



Course Specifications (Postgraduate Degree)

Course Title:	Measure and Integration
Course Code:	MAT 7111
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5(4 Lectures, 0 Lab, 2 Tutorial)		
2. Course type			
a.	University ☐	College ☐	Department ☒
b.	Required ☒	Elective ☐	Others ☐
3. Level/year at which this course is offered:	Level 1/ Year 1		
4.Pre-requisites for this course (if any):	None		
5. Co-requisites for this course (if any):	None		

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the most important ideas, basics of measure and integration theories, and proofs of the fundamental theorems underlying the theory of measure and integration. First, we introduce Caratheodory Theorems and the construction of outer measure. Integration theory is present in its abstract setting. Properties of measurable functions and integrable functions are given, leading to the definition of L^1 space and its properties. Then the main convergence theorems and their applications are proved. Starting from basic inequalities, the Banach space L^p is introduced. The Riesz Representation Theorem and dual of L^p are given. Then the concepts of density and separability are related to approximation theorems. Weak convergence and main properties are also introduced.

2. Course Main Objective

The objective of this course is to give a detailed and deep knowledge in abstract measure theory and integration over general measure spaces. This course serves as a foundation for current approaches in many areas of mathematics, such as:

functional analysis, harmonic analysis, partial differential equations, probability theory, fractals, and dynamical systems.

The main goal of the course is to develop the basics of abstract measure theory and main properties of the integrals with respect to a measure. The students will be introduced to main theorems in Lebesgue integration and they are expected to understand new mathematical concepts and to use them in practice. They will be able to integrate a measurable function with respect to a measure, to build a measure starting from a countable additive function, and to recognize the main properties of integrable functions.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To describe the major concepts of measure and integration theory.	K1, K2
1.2	To outline the main results in measure and integration theory with applications.	K1, K2
2	Skills	
2.1	To develop techniques of proof in Lebesgue integration theory.	S1, S2
2.2	To develop oral communication and technical writing skills through convergence theorems.	S3
2.3	To use Internet in searching for different kinds of measures	S4
2.4	To demonstrate out deep proofs in L_p spaces	S1, S2
3	Values	
3.1	To work individually with initiative and responsibility	V1, V3
3.2	To work in teams with cooperation and positive collaboration	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	General Measure Spaces: Measures and Measurable Sets, Finite Measure, Null Sets, Signed Measure, Invariant Measures. The Hahn and Jordan Decompositions, The Caratheodory Measure; Construction of outer measures. The Caratheodory-Hahn Theorem	21
2	Integration Over General Measure Spaces: measurable functions, Convergence a.e., Convergence in Measure. Integration of general measurable functions, L^1 Space, Convergence in Mean, The Monotone Convergence Theorem and Applications: Beppo-Levi Theorem, Fatou's Lemma, The Lebesgue Dominated Convergence Theorem and Application: The Absolute Continuity of Integral. Derivatives of Measures, The Radon-Nikodym Theorem, The Vitali-Hahn-Saks Theorem.	21
	L_p Spaces: Review of Basic Inequalities, Containment Relations, The completeness of L_p , Linear Functionals and Duality, the Riesz Representation Theorem, Density and Approximation Theorems, Separability, Weak Convergence.	18
3	Product Measures: Fubini and Tonelli Theorems and Application, Construction of Lebesgue Measure in $\mathbb{R}^n$	14
Total		72

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	To describe the major concepts of measure and integration theory.	• 4 lecture hours\week	• Regular Exams
1.2	To outline the main results in measure and integration theory with applications.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in Lebesgue integration theory.	• Deep problems	• Short Quizzes
2.2	To develop oral communication and technical writing skills through convergence theorems.	• Self-study	• Participations
2.3	To use Internet in searching for different kinds of measures	• Self-study	• Short Quizzes
2.4	To demonstrate out deep proofs in L_p spaces	• Deep problems	• Participations
3.0	Values		
3.1	To work individually with initiative and responsibility	Personal questions	Participation
3.2	To work in teams with cooperation and positive collaboration	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	H. Royden & P. Fitzpatrick: Real Analysis, Prentice-Hall, 2010 (Main reference)
Essential References Materials	• R.F. Bass, Real Analysis for Graduate Students, version 3.1, 2016 • W. Rudin, Real and Complex Analysis, (Higher Mathematics Series), McGraw Hill, 3rd Edition, 1987. • L.F. Richardson, Measure and Integration, A Concise Introduction to Real Analysis, John Wiley & Sons, 2009.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Complex Analysis
Course Code:	MAT 7113
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered:	Level 2 / Year 1
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This Graduate Complex Analysis course describes the most important topics of analytic functions, complex integration, Cauchy's Theorem, the Maximum Modulus Principle, Liouville's Theorem, Harmonic Functions, Taylor and Laurent Series, singularities, the Residue Theorem, ... It also covers conformal mapping, normal families, the Riemann Mapping Theorem, and harmonic functions.

2. Course Main Objective

The main objective of this course is to study the theory of functions of one complex variable through investigation of the major theorems in complex analysis: the Cauchy-Riemann Equations, Cauchy's Theorem, Cauchy's Integral Formula, the Maximum Modulus Principle, Liouville's Theorem, and the Residue Theorem, Rouché's Theorem. The theory is applied to a wide range of problems including evaluation of complex line integrals and real integrals. The concept of Conformal Mapping and the Riemann Mapping Theorem will be studied as well as Harmonic Functions.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To record methods and major theorems in complex analysis.	K1, K2
1.2	To recognize concepts of conformal mapping, normal families, Riemann Mapping Theorem, and harmonic functions.	K1, K2
2	Skills:	
2.1	To create techniques of proof in Laurent series.	S1, S2
2.2	To develop oral communication and technical writing skills through harmonic functions.	S3
2.3	To use Internet in searching for conformal mappings	S4
2.4	To carry out deep and proofs in integral formulas.	S1, S2
3	Values:	
3.1	To work with independence and responsibility	V1, V3
3.2	To collaborate positively with work groups	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Review of Basics: Cauchy-Riemann Theorem and Applications, Analytic and Entire Functions, Liouville's Theorem.	16
2	Laurent Series and the Residue Theorem: Power Series and Taylor Series, Laurent's Series and Isolated Singular Points, Rouché's Theorem and the Inverse of Analytic Function, Residue Theorem and Applications, The Identity Theorem, Maximum Modulus Theorem.	20
3	Conformal Mapping and the Riemann Mapping Theorem: Conformal Mapping, Normal Families, Möbius Transformations, Riemann's Mapping Theorem of infinite Product, Runge's and Mittag-Leffler Theorems.	20
4	Harmonic Functions: Harmonic Functions, Laplace's Equation, The Maximal Principal Poisson Integral Formula, Schwarz Reflection Principle, Dirichlet's Problem on Disk.	16
Total		72

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	To record methods and major theorems in complex analysis.	• 4 lecture hours/week	• Regular Exams
1.2	To recognize concepts of conformal mapping, normal families, Riemann Mapping Theorem, and harmonic functions.	• 2 tutorial hour/week • Self-study	• Assignments • Short Quizzes
2.0	Skills		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.1	To create techniques of proof in Laurent series.	Self-study	Participations
2.2	To develop oral communication and technical writing skills through harmonic functions.	Deep problems	Short Quizzes
2.3	To use Internet in searching for conformal mappings	Self-study	Participations
2.4	To carry out deep and proofs in integral formulas.	Deep problems	Short Quizzes
3.0	Values		
3.1	To work with independence and responsibility	Personal questions	Participation
3.2	To collaborate positively with work groups	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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:

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student can get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	J. Conway; Functions of One Complex Variable, GTM, Springer-Verlag 1978. (Main Reference)
Essential References Materials	• W. Rudin; Real and Complex Analysis, McGraw-Hill 1987. • L. Ahlfors; Complex Analysis, McGraw-Hill 1966.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each classroom should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	4/14411
Date	22/04/1444 (16/11/2022)

Course Title:	Functional Analysis
Course Code:	MAT 7115
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered:	Level 3 / Year 1
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the most important ideas and theoretical results of applied functional analysis. The main topics of this course concern the functional analysis of infinite-dimensional linear spaces. The course also deals with the theory of operators: positive definite operators, Fredholm operators, compact operators, self-adjoint operators.

2. Course Main Objective

The objective of this course is to provide a deep knowledge of applied functional Analysis and to study some major theorems and concepts that can be applied in functional analysis and various problems including partial differential equations.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To name the fundamentals of the operator and spectral theories.	K1, K2
1.2	To describe the weak topology and weak and weak* convergence.	K1, K2

CLOs		Aligned PLOs
2	Skills:	
2.1	To develop techniques of proof in weak topologies.	S1, S2
2.2	To develop oral communication and technical writing skills through linear operators	S3
2.3	To use Internet in searching for resolvents of compact operators.	S4
2.4	To carry out deep and not short proofs in functional theorems.	S1, S2
3	Values:	
3.1	To do homework and assignments independently.	V1, V3
3.2	To integrate work groups in a easy way and efficiency.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Duality for normed linear spaces: Weak topologies, locally convex topological spaces, Mazur's Theorem, Krein-Milman Theorem, Alaoglu's Compactness Theorem.	24
2	Linear Operators: Continuous and bounded linear operators, adjoint operators, self-adjoint operator, compact operators, orthonormal bases in Hilbert Spaces.	20
3	Spectrum of self-adjoint compact operators: resolvents, the spectral theorem, Hilbert-Schmidt Theorem, Riesz-Schauder Theorem and Fredholm Alternative Theorems.	28
Total		72

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	To name the fundamentals of the operator and spectral theories.	• 4 lecture hours\week	Regular Exams
1.2	To describe the weak topology and weak and weak* convergence.	• 2 tutorial hour\week • Self-study	Assignments
2.0	Skills		
2.1	To develop techniques of proof in weak topologies.	Self-study	Participations
2.2	To develop oral communication and technical writing skills through linear operators	Deep problems	Short Quizzes
2.3	To use Internet in searching for resolvents of compact operators.	Self-study	Participations
2.4	To carry out deep and not short proofs in functional theorems.	Deep problems	Short Quizzes
3.0	Values		
3.1	To do homework and assignments independently.	Personal questions	Participation
3.2	To integrate work groups in a easy way and efficiency.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
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- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	H. Brezis: Functional Analysis, Sobolev spaces, and Partial Differential Equations, Springer, New York, 2010. (Main Reference)
Essential References Materials	• P. Lax, Functional Analysis with Applications, John Wiley & Sons, 2002. • Y. Eidelman, V. Milman, and Tzolomitics, Functional Analysis, An Introduction, Graduate Texts in Mathematics, American Mathematical Society, 2004. • J. Cerda, Linear functional Analysis, Graduate Texts in Mathematics, American Mathematical Society, 2010. • J.B. Conway, A course in Functional Analysis, Second Edition, Springer, Graduate Texts in Mathematics v. 96, 1990. • W. Rudin, Functional Analysis, McGraw-Hill Company, 1973.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector.

Item	Resources
	Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
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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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Groups and Fields
Course Code:	MAT 7121
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered:	Level 1 / Year 1
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the most important ideas, studying finite groups fundamental theory of studying finite groups such as: Direct and Semi-direct Products, Sylow's Theorems, Free Group, Presentation, p -Groups, Finitely Generated Abelian Groups, Nilpotent and soluble Groups, simple groups. Basics of field theory will be studied such as splitting fields, algebraic closure, field extensions, and the fundamental theory of Galois.

2. Course Main Objective

The objective of this course is to give a detailed knowledge and methods for classification of finite groups through p -groups, Sylow's subgroups, nilpotent and soluble groups. An important class of simple groups is presented by alternating groups. Moreover, the course provides the basics of field theory, and notions such as splitting fields, algebraic closure, field extensions, and the fundamental theory of Galois.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	

CLOs		Aligned PLOs
1.1	To list new tools which give answers to deep questions in finite group theory.	K1, K2
1.2	To outline complex problems that require making decisions in situations regarding the type of groups or fields studied.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in Groups and fields	S1, S2
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	S3
2.3	To use Internet in searching for p-Groups	S4
2.4	To carry out deep and not short proofs in Fields and Field extension	S1, S2
3	Values:	
3.1	To execute works independently	V1, V3
3.2	To cooperate with team work	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Groups: The Fundamental Theorem of Finitely Generated Abelian Groups, Direct and Semi-direct Products.	11
2	Group Action and Class Equation: Sylow Theorems, Chain Conditions and Krull-Schmidt Theorem, Free Group, Group Presentation.	14
3	p-Groups: Nilpotent Groups, Normal Series and Jordan-Holders Theorem, Solvable Groups, Simple Groups, and Simplicity of Alternating Groups.	11
4	Fields: Review of Basics, Splitting Extension Fields, Algebraic Closure, Separable and Normal Field Extensions.	11
5	The Fundamental Theorem of Galois: The Galois Group of a Polynomial, Cyclic and Cyclotomic Field Extensions.	14
6	Radical Field Extension: Insolubility of The Quintic, The Symmetric Polynomials and Insolubility of The General Polynomial.	11
Total		72

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	To list new tools which give answers to deep questions in finite group theory.	• 4 lecture hours\week • 2 tutorial hour\week • Self-study	• Regular Exams • Assignments • Short Quizzes
1.2	To outline complex problems that require making decisions in situations regarding the type of groups or fields studied.		
2.0	Skills		
2.1	To develop techniques of proof in Groups and fields	• Deep problems	• Short Quizzes

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	• Self-study	• Participations
2.3	To use Internet in searching for p-Groups	• Self-study	• Participations
2.4	To carry out deep and not short proofs in Fields and Field extension	• Deep problems	• Short Quizzes
3.0	Values		
3.1	To execute works independently	Personal questions	Participation
3.2	To cooperate with team work	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	T. Hungerford, <i>Algebra</i> , GTM, Springer-Verlag 1974. (Main Reference)
Essential References Materials	• D. Dummit & R. Foote, <i>Abstract Algebra</i>, John Wiley 2004. • J. Weckless, <i>A First Graduate Course in Abstract Algebra</i>, Marcel Dekker, 2004.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Rings and Modules
Course Code:	MAT 7122
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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C. Course Content	4
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2. Assessment Tasks for Students	5
E. Student Academic Counseling and Support	5
F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered:	Level 2 / Year 1
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the most important ideas and theoretical results on Rings and Modules.

