT 7237**
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**

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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:					
This course describes the main theoretical results in the fixed-point theory of nonlinear operators. Further to classical theorems and continuation methods, the first part presents recent developments such that nonlinear alternatives and related refinements. The second part of the course will be entirely devoted to the investigation of some applications arising from physical considerations. These are boundary (or initial) value problems for nonlinear differential or integral operators of Hammerstein or Volterra types. However, the stress will be put on the fixed-point formulation and on the usage of the theoretical fixed point results presented in the first part of the course.					
5. Pre-requirements for this course (if any):					
None.					
6. Co-requisites for this course (if any):					
None.					
7. Course Main Objective(s):					
This course presents the most important methods of nonlinear analysis with applications to the solvability of some boundary value problems for ordinary and partial differential equations as well as to nonlinear integral equations. Firstly, the classical fixed-point theorems (Banach, Brouwer, Schauder, and Krasnosel'skii theorems) are given with some extensions and variants. Then nonlinear boundary value problems are discussed with focus on the fixed point formulation and on the fixed point methods of study.					

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**	**30**
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	**Identify some convenient fixed-point techniques.**	**K1, K2**	**4 lecture hours\week**	**Direct: Regular Exams**
1.2	**Describe different types of nonlinear problems that require fixed point formulation in special functional space framework.**	**K1, K2**	• **4 lecture hours\week** • **Self-study**	**Direct: Short Quizzes**
2.0	**Skills**			
2.1	**Use techniques of proof in existence via fixed point theory.**	**S1, S2**	**Self-study**	**Direct:** • **Participations** • **Short Quizzes**
2.2	**Develop oral communication and technical writing skills through applications of fixed point theorems.**	**S4**	**Real-life problems**	**Direct: Homework and Mini projects**
2.3	**Analyze Internet in searching for applications of main fixed point theorems.**	**S3**	**Real-life problems**	**Direct: Short Quizzes**
2.4	**Choose out deep proofs in the solvability of IVPs and BVPs.**	**S1, S2**	**Self-study**	**Direct: Participations**
3.0	**Values, autonomy, and responsibility**			
3.1	**Work with independence and responsibility.**	**V1, V2**	**Personal questions**	**Direct: Participation**
3.2	**Lead team works.**	**V1, V3**	**Teamwork and class discussions.**	**Direct: Homework and Mini projects**

C. Course Content

No	List of Topics	Contact Hours
1.	**Banach's contraction principle in complete metric spaces: Method of Proof, Generalizations, Continuation Methods, Variants, and Applications to Banach Spaces, Ekeland's Variational Principle. The Case of Nonlinear Contractions: Boyd and Wong Fixed Point Theorem and Variants.**	**10**
2.	**The finite-dimensional case: Brouwer's Fixed Point Theorem and Applications: the Domain Invariance Theorem, Hartmann-Stampacchia Theorem, Perron-Frobenius Theorem, Poinacare-Bohl Theorem.**	**10**
3.	**The infinite-dimensional case: Schauder's Fixed Point Theorem. Homotopy and Continuation Methods, Shaefer and Rothe Fixed Point Theorems, Variants. Applications: The Open Mapping Theorem, Borsuk and Borsuk-Ulam Theorems.**	**10**
4.	**The Traveling Salesman Problem:** Introduction, Heuristics for the TSP, Lower Bounds, Cutting Planes, Branch and Bound.	**15**
5.	**Applications: Solvability of Initial and Boundary Value Problems for Ordinary and Partial Differential Equations as well as Nonlinear Integral Equations of Volterra and Hammerstein types on Bounded and Unbounded Domains of the Euclidian Space.**	**15**
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	• **K.C. Chang, Methods in Nonlinear Analysis; Springer, Berlin, 2005.**
Supportive References	1. **P. Drakek and J. Minolta, *Methods of Nonlinear Analysis*; Birkhauser, Springer, Basel, 2013** 2. **Granas and J. Dugundji, Fixed Point Theory, Springer Monographs in Mathematics, Springer, 2003.** 3. **E. Zeidler, *Nonlinear Functional Analysis and its Applications. Vol. I: Fixed Point Theorems; Springer-Verlag, New-York, 2013.***
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.
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)