2. Course Main Objective

The main objective of this course is to study important algebraic structures of rings and modules, with a discussion of some important classes of rings such as Noetherian and Artinian rings, and important classes of modules, such as injective and projective modules, in addition to tensor product and groups algebra.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To name mathematical structures of rings and modules.	K1, K2
1.2	To list important classes of rings and modules	K1, K2
2	Skills:	

CLOs		Aligned PLOs
2.1	To develop techniques of proof in modules and sub-modules.	S1, S2
2.2	To develop oral communication and technical writing skills through rings and modules.	S3
2.3	To use Internet in searching for Noetherian and Artinian Modules	S4
2.4	To demonstrate deep proofs in Algebras and Tensors products.	S1, S2
3	Values:	
3.1	To work responsibility and independence.	V1, V3
3.2	To work and cooperate in team work.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Basic Definitions of Modules, Submodules, Quotient Modules	12
2	Direct Product and Direct Sum of Modules, Free Modules, Modules Over PID,	15
3	Noetherian and Artinian Modules, Composition Series and Jordan-Holders Theorem,	12
4	Simple Rings and Simple Modules, Semi-Simple Rings, Wedderburn-Artin Theorem, Exact Sequences, Projective and Injective Modules,	20
5	Tensor Products, Flat Modules, Algebras, Semi-Simple, Simple and Division Algebras, Group Algebra and Maschke's Theorem.	13
Total		72

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	To name mathematical structures of rings and modules.	• 4 lecture hours\week	• Regular Exams
1.2	To list important classes of rings and modules	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in modules and sub-modules.	Self-study	Short Quizzes
2.2	To develop oral communication and technical writing skills through rings and modules.	Deep problems	Participations
2.3	To use Internet in searching for Noetherian and Artinian Modules	Self-study	Short Quizzes
2.4	To demonstrate deep proofs in Algebras and Tensors products.	Deep problems	Participations
3.0	Values		
3.1	To work responsibility and independence.	Personal questions	Participation

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
3.2	To work and cooperate in team work.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	T. Hungerford, <i>Algebra</i> , GTM, Springer-Verlag 1974. (Main Reference)
Essential References Materials	• J. Weckless, <i>A First Graduate Course in Abstract Algebra</i>, Marcel Dekker, 2004. • D. Dummit & R. Foote, <i>Abstract Algebra</i>, John Wiley 2004.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.

Item	Resources
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Advanced Partial Differential Equations
Course Code:	MAT 7131
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered:	Level 2 / Year 1
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The objective of this course is to give a detailed description of many important topics in the theory of partial differential equations (PDEs), with particular attention to modern approaches. Some classical theorems of existence and uniqueness solutions for classes of linear PDEs are also presented. Various methods such that energy methods will be given in the framework of Sobolev Spaces.

2. Course Main Objective

This course aims at presenting the most important notions on the Sobolev spaces theory and their main properties. These are spaces that represent the functional setting to discuss partial differential equations. The course also includes the concept of weak solutions in Sobolev Spaces. However, the emphasis will be on some theoretical results regarding questions of existence and uniqueness for BVPs describing physical models.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To list the basic definitions and main properties of Sobolev spaces.	
1.2	To record the most important inequalities.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in Sobolev spaces.	S1, S2
2.2	To develop oral communication and technical writing skills through formulations of boundary value problems.	S3
2.3	To use Internet in searching for examples of linear PDES.	S4
2.4	To write deep proofs of solvability of classical PDEs.	S1, S2
3	Values:	
3.1	To do personal works independently.	V1, V3
3.2	To collaborate with work groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Sobolev Spaces: Weak Derivatives, Definition and Main Properties, Sobolev Embeddings and Inequalities, Gagliardo and Morrey's Inequalities, Poincare's Inequalities, General Sobolev Inequalities	16
2	The Dual Space, The Space H^{-1} . Approximation by Smooth Functions, Traces.	16
3	Applications: Variational Formulation of Some Boundary Value Problems for Linear PDEs, Lax-Milgram Theorem	10
4	Second-Order Elliptic Equations: Elliptic Equations, Weak Solutions, Existence of Weak Solutions. Regularity, Maximum Principles: Weak maximum principle, Strong Maximum Principle.	10
5	Second-Parabolic equations: Existence of Weak Solutions, Regularity, Maximum Principle.	10
6	Second-Order Hyperbolic equations: Existence of Weak Solutions, Regularity.	10
Total		72

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	To list the basic definitions and main properties of Sobolev spaces.	4 lecture hours/week	Regular Exams
1.2	To record the most important inequalities.	2 tutorial hour/week	Assignments
2.0	Skills		
2.1	To develop techniques of proof in Sobolev spaces.	Self-study	Participations

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.2	To develop oral communication and technical writing skills through formulations of boundary value problems.	Deep problems	Short Quizzes
2.3	To use Internet in searching for examples of linear PDEs.	Self-study	Participations
2.4	To write deep proofs of solvability of classical PDEs.	Deep problems	Short Quizzes
3.0	Values		
3.1	To do personal works independently.	Personal questions	Participation
3.2	To collaborate with work groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	L. C. Evans: <i>Partial Differential Equations</i> ; American Mathematical Society, 2 nd Ed. 2010.
Essential References Materials	H. Brezis: <i>Functional Analysis, Sobolev Spaces, and Partial Differential Equation</i> , Springer 2011. R McOwen: <i>Partial Differential Equations: Methods and Applications</i> ; 2 nd Ed. 2002.
Electronic Materials	None

Other Learning Materials	None
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2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Advanced Numerical Analysis
Course Code:	MAT 7141
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered:	Level 3 / Year 1
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course introduces the theory and implementation of some advanced numerical methods for solving Partial Differential Equations (elliptic, parabolic, and hyperbolic), namely, the Finite Difference Method (FDM) and the Finite Element Method (FEM).

The course covers the mathematical formulation of the methods, the study of convergence and error estimates, and the stability analysis and scheme consistency. Computer implementation will be performed too.

2. Course Main Objective

The aim of the course is to introduce two numerical techniques, the Finite Difference Method (FDM) and Finite Element Method (FEM), used worldwide to solve PDEs stem from problem modeling. The theoretical part will be presented and the convergence as well as the stability analysis is considered in order to make appropriate choice of algorithms. The reliability of numerical results will be examined too. Study of classical cases will be undertaken. After successful completion of the course, the students should be able to understand the FDM and FEM and work independently to implement these methods in industrial or academic research area.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To state high level numerical methods, such as FDM and FEM to solve various mathematical problems for which analytical solution is not affordable.	K1, K2
1.2	To describe FDM and FEM methods for problem solving and stability analysis for partial differential equations.	K1, K2
2	Skills:	
2.1	To develop techniques of proofs in numerical analysis.	S1, S2
2.2	To develop oral communication and technical writing skills through approximation of some PDEs.	S3
2.3	To use Internet in searching for finite elements schemes.	S4
2.4	To carry out deep proofs in conforming and nonconforming elements.	S1, S2
3	Values:	
3.1	To do assignments and homework independently.	V1, V3
3.2	To collaborate with work groups with efficiency.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Finite Differences: Approximation of first and second order derivatives, one-sided finite differences, analysis of truncation error, Higher order approximation, Example of 1D and 2D Poisson equation, Crank–Nicolson Approximation to the Heat Equation, Treatment of complex geometries, Evolution problems, analysis of convergence, stability and Consistency of a scheme. Nonlinear boundary value problems.	28
2	Finite Elements: Mathematical Formulation of FEM and Galerkin methods, discretization, Triangulation and meshing, Finite elements P1, conforming and nonconforming elements, integration over one finite element, Approximation, Shape functions and piecewise linear interpolation, the element stiffness matrix, assembly of global matrix, Convergence and error estimation. Classical and weak solutions, regularity results. Functions spaces and norms. Lemma of Céa.	28
3	Computer Implementation: Applications to engineering problems.	16
Total		72

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	To state high level numerical methods, such as FDM and FEM to solve various mathematical problems for which analytical solution is not affordable.	• 4 lecture hours\week	Regular Exams
1.2	To describe FDM and FEM methods for problem solving and stability analysis for partial differential equations.	• 2 tutorial hour\week • Self-study	Assignments
2.0	Skills		
2.1	To develop techniques of proofs in numerical analysis.	Self-study	Participations
2.2	To develop oral communication and technical writing skills through approximation of some PDEs.	Deep problems	Short Quizzes
2.3	To use Internet in searching for finite elements schemes.	Self-study	Participations
2.4	To carry out deep proofs in conforming and nonconforming elements.	Deep problems	Short Quizzes
3.0	Values		
3.1	To do assignments and homework independently.	Personal questions	Participation
3.2	To collaborate with work groups with efficiency.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	R. Leveque, <i>Finite Difference Methods for Ordinary and Partial Differential Equations</i>; Steady-State and Time-Dependent Problems, SIAM, 2007.
Essential References Materials	S. Brenner and R. Scott; <i>The Mathematical Theory of Finite Element Methods</i>; Springer, 3rd Edition, 2008. T. Chandrupatla and A. Belegundu, <i>Introduction to Finite Elements in Engineering</i>; International Edition, Pearson, 2012.
Electronic Materials	None
Other Learning Materials	

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	Each class room should be equipped with a whiteboard and a projector. Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Probability Theory
Course Code:	MAT 7201
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The course covers the basic principles of the measure-theoretic probability theory. Topics include the axioms of probability, random variables and vectors, independence of events and variables; modes of probabilistic convergence, laws of large numbers; characteristic functions, the central limit theorem, conditional probability and expectation, introduction to martingales.

2. Course Main Objective

The objective of this course is first to understand general concepts in measure-theoretic probability theory: random variable, independence, and different type of convergence, laws of large numbers, and the Central Limit Theorem. As application, limit theorems are used to approximate probabilities of average and sums of independent identically-distributed random variables. Finally the conditional expectation with respect to a sigma-field is introduced and applied to martingales.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To list the different types of convergences, the laws of large numbers, and the central limit theorem.	K1, K2
1.2	To reproduce the notions of conditional expectation and martingale	K1, K2
2	Skills:	
2.1	To develop techniques of proof in probability theory.	S1, S2
2.2	To develop oral communication and technical writing skills through random variables.	S3
2.3	To use Internet in searching for different types of modes of convergences.	S4
2.4	To write out deep proofs in applications of Central Limit Theorem.	S1, S2
3	Values:	
3.1	To execute assignments and homework with independence and responsibility.	V1, V3
3.2	To cooperate with team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Foundations of Probability: Probability Space and Random Variables, Distribution Function of a Random variable, Random Elements, Vectors and Joint Distributions, Expectation and Moments, Inequalities for Moments and Probabilities.	14
2	Independence: Independent Events and Classes, Independent Random Elements, Independent Random Variables, Addition of Independent Random variables, Borel–Cantelli Lemma and zero-one Law.	14
3	Convergence and Related Topics: Modes of Probabilistic Convergence: Almost Sure Convergence, Convergence in Probability, Convergence in Order Mean, Convergence in Distribution, Relationships Between Forms of Convergence, Series of Independent Random Variables, Laws of Large Numbers.	18
4	Characteristic Functions and Central Limit Theorem: Definition and Simple Properties, Characteristic Function and Moments, Inversion and Uniqueness, Continuity Theorem for Characteristic Functions, Some Applications (Central Limit Theorem).	13
5	Conditioning and Martingales: Conditional Expectation Given a Sigma-Field, Conditional Probability Given a Sigma-Field, Definition and Basic Properties of Martingales	13
Total		72

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		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.1	To list the different types of convergences, the laws of large numbers, and the central limit theorem.	• 4 lecture hours\week	• Regular Exams
1.2	To reproduce the notions of conditional expectation and martingale	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in probability theory.	Self-study	Participations
2.2	To develop oral communication and technical writing skills through random variables.	Deep problems	Short Quizzes
2.3	To use Internet in searching for different types of modes of convergences.	Self-study	Participations
2.4	To write out deep proofs in applications of Central Limit Theorem.	Deep problems	Short Quizzes
3.0	Values		
3.1	To execute assignments and homework with independence and responsibility.	Personal questions	Participation
3.2	To cooperate with team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	R. Leadbetter et al., <i>A Basic Course in Measure and Probability, Theory for Applications</i> , Cambridge University Press 2014. (Main Reference)
Essential References Materials	• G. Tucker, <i>A Graduate Course in Probability, Probability and Mathematical Statistics</i>, Dover publications, 2014. • E. Çinlar, <i>Probability and Stochastics</i>, Graduate Texts in Mathematics, 261, Springer, 2011.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
		Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Stochastic Differential Equations
Course Code:	MAT 7203
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The course covers the basic principles of the theory of stochastic differential equations. Topics include the stochastic calculus on Brownian motion, the construction of the Ito integral, the Ito formula, and the integral calculus. Moreover, the concept of stochastic differential equation is introduced, some uniqueness and existence results are proved, and some solvability methods are given.

2. Course Main Objective

The aim of this course is first to use the stochastic calculus on Brownian motion and understand the concept of the Ito integral and the Ito isometry in one and many dimension. The Ito formula is used to obtain explicit integral calculus and then to solve the martingale representation theorem. The concept of stochastic differential equations is presented and the solvability of some classical examples is considered.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To outline the concept of Ito integral and computation methods using the Brownian motion and the Ito isometry.	K1, K2
1.2	To record some examples of stochastic differential equations and their solutions.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in Brownian Motion.	S1, S2
2.2	To develop oral communication and technical writing skills through study of stochastic integrals.	S3
2.3	To use Internet in searching for Ito formula,	S4
2.4	To demonstrate deep proofs in stochastic differential equations.	S1, S2
3	Values:	
3.1	To work with responsibility and independence.	V1, V3
3.2	To work with cooperation and collaboration in team groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Brownian Motion: Basics on Probability Theory, Introduction to Continuous-Time Stochastic Process, Definition of Brownian Motion, Stochastic Calculus on Brownian Motion.	15
2	Stochastic Integrals: Construction of the Ito Integral, Ito Isometry, Properties of the Ito Integral, Extension of the Ito Integral, Multi-Dimensional Ito Integral, Comparison with Stratonovich Integrals.	18
3	Ito Formula: One Dimensional Ito Formula, Ito Process, Integral Calculus, Multi-Dimensional Ito Formula, The Martingale Representation Theorem.	15
4	Introduction to Stochastic Differential Equations: Definition and Elementary Examples, Existence and Uniqueness Result, Weak and Strong Solution, Resolution Methods.	24
Total		72

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	To outline the concept of Ito integral and computation methods using the Brownian motion and the Ito isometry.	• 4 lecture hours\week	• Regular Exams
1.2	To record some examples of stochastic differential equations and their solutions.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in Brownian Motion.	Self-study	Participations

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.2	To develop oral communication and technical writing skills through study of stochastic integrals.	Deep problems	Short Quizzes
2.3	To use Internet in searching for Ito formula,	Self-study	Participations
2.4	To demonstrate deep proofs in stochastic differential equations.	Deep problems	Short Quizzes
3.0	Values		
3.1	To work with responsibility and independence.	Personal questions	Participation
3.2	To work with cooperation and collaboration in team groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	B. Oksendal , <i>Stochastic Differential Equations</i> , 6 th Edition, Springer-Verlag, 2006. (Main Reference)
Essential References Materials	• H.H. Kuo, <i>Introduction to Stochastic Integration</i>, Springer-Verlag 2006. • P.E. Kloeden and E. Platen, <i>Numerical Solutions of Stochastic Differential Equations</i>, Springer-Verlag, 2013.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Random Dynamical Systems
Course Code:	MAT 7205
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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1.Learning Resources	6
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G. Course Quality Evaluation	6
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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The course covers the basic principles of the theory of random dynamical systems. Topics include infinite dimensional Dynamical Systems (DS) on probability spaces, Metric Dynamical Systems, Cocycles over a DS, Random Dynamical Systems (RDS), fundamental examples of RDS and invariant measures for RDS.

2. Course Main Objective

The aim of this course is to use the translation shift and the Wiener shift as metric dynamical systems to understand the concept of random dynamical system as a cocycle over a dynamical system. It is also concerned with the analysis of different types of random dynamical systems. Understanding the concepts of invariant measure and random fixed point for a random dynamical system is a very important issue of this course.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	

CLOs		Aligned PLOs
1.1	To define the concept of cocycle over a metric dynamical system given by translation and Wiener shifts.	K1, K2
1.2	To record the concept of random dynamical systems and the associated invariant measures.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in measurable and dynamical systems.	S1, S2
2.2	To develop oral communication and technical writing skills through random differential equations.	S3
2.3	To use Internet in searching for invariant measures.	S4
2.4	To carry out deep proofs in factorization of measures.	S1, S2
3	Values:	
3.1	To work independently.	V1, V3
3.2	To collaborate and work in team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Measurable Dynamical Systems (DS): Definition, Measure Preserving DS, Stochastic Processes and DS, DS Defined by the Translation Shift, Wiener DS.	16
2	Random Dynamical Systems (RDS): Cocycle over a DS, Measurable RDS, Continuous RDS, Smooth RDS, Linear RDS, Two-sided Time RDS, Perfection of a Crude Cocycle.	18
3	Fundamental Examples of RDS: Discrete Time RDS, Random Iteration, Continuous Time RDS 1, Random Differential Equations, Continuous Time RDS 2, Stochastic Differential Equations.	18
4	Invariant Measures for RDS: Skew Product Defined By a RDS, Factorization of Measures, Invariance in Terms of Factorization, Invariant Product Measure, Random Fixed Points, Invariant Measures for Continuous RDS.	18
Total		72

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	To define the concept of cocycle over a metric dynamical system given by translation and Wiener shifts.	• 4 lecture hours/week	• Regular Exams
1.2	To record the concept of random dynamical systems and the associated invariant measures.	• 2 tutorial hour/week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in measurable and dynamical systems.	Self-study	Participations

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.2	To develop oral communication and technical writing skills through random differential equations.	Deep problems	Short Quizzes
2.3	To use Internet in searching for invariant measures.	Self-study	Participations
2.4	To carry out deep proofs in factorization of measures.	Deep problems	Short Quizzes
3.0	Values		
3.1	To work independently.	Personal questions	Participation
3.2	To collaborate and work in team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	L. Arnold, <i>Random Dynamical Systems</i> ; Springer-Verlag, 1998. (Main Reference)
Essential References Materials	• R. Bhattacharya and M. Majumdar, <i>Random Dynamical Systems: Theory and Applications</i>, Cambridge Univ. Press, 2007. • A. Swischuk and S. Islam, <i>Random Dynamical System in Finance</i>, CRC Press, Taylor and Francis Group, 2013.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Functional Analysis
Course Code:	MAT 7215
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the most important ideas and theoretical results of applied functional analysis. The main topics of this course concern the functional analysis of infinite-dimensional linear spaces. The course also deals with the theory of operators: positive definite operators, Fredholm operators, compact operators, self-adjoint operators.

2. Course Main Objective

The objective of this course is to provide a deep knowledge of applied functional Analysis and to study some major theorems and concepts that can be applied in functional analysis and various problems including partial differential equations.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To name the fundamentals of the operator and spectral theories.	K1, K2
1.2	To describe the weak topology and weak and weak* convergence.	K1, K2

CLOs		Aligned PLOs
2	Skills:	
2.1	To develop techniques of proof in weak topologies.	S1, S2
2.2	To develop oral communication and technical writing skills through linear operators	S3
2.3	To use Internet in searching for resolvents of compact operators.	S4
2.4	To carry out deep and not short proofs in functional theorems.	S1, S2
3	Values:	
3.1	To do homework and assignments independently.	V1, V3
3.2	To integrate work groups in a easy way and efficiency.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Duality for normed linear spaces: Weak topologies, locally convex topological spaces, Mazur's Theorem, Krein-Milman Theorem, Alaoglu's Compactness Theorem.	24
2	Linear Operators: Continuous and bounded linear operators, adjoint operators, self-adjoint operator, compact operators, orthonormal bases in Hilbert Spaces.	20
3	Spectrum of self-adjoint compact operators: resolvents, the spectral theorem, Hilbert-Schmidt Theorem, Riesz-Schauder Theorem and Fredholm Alternative Theorems.	28
Total		72

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	To name the fundamentals of the operator and spectral theories.	• 4 lecture hours\week	Regular Exams
1.2	To describe the weak topology and weak and weak* convergence.	• 2 tutorial hour\week • Self-study	Assignments
2.0	Skills		
2.1	To develop techniques of proof in weak topologies.	Self-study	Participations
2.2	To develop oral communication and technical writing skills through linear operators	Deep problems	Short Quizzes
2.3	To use Internet in searching for resolvents of compact operators.	Self-study	Participations
2.4	To carry out deep and not short proofs in functional theorems.	Deep problems	Short Quizzes
3.0	Values		
3.1	To do homework and assignments independently.	Personal questions	Participation
3.2	To integrate work groups in a easy way and efficiency.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- **Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).**
- **The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.**
- **Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.**
- **A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.**

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	H. Brezis: Functional Analysis, Sobolev spaces, and Partial Differential Equations, Springer, New York, 2010. (Main Reference)
Essential References Materials	• P. Lax, Functional Analysis with Applications, John Wiley & Sons, 2002. • Y. Eidelman, V. Milman, and Tsoolomitics, Functional Analysis, An Introduction, Graduate Texts in Mathematics, American Mathematical Society, 2004. • J. Cerda, Linear functional Analysis, Graduate Texts in Mathematics, American Mathematical Society, 2010. • J.B. Conway, A course in Functional Analysis, Second Edition, Springer, Graduate Texts in Mathematics v. 96, 1990. • W. Rudin, Functional Analysis, McGraw-Hill Company, 1973.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector.

Item	Resources
	Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Harmonic Analysis
Course Code:	MAT 7219
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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2. Assessment Tasks for Students	5
E. Student Academic Counseling and Support	5
F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The course describes the most important ideas in the analysis of compact (and locally compact) groups as well as group representation of groups. In this respect, fundamental theorems are provided.

2. Course Main Objective

The objective of this course is to give a thorough introduction to Harmonic analysis in abstract setting. More precisely the course intends to generalize the classical Fourier series from standard topological groups (the unit circle, the integers, and the real line) to locally compact Abelian groups.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To record Harmonic analysis techniques as well as classical and modern methods.	K1, K2
1.2	To list important theorems in connection with representation and compact group theories.	K1, K2
2	Skills:	

CLOs		Aligned PLOs
2.1	To develop techniques of proof in algebra and spectral theories.	S1, S2
2.2	To develop oral communication and technical writing skills through representation theory.	S3
2.3	To use Internet in searching for locally compact groups.	S4
2.4	To state deep proofs of most important theorems.	S1, S2
3	Values:	
3.1	To work individually.	V1, V3
3.2	To work in groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Banach Algebra: Basic Concepts, Gelfand Theory, Spectral Theory, Maximal Ideals, Basics of C^* -algebra Theory.	14
2	Locally Compact Groups: Topological Groups, Haar Measure, The Modular Function, Convolutions, The Topology of Locally Compact Groups.	17
3	Representation Theory: Unitary Representations, Group Algebra, Representations of Groups, Functions of Positive Types.	12
4	Analysis on Locally Compact Groups: The Dual Group, The Character Group, Fourier Transform, Pontryagin Duality Theorem, The Bochner & The Plancherel Theorems, The Bohr Compactification.	17
5	Analysis on Compact Groups: Group algebra of Compact groups, Representations of Compact Groups, The Peter – Weyl Theorem. Tannaka-Krein duality.	12
Total		72

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	To record Harmonic analysis techniques as well as classical and modern methods.	• 4 lecture hours\week	• Regular Exams
1.2	To list important theorems in connection with representation and compact group theories.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in algebra and spectral theories.	Deep problems	Participations
2.2	To develop oral communication and technical writing skills through representation theory.	Self-study	Short Quizzes
2.3	To use Internet in searching for locally compact groups.	Deep problems	Participations

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.4	To state deep proofs of most important theorems.	Self-study	Short Quizzes
3.0	Values		
3.1	To work individually.	Personal questions	Participation
3.2	To work in groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	• Y. Katznelson, <i>An Introduction to Harmonic Analysis</i>, Cambridge Library, 3rd edition, 2004. • H. Reiter and J.D. Stegeman, <i>Classical Harmonic Analysis and Locally Compact Groups</i> (London Mathematical Society Monographs), 2nd edition, Oxford University, 2001. • E. Hewitt and K.A. Ross, <i>Abstract Harmonic Analysis</i>, Volume I: Structure of topological groups, Integration theory, Group representation, Springer, 2nd edition, 1979. • L.H. Loomis, <i>An Introduction to Abstract Harmonic Analysis</i>, Dover Publ, 2011.
Essential References Materials	None

Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Theory of Numbers
Course Code:	MAT 7223
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The target of this course is three-fold: the reduction of an integer modulo a prime number which is one of the main methods to solve a diophantine equation is first studied. The second step is to give conditions which ensure that a positive integer is the sum of squared integers. This leads to the arithmetic theory of quadratic forms. The last part of the course concerns the notion of continued fractions which is defined for any positive real number. This notion allows one to detect some arithmetic properties such as rationality, algebraicity in a very efficient way.

It also prepares to the theory of Diophantine approximation. However, the focus will be on concrete examples and applications to cryptography.

2. Course Main Objective

The objective of this course is to initiate the student to some aspects of number theory and some related problems.

3. Course Learning Outcomes

	CLOs	Aligned PLOs
1	Knowledge and Understanding	

CLOs		Aligned PLOs
1.1	To record some methods specific to Number Theory.	K1, K2
1.2	To outline different kinds of mathematical proofs in number theory	K1, K2
2	Skills:	
2.1	To develop techniques of proof in Diophantine Equations.	S1, S2
2.2	To develop oral communication and technical writing skills through representation of integers and sums of squares.	S3
2.3	To use Internet in searching for continued fractions.	S4
2.4	To carry out deep proofs of linear congruence equations.	S1, S2
3	Values:	
3.1	To work with independence and responsibility.	V1, V3
3.2	To join and participate in team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Linear and Quadratic Diophantine Equations: Review of congruences, Linear congruences, Linear Diophantine equations, Quadratic Diophantine Equations, RSA Public Key Cryptosystem, Quadratic Residues: Reduction modulo a prime number, Legendre Symbol, Gauss Lemma, Quadratic Reciprocity Law, Jacobi Symbol.	23
2	Quadratic forms: Basic Properties, Equivalences of Quadratic Forms, Reduced Quadratic Forms, Quadratic Representations of integers. Representations as Sums of Squares: Two Squares Sums Representation, Four Squares Sum Representations, Lagrange's Theorem.	23
3	Continued Fractions: Definitions and Basic Properties, Uniqueness of the Representation of Real Number, Convergence. Finite Continued Fractions and Rationality. Application of Continued Fractions: Characterization of Algebraic Numbers, and Periodic Continued Fractions. Particular solutions of Linear Congruence Equation, Approximation of a real number by rational numbers, Pell's Equation.	26
Total		72

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	To record some methods specific to Number Theory.	• 4 lecture hours\week	• Regular Exams
1.2	To outline different kinds of mathematical proofs in number theory	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in Diophantine Equations.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through	Self-study	Participations

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
	representation of integers and sums of squares.		
2.3	To use Internet in searching for continued fractions.	Deep problems	Short Quizzes
2.4	To carry out deep proofs of linear congruence equations.	Self-study	Participations
3.0	Values		
3.1	To work with independence and responsibility.	Personal questions	Participation
3.2	To join and participate in team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	Stewart and D. Tall, <i>Algebraic Number Theory and Fermat's Last Theorem</i> , 3rd Ed., Peters Natick 2002.. (Main Reference)
Essential References Materials	I. Niven and Others, <i>An Introduction to The Theory of Numbers</i> , 5 th Ed., Wiley, 1991.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Algebraic Number Theory
Course Code:	MAT 7224
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	MAT 7223
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

In this course, algebraic structures which plays a central role in the study of number theory is investigated. The four operations on the set of integers are not sufficient to solve even simple diophantine equation. For this reason, one needs to introduce more abstract structure in order to catch the complexity of an arithmetical problem. The uprising of new theories such as group theory, ring theory, ideals, and Galois fields extensions among others, provides new ways to treat number theoretical problems. The introduction of such algebraic tools motivates the course. The main objective of the course is to study the properties of number fields which are finite extension of the field of rational numbers. Even in the case of a quadratic extension, the situation is still enough complicated. For example, Fermat's last Theorem was solved using deep algebraic concepts related to elliptic curves .

2. Course Main Objective

The aim of this course is to provide a strong background in algebraic number theory in order to prepare students to reach the research level in modern

number theory. This will be done by presenting the fundamental concepts which have been successful in solving problems in number theory.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To state deep questions in number theory by means of algebraic concepts.	K1, K2
1.2	To describe the algebraic structures needed in number theory with emphasis on relation with classical concepts from algebra.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in number theory.	S1, S2
2.2	To develop oral communication and technical writing skills through number fields and p-adic numbers.	S3
2.3	To use Internet in searching for examples in real and imaginary fields.	S4
2.4	To demonstrate deep proofs of main theorems in number theory.	S1, S2
3	Values:	
3.1	To deliver assignments and homework with independence.	V1, V3
3.2	To cooperate with team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Finite fields, Polynomial over Finite Fields, Roots and Multiplicities, Discriminant and Resultant, Legendre Symbol, Gauss Sums, Quadratic Reciprocity Law.	22
2	Valuations, p-adic Numbers, Product Formula, Ostrowski's Theorem, Completions, Hensel's Lemma, Structure of the Group of p-adic Units, Classification of Quadratic Forms over a p-adic Field and The rationals. Local-global Principles and Minkowski-Hasse Theorem. Number Fields, Ring of Integers, Quadratic Extensions, Galois Theory of Number Fields. Geometry of Numbers: Lattice Structure of the Ring of Integers, Minkowski's Convex Body Theorem, Norm of an Ideal, Ideal Class Group and Finiteness. Units in the Ring of Integers, Embeddings and Dirichlet's Theorem, Examples in Real and Imaginary Fields.	24
3	Decomposition of a Prime Ideal in the Ring of Integers, Ramification Index of Galois Extensions, Kummer-Dedekind Theorem. Cyclotomic fields, Frobenius Elements, Dirichlet Characters. Zeta-Dedekind Function and L-functions, Class Number of a Quadratic Field Extension, Regulators, Dirichlet Class Number Formula. Elliptic Curves, The Torus of Complex Points, j-invariant, pi-Weisstrass Elliptic Functions, Eisenstein Series. Group of Rational points, Mordell-Weil Theorem. The Space of Modular Forms of Weight k, Dimension and Basis, Fourier Expansion, Examples (Ramanujan, Jacobi).	26
Total		72

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	To state deep questions in number theory by means of algebraic concepts.	• 4 lecture hours\week	• Regular Exams
1.2	To describe the algebraic structures needed in number theory with emphasis on relation with classical concepts from algebra.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in number theory.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through number fields and p-adic numbers.	Self-study	Participations
2.3	To use Internet in searching for examples in real and imaginary fields.	Deep problems	Short Quizzes
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3.0	Values		
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2. Assessment Tasks for Students

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- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	J. Marcus, <i>Number Fields</i>, Universitext, Springer-Verlag, New York-Heidelberg, 1977.. (Main Reference)
Essential References Materials	• Neukrich, <i>Algebraic Number Theory</i>, Springer-Verlag Berlin, 1999. • W. Rudin, <i>Functional Analysis</i>, McGraw-Hill Company, 1973. • G. Janusz, <i>Algebraic Number Fields</i>, AMS GSM vol. 7, 1996.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
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	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
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	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
		Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	4/14411
Date	/2022)11/16/1444 (4/022

Course Title:	Galois Theory and Fields
Course Code:	MAT 7225
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The first part of the present course may be viewed as an investigation of infinite algebraic extensions. To obtain an analogue of the fundamental theorem of Galois theory, a topology on the Galois group of an infinite dimensional Galois extension (called the Krull topology) is defined, and then this topology is used to determine which subgroups of the Galois group arise as Galois groups of intermediate extensions. In the second part transcendental extensions are investigated with focus on finitely generated ones. Using algebraic analogs of derivations and differentials, these extensions lead to some geometric information. Finally, a complete proof of the Artin-Schreier theorem is given by developing some general theory.

2. Course Main Objective

The aim of this course is to prove two well-known results about extensions of fields. The first one is an analogue of the fundamental theorem of Galois theory for infinite Galois extensions, and the second one is the Artin-Schreier theorem

about the algebraic closure of a field. Also, we study field extensions that are not algebraic, and show how these extensions arise in algebraic geometry.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To define infinite Galois extensions and transcendental extensions.	K1, K2
1.2	To recognize an analogue of the fundamental theorem of Galois theory in the infinite case.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in group and field theory.	S1, S2
2.2	To develop oral communication and technical writing skills through infinite Galois extensions.	S3
2.3	To use Internet in searching for scientific transcendental extensions.	S4
2.4	To carry out deep proofs of main theorems in Galois Theory.	S1, S2
3	Values:	
3.1	To execute class duties with independence.	V1, V3
3.2	To collaborate with team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Basic definitions and results on: Ring Theory, Topology, Group Theory, Vector Spaces and Field Theory..	16
2	Infinite Galois extensions: Topological Groups, The Krull Topology on the Galois Group, the Fundamental Theorem of Infinite Galois Theory, Galois Groups as Inverse Limits, Some Infinite Galois Extensions. Transcendental extensions: Algebraic Dependence, Transcendence Bases, Purely Transcendental Extensions, The Transcendence Degree, Linear Disjointness and Separability, Algebraic Varieties, Algebraic Function Fields, Derivations and Differentials.	28
3	The Artin-Schreier theorem: Ordered and Pre-ordered Fields, Real Closed Fields, Artin-Schreier theorem, Applications of Artin-Schreier Theorem to the Galois Theory of Infinite Extensions. Artin- Schreie Theorem, Totally Positive Element, Artin's Solution of Hilbert's 17th Problem.	28
Total		72

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	To define infinite Galois extensions and transcendental extensions.	• 4 lecture hours\week	• Regular Exams

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.2	To recognize an analogue of the fundamental theorem of Galois theory in the infinite case.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in group and field theory.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through infinite Galois extensions.	Self-study	Participations
2.3	To use Internet in searching for scientific transcendental extensions.	Deep problems	Short Quizzes
2.4	To carry out deep proofs of main theorems in Galois Theory.	Self-study	Participations
3.0	Values		
3.1	To execute class duties with independence.	Personal questions	Participation
3.2	To collaborate with team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	F. Lorenz, <i>Algebra I: Fields and Galois Theory</i> , Springer-Verlag 2006.. (Main Reference)
Essential References Materials	• F. Lorenz, <i>Algebra II: Fields and Structures</i>, Springer-Verlag 2008.. • M. Nagata, <i>Theory of Commutative Fields</i>, AMS 1993. • J. S. Milne, <i>Fields and Galois theory</i>, Kluwer Academic Publishers, 2015.

Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)



Course Title:	Analytic Number Theory
Course Code:	MAT 7226
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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1.Learning Resources	6
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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

In this course we will study many ways to solve an arithmetical problem by using analytic methods, that is methods from complex analysis. One of main concern in analytic number theory is the asymptotic behaviour of some auxiliary functions called arithmetic functions (Euler totient, Van Mangolt, Mobius...). In this setting, the most important function is by far, the Riemann Zeta function. This function encodes many of the information about the distribution of prime numbers. The aim of the first chapter is to present a short proof of this deep result. The Riemann Zeta function has been generalized to the so-called L-functions. The nonvanishing of a suitable L-function gives the proof of the Dirichlet Theorem on Arithmetic progression. Another topic of this course is the Circle method introduced by Hardy and Littlewood useful dealing with sums of powers. The end of this course will be devoted to introduce sieving methods which is a way to estimate partial sums over primes discarding a given amount of them..

2. Course Main Objective

The objective of this course is to provide a deep knowledge of analytic number theory and to study some major theorems and concepts that can be applied in various problems including number theory.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To describe the link between classical analysis (real and complex) and arithmetical concepts.	K1, K2
1.2	To list most advanced methods that are useful in answering deep questions in number theory.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in complex analysis and arithmetic functions.	S1, S2
2.2	To develop oral communication and technical writing skills through series and functional equations.	S3
2.3	To use Internet in searching for Dirichlet formulas	S4
2.4	To write deep proofs of some theorems in analytic number theory.	S1, S2
3	Values:	
3.1	To execute course duties with independence and responsibility.	V1, V3
3.2	To collaborate with class team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Review of Basics in Complex Analysis, Analytic Continuation, Poles, The Riemann Zeta Function, Trivial Zeros, Functional Equation, Newman's proof of the Prime Number Theorem. Arithmetic Functions, Euler Totient Function, Dirichlet Product, Mobius Function and Inversion. The Mangolt Function and Relation with Zeta Functions, the Divisor Function.	23
2	Dirichlet Characters and Series, Analytic Continuation, Functional Equation, Euler Factorization, Nonvanishing of L-Function and Application to The Dirichlet Theorem on Arithmetic Progression. Dirichlet Class Number Formula for Quadratic Fields, Siegel Bounds, Application to The Number of Representations as Sums of Squares and Theta Functions.	26
3	Exponential Sums, Gauss Sums, Kloostermann Sums, Hardy-Littlewood Circle Method, Application to the Waring Problem. Concept of Sieving, Brun and Selberg Sieves, Large Sieve, Bombieri-Vinogradov Theorem.	23
Total		72

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		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.1	To describe the link between classical analysis (real and complex) and arithmetical concepts.	• 4 lecture hours\week	• Regular Exams
1.2	To list most advanced methods that are useful in answering deep questions in number theory.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in complex analysis and arithmetic functions.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through series and functional equations.	Self-study	Participations
2.3	To use Internet in searching for Dirichlet formulas	Self-study	Participations
2.4	To write deep proofs of some theorems in analytic number theory.	Deep problems	Short Quizzes
3.0	Values		
3.1	To execute course duties with independence and responsibility.	Personal questions	Participation
3.2	To collaborate with class team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	T.M. Apostol, Introduction to Analytic Number Theory, Undergraduate Texts, in Mathematics, Springer-Verlag 2006. (Main Reference)
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Essential References Materials	• J. De Koninck, Analytic Number Theory, American Mathematical Society (GSM) 2012. • M. Overholt, A Course in Analytic Number Theory, American Mathematical Society (GSM) 2014.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	

Evaluation Areas/Issues	Evaluators	Evaluation Methods
		Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Commutative Algebra
Course Code:	MAT 7227
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3 / Year 2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

Commutative Algebra is the study of commutative rings, and their modules and ideals. This theory has developed over the last 150 years not just as an area of algebra considered for its own sake, but as a tool in the study of two important branches of mathematics: algebraic geometry and algebraic number theory. The resulting unification, where the same underlying algebraic structures arise both in geometry and in number theory, has been one of the crowning glories of twentieth century mathematics and still plays a fundamental role in current work in both these fields.

One simple example of this unification will be familiar already to anyone who has noticed the strong parallels between the ring $\mathbb{Z}$ (a Euclidean Domain and hence also a Unique Factorization Domain) and the ring $\mathbb{F}[X]$ of polynomials over a field (which has both the same properties). More generally, the rings of algebraic integers over $\mathbb{Q}$ which have been studied since the 19th century to solve problems in number theory have parallel structures for functions rings on algebraic curves over complex numbers.

2. Course Main Objective

The main objective of this course is to provide a solid grounding in commutative algebra to be used in algebraic geometry and number theory. The course will deepen and extend students' knowledge and understanding of commutative algebra. Moreover, familiar mathematical objects such as polynomials and algebraic numbers are presented.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To state new tools that are useful in answering deep questions in commutative algebra.	K1, K2
1.2	To list problems that are easily treated by applying commutative algebra methods.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in commutative algebra.	S1, S2
2.2	To develop oral communication and technical writing skills through rings and modules.	S3
2.3	To use Internet in searching for ideals and rings.	S4
2.4	To write deep proofs of theorems on ideals and rings.	S1, S2
3	Values:	
3.1	To do course duties with independence and responsibility.	V1, V3
3.2	To participate with efficiency and cooperation in work groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Operations on Ideals and Submodules, Primary Ideals and Submodules, Primary Decompositions in Noetherian Rings, Rings and Modules of Quotients.	11
2	Total Ring of Quotients Artin-Rees Lemma and Krull Intersection Theorem, Nakayama Lemma.	11
3	Tensor Product and Flatness, Flat and Projective Ideals, Hereditary and Semi Hereditary Rings, Finitely Presented Ideals and Coherent Rings.	11
4	Integral and Complete Integral Extensions.	11
5	Krull Dimension, Valuation Rings, Krull Domains, Fractional and Invertible Ideals, Prufer Domains, Dedekind Domains, Arithmetical Rings.	19
6	R-Sequences and Macaulay Rings, Principal Ideal Theorem, Regular Rings.	9
Total		72

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		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.1	To state new tools that are useful in answering deep questions in commutative algebra.	• 4 lecture hours\week	• Regular Exams
1.2	To list problems that are easily treated by applying commutative algebra methods.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in commutative algebra.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through rings and modules.	Self-study	Participations
2.3	To use Internet in searching for ideals and rings.	Deep problems	Short Quizzes
2.4	To write deep proofs of theorems on ideals and rings.	Self-study	Participations
3.0	Values		
3.1	To do course duties with independence and responsibility.	Personal questions	Participation
3.2	To participate with efficiency and cooperation in work groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homework's, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	M. Larson, <i>Multiplicative Theory of Ideals</i> , Academic Press 1971 (Main Reference)
Essential References Materials	M. F. Atiyah & I. G. Macdonald, <i>Introduction to Commutative Algebra</i> , Academic Press, INC.

Electronic Materials	I. Kaplansky, <i>Commutative Rings</i>, Chicago University Press 1974. R. Gilmer, <i>Multiplicative Ideal Theory</i>, Queens Papers in Math 1992.
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	4/14411
Date	/2022)11/16/1444 (4/022

Course Title:	Group Representation
Course Code:	MAT 7228
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 4 / Year 2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The course consists mainly of two parts. First, some abstract ring theory and other basic concepts regarding group representation theory are presented. Secondly, the character theory of finite groups, or equivalently, representation theory of finite groups over a field of characteristic zero is described with applications: Burnside's $p^a q^b$ theorem, the character theory in subgroup structure, the representation theory in molecular vibration.

2. Course Main Objective

The main purpose of this course is to acquire knowledge and skills in group representation theory and related areas of algebra. The course explains some fundamental applications of linear algebra to the study of finite groups. And the main results in representation theory of finite groups such as Maschke and Schur Theorems are presented together with some applications, as in group theory and computation of character tables of finite groups of various types.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To list new tools that are useful in answering deep questions in representation theory of finite groups.	K1, K2
1.2	To record algebraic and computational properties that can be easily treated by applying these methods in character tables.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in representation and reduction of modules.	S1, S2
2.2	To develop oral communication and technical writing skills through character tables.	S3
2.3	To use Internet in searching for computing character tables.	S4
2.4	To describe some applications of characters of finite product of groups.	S1, S2
3	Values:	
3.1	To work individually.	V1, V3
3.2	To work in groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Definitions and Examples, Equivalent Representations, Regular Representation, Permutation Representation.	11
2	Group Algebras, Group Algebras Modules and Submodules, Irreducible Modules and Completely Reducible Modules, Module homomorphisms, Isomorphic Modules.	13
3	Mschke's theorem, Schur's Lemma and Applications. The Conjugacy Class Equation, Center of Group Algebra, Characters, Irreducible.	13
4	Regular and Faithful Characters. Inner Products of Characters, The Number of Irreducible Characters, Character Tables, Row and Column Orthogonality Relations of Characters.	13
5	Computing Character Tables of Small Orders Groups. Lifted Characters, Finding Linear Characters by Lifting. Tensor Product of Representations and their Characters.	11
6	Characters of Finite Direct Product of Groups. Application in the Burnside's theorem and in the investigations of molecular vibration.	11
Total		72

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		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.1	To list new tools that are useful in answering deep questions in representation theory of finite groups.	• 4 lecture hours\week	• Regular Exams
1.2	To record algebraic and computational properties that can be easily treated by applying these methods in character tables.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in representation and reduction of modules.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through character tables.	Self-study	Participations
2.3	To use Internet in searching for computing character tables.	Deep problems	Short Quizzes
2.4	To describe some applications of characters of finite product of groups.	Self-study	Participations
3.0	Values		
3.1	To work individually.	Personal questions	Participation
3.2	To work in groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	G. James and M. Liebeck, <i>Representations and Characters of Groups</i>; 2nd ed., Cambridge 2001. (Main Reference)
Essential References Materials	M. Burrow, <i>Representation Theory of Finite Groups</i>; Dover Pub. 2011. L. Dornhoff, <i>Group Representation Theory - Part A</i>; Marcel Dekker 1971.
Electronic Materials	The GAP Group, GAP -- Groups, Algorithms, and Programming, Version 4.8.6; 2016. (http://www.gap-system.org)
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
		Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Homological Algebra
Course Code:	MAT 7229
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The course starts with the introduction of basic concepts in homology and cohomology theories, such as: Covariant and Contravariant Functors, Additive Functors, Left and Right Exact Functors, as well as exact Sequences. Categories of Left and Right Modules, Tensor Products, Hom and Tensor Functors, Free Modules, Projective, Injective, and Flat Modules are also described.

The course ends with the main properties of Chain and Cochains Complexes, Homology and Cohomology Groups, and Derived Functors.

2. Course Main Objective

The objective of this course is to give new tools in order to deal with algebraic problems. It turns out that several important problems in topology, commutative algebra, and representation theory became handy by the aid of homology and cohomology.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To list new tools that are useful in answering deep questions in homological algebra.	K1, K2
1.2	To recognize algebraic and topological problems that are easily treated by applying these methods.	K1, K2
2	Skills:	
2.1	To develop techniques of proof using categories and functors.	S1, S2
2.2	To develop oral communication and technical writing skills through exact sequences.	S3
2.3	To use Internet in searching for some categories of modules.	S4
2.4	To carry out deep proofs in Homology Theory.	S1, S2
3	Values:	
3.1	To work with independence and responsibility.	V1, V3
3.2	To lead team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Categories and Functors: Basics, Covariant and Contravariant Functors, Additive Functors, Left and Right Exact Functors.	12
2	Sequences: Exact and Split Exact Sequences, 5-Lemma and Snake Lemma, Natural Equivalence of Functors.	12
3	Categories of Modules: Categories of Left and Right Modules, Tensor Products, Hom and Tensor Functors.	12
4	Some Types of Modules: Free Modules, Projective, Injective and Flat Modules.	12
5	Homology and Cohomology groups: n-Chain and Chain and Cochains Complexes, Homology and Cohomology Groups, The Long Exact Sequences and The Connected Homomorphism δ_n .	12
6	Ext and Tor Functors: The Projective Resolution of a Module, The Derived Functor, Tor and Ext Functors, The Two Long Exact Sequence Theorems for Tor and Ext.	12
Total		72

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	To list new tools that are useful in answering deep questions in homological algebra.	• 4 lecture hours/week	• Regular Exams
1.2	To recognize algebraic and topological problems that are easily treated by applying these methods.	• 2 tutorial hour/week • Self-study	• Assignments • Short Quizzes
2.0	Skills		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.1	To develop techniques of proof using categories and functors.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through exact sequences.	Self-study	Participations
2.3	To use Internet in searching for some categories of modules.	Deep problems	Short Quizzes
2.4	To carry out deep proofs in Homology Theory.	Self-study	Participations
3.0	Values		
3.1	To work with independence and responsibility.	Personal questions	Participation
3.2	To lead team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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:

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student can get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	M. Osborne , <i>Basic Homological Algebra</i> , GTM, Springer-Verlag 2000. (Main Reference)
Essential References Materials	• P. Hilton and U. Stammbach, <i>A course in Homological Algebra</i>, GTM, Springer-Verlag 1970. • J. Rotman, <i>An Introduction to Homological Algebra</i>, GTM, Springer-Verlag 2009.
Electronic Materials	None

Other Learning Materials	None
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2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each classroom should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Ordinary Differential Equations and Dynamical Systems
Course Code:	MAT 7233
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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1.Learning Resources	6
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G. Course Quality Evaluation	6
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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course deals with the mathematical structure of differential equations. It covers the abstract theory of ordinary differential equations aiming at understanding some mathematical models. More precisely it deals with the study of well-posedness, existence of solution(s), and uniqueness. Of particular interest is to know how to find and/or compute solutions and to provide methods of solvability. The theory is extended to linear systems of differential equations as well as to Hamiltonian systems. Finally a qualitative study is given with regards to the questions of stability and behavior of solutions. Methods such as Lyapunov Direct method are employed to identify, analyze, and interpret the asymptotic behavior of solutions.

2. Course Main Objective

This course provides a deep exposition of the theory of ordinary differential equations (ODEs) and systems of ODEs. It strongly focuses on theoretical, analytical techniques, and their applications. The interests of this course include

existence, uniqueness, stability, and behavior of linear and nonlinear ODEs as well as systems of ODEs. This course could form the basis for further courses on partial differential equations, dynamical systems, bifurcation theory, mathematical modeling, and related topics.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To name the fundamentals of the operator and spectral theories.	K1, K2
1.2	To describe the weak topology and weak and weak* convergence.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in differential inequalities.	S1, S2
2.2	To develop oral communication and technical writing skills through existence theory in ODEs.	S3
2.3	To use Internet in searching for examples of systems of ODEs.	S4
2.4	To carry out deep short proofs in dynamical systems.	S1, S2
3	Values:	
3.1	To execute his class duties with independence and responsibility.	V1, V3
3.2	To lead team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Ordinary differential equations: Grownwall's inequality, existence of solutions via Picard-Lindelöf theorem and Cauchy-Peano theorem; global properties of solutions; Analytic differential equations and dependence on initial conditions and parameters; examples of non-uniqueness; the Kneser theorem; Solution curves, maximal and minimal solutions; comparison theorem; sufficient conditions for uniqueness.	24
2	Systems of ODEs: Fundamental solutions, matrix exponent, solutions of linear systems with constant coefficients; linear systems with periodic coefficients; Floquet's theorem; linear Hamiltonian systems	24
3	Dynamical Systems: Stability of dynamical systems, Lyapunov functions, stability of linear and perturbed linear systems, Lyapunov's direct method, asymptotic behavior and stability, stability of periodic orbits, Poincare-Bendixon Theorem.	24
Total		72

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	To name the fundamentals of the operator and spectral theories.	• 4 lecture hours\week	• Regular Exams
1.2	To describe the weak topology and weak and weak* convergence.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.0	Skills		
2.1	To develop techniques of proof in differential inequalities.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through existence theory in ODEs.	Self-study	Participations
2.3	To use Internet in searching for examples of systems of ODEs.	Deep problems	Short Quizzes
2.4	To carry out deep short proofs in dynamical systems.	Self-study	Participations
3.0	Values		
3.1	To execute his class duties with independence and responsibility.	Personal questions	Participation
3.2	To lead team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

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E. Student Academic Counseling and Support

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

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	a. P. Hasieh & Y. Sibuya, <i>Basic Theory of Ordinary Differential Equations</i>. Universitext. Springer-Verlag, New York, 1999 (Main reference) b. L. Perko, <i>Differential Equations and Dynamical Systems; Texts in Applied Mathematics</i>, vol. 7, Springer, 3rd Edition, 2001. c. M.W. Hirsch, S. Smale, and R.L. Devaney, <i>Differential Equations, Dynamical Systems, and Introduction to Chaos</i>; Academic Press, Elsevier, 3rd Edition, 2013
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	d. F. Brauer & J. Nohel, The Qualitative Theory of ODE: An Introduction, Dover Publications, 1989. e. A. Coddington & N. Levinson, Theory of Ordinary Differential Equation. McGraw-Hill, 1984
Essential References Materials	W. Water, Ordinary Differential Equations, Graduate Texts in Mathematics, Springer-Verlag, New York, 1998. K. Schmitt & R. Thompson, Nonlinear Analysis and Differential Equations, 2004.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
		Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Integral Equations
Course Code:	MAT 7235
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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E. Student Academic Counseling and Support	5
F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course 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.

2. Course Main Objective

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.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To name some new tools that are useful in answering deep questions in integral equations.	K1, K2
1.2	To list problems that are can be treated by classical methods and specific techniques.	K1, K2

CLOs		Aligned PLOs
2	Skills:	
2.1	To develop techniques of proof of solvability of linear equations.	S1, S2
2.2	To develop oral communication and technical writing skills through transformation of ODEs in integral equations.	S3
2.3	To use Internet in searching for classification of integral equations.	S4
2.4	To carry out deep proofs of existence of solutions to integral equations.	S1, S2
3	Values:	
3.1	To work with independence and responsibility.	V1, V3
3.2	To work in groups.	V1, V2

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 Integro - Differential Equations, Converting Volterra Equation to an ODE and Vice-Versa, Converting BVP to Fredholm Equation.	8
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.	12
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.	12
6	Integro-differential equations: Introduction - Volterra integro-differential equations - The series solution method-The	10

	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	
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.	10
Total		72

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	To name some new tools that are useful in answering deep questions in integral equations.	• 4 lecture hours\week	• Regular Exams
1.2	To list problems that are can be treated by classical methods and specific techniques.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof of solvability of linear equations.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through transformation of ODEs in integral equations.	Self-study	Participations
2.3	To use Internet in searching for classification of integral equations.	Deep problems	Short Quizzes
2.4	To carry out deep proofs of existence of solutions to integral equations.	Self-study	Participations
3.0	Values		
3.1	To work with independence and responsibility.	Personal questions	Participation
3.2	To work in groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).

- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	<i>A.M. Wazwaz, Linear and Nonlinear Integral Equations, Springer-Verlag Berlin Heidelberg, 2011.</i>
Essential References Materials	<i>1. A.J. Jerri, Introduction to Integral Equations with Applications, John Wiley and Sons, 2nd Edition, 1999.</i> <i>2. M. Rahman, Integral Equations and Their Applications, WIT Press, 2007.</i>
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

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

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2. Facilities Required.....	6
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H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course 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.

2. Course Main Objective

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.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To name some convenient fixed-point techniques.	K1, K2
1.2	To list different types of nonlinear problems that require fixed point formulation in special functional space framework.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in existence via fixed point theory.	S1, S2
2.2	To develop oral communication and technical writing skills through applications of fixed point theorems.	S3
2.3	To use Internet in searching for applications of main fixed point theorems.	S4
2.4	To demonstrate deep proofs in the solvability of IVPs and BVPs.	S1, S2
3	Values:	
3.1	To work with independence and responsibility.	V1, V3
3.2	To collaborate with team works.	V1, V2

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.	15
2	The finite-dimensional case: Brouwer's Fixed Point Theorem and Applications: the Domain Invariance Theorem, Hartmann-Stampacchia Theorem, Perron-Frobenius Theorem, Poincare-Bohl Theorem.	14
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.	14
4	The Krasnosel'skii fixed point theorem: The Cone Expansion and Compression in a Banach Space. The Krasnosel'skii Fixed Point Theorem for the Sum of Nonlinear Operators (Compact and Contraction mappings) and some Extensions.	14
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		72

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	To name some convenient fixed-point techniques.	• 4 lecture hours\week	• Regular Exams
1.2	To list different types of nonlinear problems that require fixed point formulation in special functional space framework.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in existence via fixed point theory.	Self-study	Participations
2.2	To develop oral communication and technical writing skills through applications of fixed point theorems.	Self-study	Participations
2.3	To use Internet in searching for applications of main fixed point theorems.	Deep problems	Short Quizzes
2.4	To demonstrate deep proofs in the solvability of IVPs and BVPs.	Deep problems	Short Quizzes
3.0	Values		
3.1	To work with independence and responsibility.	Personal questions	Participation
3.2	To collaborate with team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	K.C. Chang, <i>Methods in Nonlinear Analysis</i>; Springer, Berlin, 2005.
Essential References Materials	• P. Drakek and J. Minolta, <i>Methods of Nonlinear Analysis</i>; Birkhauser, Springer, Basel, 2013 • Granas and J. Dugundji, <i>Fixed Point Theory</i>, Springer Monographs in Mathematics, Springer, 2003. • E. Zeidler, <i>Nonlinear Functional Analysis and its Applications. Vol. I: Fixed Point Theorems</i>; Springer-Verlag, New-York, 2013.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Calculus of Variations
Course Code:	MAT 7239
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the most important techniques and theoretical results in the calculus of variations: existence and regularity of minimizers and critical point theorems, coercivity, lower semi-continuity, convexity, and weak solutions. As applications, Euler-Lagrange formulation for minimization integral problems will be investigated. The stress will be put on the physical origin of the problems such that minimal surface problems, stationary values of integrals, problems governing the equilibrium states of physical systems.

2. Course Main Objective

This course presents one of the more important methods in nonlinear analysis, namely the variational method. The basic tools and the main theorems will be detailed. A particular attention will be paid to applications: solvability of some boundary value problems for ordinary and partial differential equations as well as some nonlinear integral equations. So the course aims at familiarizing students with the basic techniques used in the calculus of variations emphasizing on variational approaches commonly used to handle some concrete mathematical problems from physics and engineering, nonlinear elasticity, mechanics, ...

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To outline the main classical and recent techniques in the calculus of variation.	K1, K2
1.2	To state the fundamental notions and concepts commonly used in the calculus of variations.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in calculus of Variations.	S1, S2
2.2	To develop oral communication and technical writing skills through existence of minimizers.	S3
2.3	To use Internet in searching for different types of convergences.	S4
2.4	To carry out deep proofs in the solvability of some nonlinear equations.	S1, S2
3	Values:	
3.1	To execute assignments and homework's with independence and responsibility.	V1, V3
3.2	To lead work groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Differential Calculus in Banach spaces: Gateaux and Frechet Derivatives; Potential Operators, and Integral Representation.	12
2	Main concepts: Homogeneity, Lower Semi-continuity, Convexity, Coercivity	12
3	Direct Methods of the Calculus of Variations: Existence of Minimizers for Linear and Nonlinear Functionals; Weak Solutions of Euler-Lagrange Equations in Sobolev Spaces	12
4	Minimax methods in critical point theory: Ekeland's Variational Principle (Strong and Weak Formulations); Deformation Lemmas, Ambrosetti-Rabinowitz Mountain Pass Theorem.	12
5	Relaxation and quasi-convexity: Gamma Convergence, Young's Measures, and Singular Perturbation.	12
6	Solvability of nonlinear equations in Hilbert spaces: Nonlinear Integral Equations, Semi-Linear Elliptic PDEs, Nonlinear Eigenvalue Problems, and p-Laplacian Problems.	12
Total		72

6

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	To outline the main classical and recent techniques in the calculus of variation.	• 4 lecture hours/week	• Regular Exams

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.2	To state the fundamental notions and concepts commonly used in the calculus of variations.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in calculus of Variations.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through existence of minimizers.	Self-study	Participations
2.3	To use Internet in searching for different types of convergences.	Deep problems	Short Quizzes
2.4	To carry out deep proofs in the solvability of some nonlinear equations.	Self-study	Participations
3.0	Values		
3.1	To execute assignments and homework's with independence and responsibility.	Personal questions	Participation
3.2	To lead work groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	B. Dacorogna, <i>Introduction to the Calculus of Variations</i> ; Imperial College Press, London, 2004.
Essential References Materials	• D. Motreanu, V.V. Motreanu, and N. Papageorgiou, <i>Topological and Variational Methods With Applications To Nonlinear Boundary Value Problems</i>, Springer, 2014.

	• L.C. Evans, <i>Partial Differential Equations; Graduate Studies In Mathematics</i>, Providences, RI, 2010.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Spectral Methods
Course Code:	MAT 7243
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
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G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 1 Lab, 1 Tutorial)		
2. Course type			
a.	University ☐	College ☐	Department ☒
b.	Required ☐	Elective ☒	Others ☐
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2		
4. Pre-requisites for this course (if any):	None		
5. Co-requisites for this course (if any):	None		

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	12
3	Seminars	0
4	Tutorials	12
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This is an introductory course on spectral methods for solving both ordinary and partial differential equations (ODEs, PDEs) and addresses graduate students who are interested in numerical methods. Some basic theoretical results on spectral approximations with practical algorithms for implementing spectral methods are presented. The course specially emphasizes on how to design efficient and accurate spectral algorithms on different geometry for solving PDEs of current interest.

2. Course Main Objective

The objectives of the course are essentially twofold: first, provide and help the students to understand the essential of the advanced mathematical foundations for any classical numerical methods, and, secondly, introduce students to spectral methods and related computer algorithms. The course also allows to show that how spectral methods can be used in different applications and settings for both differential and partial differential equations. The emphasis will be both theoretical aspects, such as error and stability analysis, as well as certain implementation issues. The presented methods will be illustrated using well-known PDEs from mathematical physics.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To list spectral methods for a given problem.	K1, K2
1.2	To write suitable computer program/code to solve a given problem.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in the collocation methods.	S1, S2
2.2	To develop oral communication and technical writing skills through spectral-Galerkin Methods.	S3
2.3	To use Internet in searching for more spectral-Galerkin Methods.	S4
2.4	To demonstrate deep proofs in using different spectral methods.	S1, S2
3	Values:	
3.1	To work individually.	V1, V3
3.2	To work in groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Spectral-Collocation Methods: Differentiation Matrices for Fourier Collocation Methods, Differentiation Matrices for Polynomial Basis Functions, Fourier Collocation Method for PDEs, Review on Time Discretization Methods, Chebyshev Collocation Methods, Legendre Collocation Method, Collocation Methods in Weak Form.	18
2	Spectral-Galerkin Methods: Introduction and General Set Up, Fourier Spectral and Pseudo-spectral Method, Legendre-Galerkin Method, Chebyshev-Galerkin Method, Iterative Methods and Pre-Conditioning, Spectral-Galerkin for Higher Order Equations, Error Estimates	18
3	Spectral Methods in Unbounded Domains: Hermite Spectral Methods, Laguerre Spectral Methods, Spectral Methods with Rational Functions	9
4	Spectral Methods in Multi-Dimensional Domains (optional if time allow): Spectral-Collocation in Rectangular Domains, Spectral-Galerkin in Rectangular Domains, Fast Poisson Solver	9
5	Applications: Spectral Methods for Wave Equation, Spectral Approximation of Stokes Equations Spectral Approximation of Navier-Stokes Equations	18
Total		72

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	To list spectral methods for a given problem.	• 4 lecture hours/week	• Regular Exams

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.2	To write suitable computer program/code to solve a given problem.	• 1 tutorial hour\week • 1 lab hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in the collocation methods.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through spectral-Galerkin Methods.	Self-study	Participations
2.3	To use Internet in searching for more spectral-Galerkin Methods.	Deep problems	Short Quizzes
2.4	To demonstrate deep proofs in using different spectral methods.	Self-study	Participations
3.0	Values		
3.1	To work individually.	Personal questions	Participation
3.2	To work in groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
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E. Student Academic Counseling and Support

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

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	Jie Shen and Tao Tang, Spectral and High-Order Methods with Applications; Science Press, China, 2006.
Essential References Materials	• Lloyd N. Trefethen, <i>Spectral Methods in Matlab</i>, SIAM, USA, 2000

	• C Canuto et al., <i>Spectral Methods, Fundamentals in Single Domains</i>, Springer-Verlag, Berlin, 2006 (Can be found as electronic resource at NUS central library.) • C Canuto et al., <i>Spectral Methods, Evolution to Complex Geometries and Applications to Fluid Dynamics</i>, Springer-Verlag, Berlin, 2007.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
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	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Numerical Optimization
Course Code:	MAT 7245
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)		
2. Course type			
a.	University ☐	College ☐	Department ☒
b.	Required ☐	Elective ☒	Others ☐
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2		
4. Pre-requisites for this course (if any):	None		
5. Co-requisites for this course (if any):	None		

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes an important part of mathematics used to solve minimization problems. In this course fundamentals in optimization are developed and Matlab programming is handled. Theoretical and numerical aspects will be both considered.

2. Course Main Objective

The objective of this course is to provide a good understanding on constrained and unconstrained optimization in one and several dimension spaces. For nonlinear problems. Convex problems will also be considered. In addition, the course helps to perform some algorithms and codes in order to deepen programming and numerical analysis. MATLAB software will be handled.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To recognize mathematical modeling and operations research techniques	K1, K2
1.2	To record complex problems that require making decisions in situations of complex and uncertain nature.	K1, K2
2	Skills:	

CLOs		Aligned PLOs
2.1	To develop techniques of proof in univariate optimization.	S1, S2
2.2	To develop oral communication and technical writing skills through techniques in constrained and Unconstrained multivariate Optimization	S3
2.3	To use Internet in searching for Gradient methods.	S4
2.4	To carry out deep proofs in linear and nonlinear optimization.	S1, S2
3	Values:	
3.1	To execute his assignments and homework's with independence.	V1, V3
3.2	To lead team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Univariate Optimization: Introduction (local and global minima, Necessary condition, etc.), Dichotomous search, Fibonacci search, Golden section search, Newton's and secant methods, remarks on line search methods. Quadratic and cubic interpolations, Algorithm of Davies, Swann and Campey, Inexact line Searches	20
2	Unconstrained multivariate Optimization: Gradient methods: Steepest-Descent Method, Newton Method, Gauss-Newton Method, Conjugate-direction methods: Conjugate Directions, Basic Conjugate-Directions Method, Conjugate-Gradient Method, Minimization of Nonquadratic Functions, Fletcher-Reeves Method, Powell's Method, Partan Method. Minimax methods: Problem Formulation, Minimax Algorithms, Improved Minimax Algorithms. Quasi- Newton methods Rank-One Method, Davidon-Fletcher-Powell Method, The Broyden Family	24
3	Constrained multivariate Optimization: Fundamentals of constrained optimization: Lagrange Multipliers, First-Order Necessary Conditions, Second-Order Conditions, Convexity, Duality, Quadratic and convex programming: Convex QP Problems with Constrained multivariate Optimization: Fundamentals of constrained optimization: Lagrange Multipliers, First-Order Necessary Conditions, Second-Order Conditions, Convexity, Duality, Quadratic and convex programming: Convex QP Problems with Equality Constraints, Interior-Point Methods for Convex QP Problems, Cutting-Plane Methods for CP Problems, Semidefinite and second-order cone programming: Primal and Dual SDP Problems, Primal-Dual Path-Following Method, Predictor-Corrector Method, Projective Method of Nemirovski and Gahinet, Second-Order Cone Programming. General nonlinear optimization problems: Sequential Quadratic Programming Methods, Modified SQP Algorithms, Interior-Point Methods	28
Total		72

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		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
1.1	To develop techniques of proof in univariate optimization.	• 4 lecture hours\week	• Regular Exams
1.2	To develop oral communication and technical writing skills through techniques in constrained and Unconstrained multivariate Optimization	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in univariate optimization.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through techniques in constrained and Unconstrained multivariate Optimization	Self-study	Participations
2.3	To use Internet in searching for Gradient methods.	Deep problems	Short Quizzes
2.4	To carry out deep proofs in linear and nonlinear optimization.	Self-study	Participations
3.0	Values		
3.1	To execute his assignments and homework's with independence.	Personal questions	Participation
3.2	To lead team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	- Andreas Antoniou, Wu-Sheng Lu, PRACTICAL OPTIMIZATION Algorithms and Engineering Application, Springer, 2007 J. Nocedal and S. J. Wright, <i>Numerical Optimization</i>; Springer, 2nd Ed. 2006.
Essential References Materials	N. Gould and S. Leyffer, <i>An Introduction to Algorithms for Nonlinear Optimization</i>; Springer 2003. S. Chandra, Jayadev and Aparna Mehra, <i>Numerical Optimization with Applications</i>, Alpha Science Intl Ltd; 1st Ed., 2009.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Approximation Theory
Course Code:	MAT 7247
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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1.Learning Resources	6
2. Facilities Required.....	6
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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)			
2. Course type				
a.	University ☐	College ☐	Department ☒	Others ☐
b.	Required ☐	Elective ☒		
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2			
4. Pre-requisites for this course (if any):	None			
5. Co-requisites for this course (if any):	None			

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description:

Approximation Theory is concerned with approximating functions into more simple building blocks, such as polynomials, Splines, Wavelets, or other special functions. The primary focus is analyzing how properties, such as smoothness or variation, of the function govern the rates of convergence of the approximating classes of functions. The efficient solutions of such problems are of great importance for computing, and this module will introduce the mathematical theory behind many approximation methods in common use.

2. Course Main Objective

The course has been designed to emphasize the theory of approximation theory which serves either directly as the basis for much of numerical analysis or at the very least enters in a critical way in its development. The primary goal of the discipline is to approximate functions by simpler functions with interesting properties, e.g. by polynomials, splines, etc. This course also covers the necessary background for study in modern topics in pure and applied mathematics, which include Lagrange and Hermite Interpolation, Approximation of Linear Equations, Polynomials Approximation, Least Squares Approximation, Rational Approximation, Cubic and B-Splines.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To record some theories and concepts used in approximation theory.	K1, K2
1.2	To outline the fundamental methods and theoretical basis of approximation theory.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in interpolation and approximations.	S1, S2
2.2	To develop oral communication and technical writing skills through error analysis and best approximations.	S3
2.3	To use Internet in searching for some algorithms.	S4
2.4	To carry out deep proofs when using B-splines	S1, S2
3	Values:	
3.1	To work independently.	V1, V3
3.2	To work with collaboration and cooperation.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Polynomial interpolation: The Lagrange Interpolation. The error in Polynomial Interpolation. The norm of the Lagrange Interpolation Operator. Hermite Interpolation.	7
2	The uniqueness of best approximations: Convexity Conditions. Conditions For the Uniqueness of Best Approximation. The Continuity of Approximation Operators. The L_1 , L_2 , L_∞ - Norms.	7
3	Polynomial interpolation: The Lagrange Interpolation. The error in Polynomial Interpolation. The norm of the Lagrange Interpolation Operator. Hermite Interpolation.	9
4	Approximate Solution of Over-Determined System of Linear Equations: Chebyshev Solution of Linear Equations. Systems of Equations with one Unknown. Characterization of the Solution. The Special Cases, Polya's Algorithm. The Descent Algorithm. Convex Programming.	9
5	Least-Squares Approximation and related topics: Inner Products. Various Orthogonal Systems. Orthogonal Systems of Polynomials. Convergence of Orthogonal Expansion. Approximation by Series of Chebyshev Polynomials. Discrete Least Squares Approximation. Jackson Theorems.	10
6	Rational Approximation: Conversion of rational functions to continued fractions. Existence of best rational approximation. Characterization of best approximation. Uniqueness; Continuity of best approximation operators Algorithms. Padé approximation and its generalizations. Continued fractions.	10
7	Interpolation by piecewise polynomials: Local Interpolation methods. Cubic spline interpolation. End condition for Cubic Splines Interpolation. Interpolating Splines of Other Degrees.	10

8	B-Splines: The Parameters of a Spline Function. The Form of B-Splines. B-Splines as basic Functions. A Recurrence Relation for B-Splines. The Schoenberg-Whitney Theorem. Convergence Properties of Spline Approximation.	10
Total		72

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	To record some theories and concepts used in approximation theory.	• 4 lecture hours\week	• Regular Exams
1.2	To outline the fundamental methods and theoretical basis of approximation theory.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in interpolation and approximations.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through error analysis and best approximations.	Self-study	Participations
2.3	To use Internet in searching for some algorithms.	Self-study	Participations
2.4	To carry out deep proofs when using B-splines	Deep problems	Short Quizzes
3.0	Values		
3.1	To work independently.	Personal questions	Participation
3.2	To work with collaboration and cooperation.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.

- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	N.I. Achieser, <i>Theory of Approximations</i> , Dover, NY, 1992 (2004).
Essential References Materials	• M.J.D. Powell, <i>Approximation Theory and Methods</i>, Cambridge 1981. • E. W. Cheney, <i>An Introduction to Approximation Theory</i>, McGraw-Hill, 1966.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Combinatorics
Course Code:	MAT 7251
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description:

Topics in combinatorics will be covered. They include Techniques in counting, Inclusion-exclusion principle, Stirling Numbers, Group Class Equation and Cycle Index Theorem, Burnside's Lemma, Identities and Expansions, General and Multivariate Generating Functions, Recurrence Relations, Partitions of Integers, Ramsey's Theorem with Applications.

2. Course Main Objective

Combinatorics has many applications in sciences, e.g., in Computer Sciences, Probability and Operation Research. The objective of this course is to give a detailed knowledge within counting techniques, Striling numbers, Burnside's Lemma and some other interesting topics in combinatorics.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To describe problems in mathematics and natural sciences using combinatorics.	K1, K2
1.2	To reproduce recurrence relations and generating functions.	K1, K2

CLOs		Aligned PLOs
2	Skills:	
2.1	To develop techniques of proof in counting and permutation methods.	S1, S2
2.2	To develop oral communication and technical writing skills through multivariate functions and recurrence relations.	S3
2.3	To use Internet in searching for some related identities.	S4
2.4	To demonstrate deep proofs of main theorems.	S1, S2
3	Values:	
3.1	To work independently.	V1, V3
3.2	To work in team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Counting and Inclusion Exclusion Principles. Real Factorials and Stirling's Formula, Stirling Numbers of First and Second Kinds.	21
2	Group Class Equation and Cycle Index Theorem, Counting by Permutation Methods. Burnside's Lemma, Identities and Expansions. General and Multivariate Generating Functions.	27
3	Recurrence Relations. Partitions of Integers, Ramsey's Theorem with Applications.	24
Total		72

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	To describe problems in mathematics and natural sciences using combinatorics.	• 4 lecture hours\week	• Regular Exams
1.2	To reproduce recurrence relations and generating functions.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in counting and permutation methods.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through multivariate functions and recurrence relations.	Self-study	Participations
2.3	To use Internet in searching for some related identities.	Deep problems	Short Quizzes
2.4	To demonstrate deep proofs of main theorems.	Self-study	Participations
3.0	Values		
3.1	To work independently.	Personal questions	Participation

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
3.2	To work in team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
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- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	C. Charalambides, <i>Enumerative Combinatorics</i> , Chapman and Hall/CRC, 2002.
Essential References Materials	• M. Aigner, <i>A Course in Enumeration</i>, Springer, 2007. • J. Van, R. Wilson, <i>A Course in Combinatorics</i>, Cambridge University Press, 2001. • R. Brualdi, <i>Introductory Combinatorics</i>, 5th Ed., Prentice-Hall, 2009.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.

Item	Resources
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
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Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Combinatorial Optimization
Course Code:	MAT 7253
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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E. Student Academic Counseling and Support	5
F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the most important ideas, theoretical results, and algorithms in combinatorial optimization. The course includes the essential fundamentals of graph theory, linear and integer programming, and complexity theory. It covers classical topics in combinatorial optimization as well as very recent ones. The emphasis is on theoretical results and algorithms with provably good performance. Applications and heuristics are mentioned only occasionally.

2. Course Main Objective

The objective of this course is to give a detailed knowledge within combinatorial optimization. Combinatorial (or discrete) optimization is one of the most active fields in the interface of operations research, computer science, and applied mathematics. This course covers classical optimization problems in graphs and networks, matching, integral polyhedral, the traveling salesman problem, an introduction to matroids and to NP-completeness theory.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	

CLOs		Aligned PLOs
1.1	To define mathematical modeling using discrete optimization.	K1, K2
1.2	To record operations research techniques for complex problems.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in combinatorial optimization.	S1, S2
2.2	To develop techniques of algorithms writing.	S3
2.3	To develop oral communication and technical writing skills through optimization problems.	S4
2.4	To use Internet in searching for real life related problems.	S1, S2
3	Values:	
3.1	To work with independence and responsibility.	V1, V3
3.2	To collaborate with team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Problems and Algorithms: Optimal Trees and Paths, Measuring Running Times, Minimum Spanning Trees, Shortest Paths; Maximum Flow Problems, Network Flows Problems, Maximum Flow Problems, Minimum Cut Problem, Multicommodity Flows; Minimum Cost Flow Problems.	12
2	Optimal Matchings: Matchings and Alternating Paths, Maximum Matchings, Minimum Weight Perfect Matchings, T-joins and Postman Problem.	12
3	Integral Polyhedra: Convex Hulls, Polytopes, Facets, Integral Polytopes, Total Unimodularity, Total Dual Integrality, Cutting Planes, Separation and Optimization.	12
4	The Traveling Salesman Problem: Introduction, Heuristics for the TSP, Lower Bounds, Cutting Planes, Branch and Bound.	12
5	Matroids: The Greedy Algorithm, Matroids Properties, Axioms, and Constructions, Matroids Intersection, Applications.	12
6	NP and NP-completeness: Introduction, Words, Problems, Algorithms and Running Time, The Class NP.	12
Total		72

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	To define mathematical modeling using discrete optimization.	• 4 lecture hours\week	• Regular Exams
1.2	To record operations research techniques for complex problems.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.1	To develop techniques of proof in combinatorial optimization.	Deep problems	Short Quizzes
2.2	To develop techniques of algorithms writing.	Deep problems	Short Quizzes
2.3	To develop oral communication and technical writing skills through optimization problems.	Self-study	Homework
2.4	To use Internet in searching for real life related problems.	Self-study	Homework
3.0	Values		
3.1	To work with independence and responsibility.	Personal questions	Participation
3.2	To collaborate with team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homework's, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	W. Cook, W. Cunningham, W. Pulleyblank, and A. Schrijver, <i>Combinatorial Optimization</i> ; Wiley-Blackwell, 1997.
Essential References Materials	• B. Korte, and J. Vygen, <i>Combinatorial Optimization</i>, Springer, 2012. • C. Papadimitriou and K. Steiglitz, <i>Combinatorial Optimization: Algorithms and Complexity</i>, Dover Publications Inc., 2000. • D.-Z. Du and P. M. Pardalos (editors), <i>Handbook of Combinatorial Optimization</i>, Kluwer Academic Publishers, 1999.

Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Graph Theory and Applications
Course Code:	MAT 7255
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)			
2. Course type				
a.	University ☐	College ☐	Department ☒	Others ☐
b.	Required ☐	Elective ☒		
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2			
4. Pre-requisites for this course (if any):	None			
5. Co-requisites for this course (if any):	None			

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the most important ideas, theoretical results, and algorithms in graphs theory. The course includes the essential fundamentals of graph theory and complexity theory. It covers classical topics in graphs theory as well as very recent ones. The emphasis is on theoretical results and algorithms with provably good performance. Applications are also mentioned.

2. Course Main Objective

The objective of this course is to give an advanced knowledge of graph theory. Graph theory is one of the most active fields in the interface of discrete mathematics, computer science, and applied mathematics. This course covers classical problems in graphs and networks with some applications.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To recognize graph theory techniques and applications.	K1, K2
1.2	To name some complex problems that require making decisions in situations of complex and uncertain nature.	K1, K2

CLOs		Aligned PLOs
2	Skills:	
2.1	To develop techniques of proof in Graph Theory.	S1, S2
2.2	To develop oral communication and technical writing skills through structures of graphs.	S3
2.3	To use Internet in searching for some real-life applications in networks.	S4
2.4	To carry out deep validity proofs of complex algorithms.	S1, S2
3	Values:	
3.1	To work with independence and responsibility.	V1, V3
3.2	To cooperate with team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Review of Graph Theory Basics: Graphs and Their Representation, Subgraphs, Graph Isomorphism, Graphs Arising from Other Structures, Constructing Graphs from Other Graphs, Directed Graphs.	15
2	Trees: Forests and Tress, Spanning Trees, Fundamental Cycles and Bonds, Cotrees, Matroids.	15
3	Nonseparable Graphs: Cut Vertices, Separation and Blocks, Ear Decompositions, Matroids and Nonseparability.	15
4	Flows in Networks: Transportation Networks, The Max-Flow Min-Cut Theorem, Multicommodity Flows.	15
5	Complexity of Algorithms: Computational Complexity, Polynomial Reductions, NP-Complete Problems, Approximation Algorithms, Greedy Heuristics, Isomorphism-Completeness.	12
Total		72

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	To recognize graph theory techniques and applications.	• 4 lecture hours\week	• Regular Exams
1.2	To name some complex problems that require making decisions in situations of complex and uncertain nature.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in Graph Theory.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through structures of graphs.	Self-study	Participations

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.3	To use Internet in searching for some real-life applications in networks.	Self-study	Homework
2.4	To carry out deep validity proofs of complex algorithms.	Deep problems	Short Quizzes
3.0	Values		
3.1	To work with independence and responsibility.	Personal questions	Participation
3.2	To cooperate with team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	J. A. Bondy and U. S. R. Murty, <i>Graph Theory</i> ; 1 st edition, Springer Verlag, 2008.
Essential References Materials	• R. J. Wilson, <i>Introduction to Graph Theory</i>; 4th edition, Pearson Education, 2003. • J. L. Gross, J. Yellen, and P. Zhang (editors), <i>Handbook of Graph Theory</i>; 2nd edition, Chapman and Hall/CRC, 2013. • D.-Z. Du and P. M. Pardalos (editors), <i>Handbook of Combinatorial Optimization</i>, Kluwer Academic Publishers, 1999.
Electronic Materials	None

Other Learning Materials	None
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2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Mathematical Fluid Mechanics
Course Code:	MAT 7266
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

Without fluid motion on Earth, life could not be existed. For example, blood moves through the vessels in our bodies and air flows into our lungs, we simply cannot live without air and water. Beside nowadays fluid mechanics is an essential part of the comprehensive design and manufacture of nearly all modern machinery, structures, and devices. This course is a graduate course on the mathematical modelling of fluid mechanics which is a central theme in modern applied mathematics. Specifically for incompressible fluids, we use the techniques from functional analysis, the analysis of partial differential equations and model the fluid flow.

2. Course Main Objective

The objective of this course is to study the mathematical theory for some essential advances topics in fluid mechanics. In particular, the aim is to introduce tensors, elements of tensor algebra, derive governing momentum and energy equation for Newtonian fluid then introduce the Fourier transform and Galerkin Truncations for existence of the weak solution of Navier Stokes Equations (NSE).

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To describe momentum and energy equation for viscous flow and Navier- Stokes equations.	K1, K2
1.2	To state Galerkin approximation and weak solution concept.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in Tensor Calculus.	S1, S2
2.2	To develop oral communication and technical writing skills through evaluation of Energy Equations.	S3
2.3	To use Internet in searching for some fluid model equations.	S4
2.4	To demonstrate proofs of convergence of Galerkin approximation.	S1, S2
3	Values:	
3.1	To work independently.	V1, V3
3.2	To work in team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Vectors, Tensors, and Operators; Convective Derivatives and Conservation Equations; Boundary Conditions for Momentum Equation and Projection Formulation, Evaluation of Energy Equation and Vorticity.	15
2	Introduction to Viscous Fluids (Newtonian Fluid); Navier-Stokes Equation; Boussinesq Approximation.	11
3	Boundary Conditions, and Rayleigh-Benard Convection; Lorenz Equation.	11
4	Incompressible Navier-Stokes and Plane Couette Flow; Stability Plane Couette Flow; Computational Study for Stability of Plane Couette Flow.	13
5	Navier-Stokes Equations in Fourier Space and Galerkin Truncations.	11
6	Convergence of Galerkin Approximations and Weak Solution of NSE (Navier Stokes Equations).	11
Total		72

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	To describe momentum and energy equation for viscous flow and Navier- Stokes equations.	• 4 lecture hours/week • 2 tutorial hour/week • Self-study	• Regular Exams • Assignments • Short Quizzes
1.2	To state Galerkin approximation and weak solution concept.		
2.0	Skills		
2.1	To develop techniques of proof in Tensor Calculus.	Deep problems	Short Quizzes

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.2	To develop oral communication and technical writing skills through evaluation of Energy Equations.	Self-study	Participations
2.3	To use Internet in searching for some model equations.	Deep problems	Short Quizzes
2.4	To demonstrate proofs of convergence of Galerkin approximation.	Self-study	Participations
3.0	Values		
3.1	To work independently.	Personal questions	Participation
3.2	To work in team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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:

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student can get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	C. Doering, and J.D. Gibbon, <i>Applied Analysis of The Navier-Stokes Equations</i> , Cambridge University Press, 1995. (Main Reference)
Essential References Materials	• A.J. Majda and A.L. Bertozzi, <i>Vorticity and Incompressible Flow</i>, Cambridge University Press, 2002. • Chorin, and J.E. Marsden, <i>A Mathematical Introduction to Fluid Mechanics</i>, Springer, 3rd Edition, 1993. • J. Robinson, <i>Infinite-Dimensional Dynamical Systems</i>, Cambridge University Press, 2001. • R. Temam, <i>Navier-Stokes equations. Theory and numerical analysis</i>. Reprint of the 1984 edition. AMS Chelsea Publishing, Providence, RI, 2001.

	• H. Sohr, <i>The Navier-Stokes equations. An elementary functional analytic approach</i>. [2013 reprint of the 2001 original]. Modern Birkhuser Classics.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each classroom should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio. Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.
	Course Responsible	

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Algebraic Topology
Course Code:	MAT 7271
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

The course first recalls compactness, complete metric spaces, and function spaces together with some applications to some fundamental theorems. Then the basic notions of Algebraic Topology are presented in detail with application to Fundamental Groups of classical surfaces. Finally, the relative and singular homologies are introduced together with homology groups.

2. Course Main Objective

The objective of this course is to give a detailed knowledge of point set algebra and the basic notions of Algebraic Topology: The Fundamental Groups and the Fundamental Theorem of Algebra. Homotopy and Homology Theories are also investigated.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To record some fundamental groups and Homology groups.	K1, K2
1.2	To recognize the basic concepts and applications of Algebraic Topology.	K1, K2

CLOs		Aligned PLOs
2	Skills:	
2.1	To develop techniques of proof in Topology and Homotopy Theory.	S1, S2
2.2	To develop oral communication and technical writing skills through computations of some homotopy groups.	S3
2.3	To use Internet in searching for some homotopy groups of spaces.	S4
2.4	To carry out proofs in singular homology.	S1, S2
3	Values:	
3.1	To work individually.	V1, V3
3.2	To work in groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Review of Basics, Local Finiteness and Metrization Theorems, Paracompactness.	8
2	Complete Metric Spaces and Function Spaces, Compact Convergence, Arzela-Ascoli Theorem and Baire Category Theorem.	8
3	Review of Basic Homotopy Theory, The Fundamental Theorem of Algebra and Borsuk-Ulam Theorem, Seifert-Van Kampen Theorem.	14
4	Manipulations of Fundamental Groups of (Projective Plane, Punctured Plane, Torus and Double Torus).	14
5	Singular Homology Theory, Homotopy Invariance of Homology, Relation Between Homotopy Groups and Homology Groups	14
6	Relative Homology, Exact Homology Sequence, The Excision Theorem, Mayer-Vietoris Sequence.	14
Total		72

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	To record some fundamental groups and Homology groups.	• 4 lecture hours/week	• Regular Exams
1.2	To recognize the basic concepts and application of Algebraic Topology.	• 2 tutorial hour/week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in Topology and Homotopy Theory.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through computations of some homotopy groups.	Self-study	Participations
2.3	To use Internet in searching for some homotopy groups of spaces.	Deep problems	Short Quizzes

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
2.4	To carry out proofs in singular homology.	Self-study	Participations
3.0	Values		
3.1	To work individually.	Personal questions	Participation
3.2	To work in groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student can get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	J. Munkres; Topology, Prentice-Hall 2000. (Main Reference)
Essential References Materials	• M. Greenburg & J. Harper, <i>Algebraic Topology</i>, Benjamin/Cummings 1981. • G. McCarty; <i>Topology</i>, Dover 2003.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each classroom should be equipped with a whiteboard and a projector.

Item	Resources
	Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Algebraic Geometry
Course Code:	MAT 7273
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the basic ideas of Affine and Projective Varieties, Coordinate Rings, Morphisms and Rational Maps, Local Ring of a point, Function Fields, Dimension of a Variety. Also, the course discusses Singular Points and Tangent Lines, Multiplicities and Local Rings, Intersection Multiplicities, Bezout's Theorem for plane curves, Max Noether's Theorem and Applications, Group Operation on Cubic Curve, rational Parametrization, Branches and Valuations.

2. Course Main Objective

The objective of this course is to give a detailed knowledge of Varieties, Dimension of a Variety, Curves, Intersection multiplicities, Bezout's Theorem, Max Noether's Theorem, and Rational Parametrization.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To list the basic concepts and applications of algebraic Geometry	K1, K2

CLOs		Aligned PLOs
1.2	To record Bezout's Theorem for plane curves, Max Noether's Theorem, Group Operation on cubic Curve.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in algebraic geometry.	S1, S2
2.2	To develop oral communication and technical writing skills through function fields and varieties.	S3
2.3	To use Internet in searching for singular points of curves.	S4
2.4	To demonstrate proofs of main theorems.	S1, S2
3	Values:	
3.1	To work with independence.	V1, V3
3.2	To work in team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	- Varieties: Affine and Projective Varieties. - Coordinate Rings, Morphisms and Rational Maps, Local Ring of a point.	24
2	- Function Fields, Dimension of a Variety. - Curves: Singular Points and Tangent Lines, Multiplicities and Local Rings.	24
3	- Bezout's Theorem for plane curves, Max Noether's Theorem and Applications. - Group Operation on Cubic Curve, Rational Parametrization, Branches and Valuations.	24
Total		72

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	To list the basic concepts and applications of algebraic Geometry	• 4 lecture hours\week	• Regular Exams
1.2	To record Bezout's Theorem for plane curves, Max Noether's Theorem, Group Operation on cubic Curve.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in algebraic geometry.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through function fields and varieties.	Self-study	Participations
2.3	To use Internet in searching for singular points of curves.	Deep problems	Short Quizzes
2.4	To demonstrate proofs of main theorems.	Self-study	Participations

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
3.0	Values		
3.1	To work with independence.	Personal questions	Participation
3.2	To work in team works.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	R. Walker: <i>Algebraic Curves</i> , Springer-Verlag 2013.
Essential References Materials	• E. Kunz, <i>Introduction to Plane Algebraic Curves</i>, Birkhauser 2005. • W. Fulton, <i>Algebraic Curves</i>, The Benjamin/Cummings 1969.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.

Item	Resources
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Differential Geometry
Course Code:	MAT 7275
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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G. Course Quality Evaluation	6
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A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course describes the essential fundamentals concepts of the local theories of curves and surfaces in the three-dimensional space.

2. Course Main Objective

The objective of this course is to give a detailed knowledge in differential geometry. More precisely, the course is concerned with the geometry of curves and surfaces in three dimensional-spaces.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To list theories and concepts used in Differential Geometry.	K1, K2
1.2	To recognize the contribution and impacts of differential geometry in Real life problems.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in differential geometry.	S1, S2
2.2	To develop oral communication and technical writing skills through different manifolds.	S3

CLOs		Aligned PLOs
2.3	To use Internet in searching for examples of manifolds.	S4
2.4	To carry out deep proofs of the main theorems.	S1, S2
3	Values:	
3.1	To work individually.	V1, V3
3.2	To work in groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Theory of curves in space, Regular curves, Arc Length and reparametrization, natural parametrization.	14
2	Serret-Frenet apparatus, existence and uniqueness theorem for space curves.	10.5
3	Bertrand curves, Involutes, and evolutes.	10.5
4	Local theory of surfaces: Simple surfaces, coordinate transformations, tangent vectors and tangent spaces, First and second fundamental forms.	14
5	Normal and geodesic curvatures, Weingarten map, principal curvatures, Gaussian and mean curvatures.	13
6	Geodesics, equations of Gauss and Codazzi-Mainardi.	10
Total		72

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	To list theories and concepts used to explain new concepts in Differential Geometry.	4 lecture hours/week	Regular Exams
1.2	To recognize the contribution and the impacts of differential geometry in real life problem.	2 tutorial hour/week Self-study	Assignments Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in the Differential Geometry.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through writing and oral presentation of the theory.	Self-study	Participations
2.3	To use Internet in searching for results in connection with Differential Geometry.	Deep problems	Short Quizzes
2.4	To carry out deep and short proofs of the main theorems.	Self-study	Participations
3.0	Values		
3.1	To work individually.	Personal questions	Participation

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
3.2	To work in groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	R. S. Millman and G. D. Parker, Elements of Differential Geometry, Prentice-Hall, Englewood Cliffs, NJ, 1977.
Essential References Materials	• B. O'Neill, Elementary Differential Geometry, Academic Press Inc. 1966 • W. Kühnel; Differential Geometry: Curves – Surfaces – Manifolds; 2nd Edition, American Mathematical Society, 2004.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources	The rooms are equipped with data show and Smart Board.

Item	Resources
(AV, data show, Smart Board, software, etc.)	
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Introduction to Manifolds
Course Code:	MAT 7277
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

This course is devoted to differentiable manifolds with a stress on differential maps between them. Relevant topics that are discussed include submanifolds, the Inverse Function Theorem, the Embedding Theorem, Partition of Unity, Tangent Spaces, Tangent and Cotangent Bundles, Vector Fields, and Forms In Euclidean Spaces. The course considers the concepts of integration of differential forms, the exterior derivative, manifolds with boundary, the general Stokes' theorem, manifolds without boundary and the Gauss-Bonnet theorem.

2. Course Main Objective

The main objective of this course is to provide the student with a solid grounding in manifold theory which has many applications in differential geometry, geometric analysis, as well as in mathematical physics.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	To list new tools that are useful in answering deep questions in manifold theory.	K1, K2

CLOs		Aligned PLOs
1.2	To record problems that are easily treated by applying manifold methods.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in differential geometry.	S1, S2
2.2	To develop oral communication and technical writing skills through maps between manifolds.	S3
2.3	To use Internet in searching for examples of manifolds.	S4
2.4	To carry out deep proofs of main theorems.	S1, S2
3	Values:	
3.1	To work individually.	V1, V3
3.2	To work in groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Differentiation in $\mathbb{R}^n$, The inverse function theorem in $\mathbb{R}^n$, Submanifolds of $\mathbb{R}^n$.	14
2	Differentiable Manifolds: charts, atlases, and Examples.	14
3	Tangent space, Vector fields and flows.	10
4	Differentiable maps between manifolds, Immersions and Submersions, The inverse function theorem between manifolds.	14
5	Differential Forms, Integration over Manifolds, The General Stock's Theorem.	14
6	The Gauss-Bonnet Theorem.	5
Total		72

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	Record new tools that are useful in answering deep questions in manifold theory.	• 4 lecture hours\week	• Regular Exams
1.2	List problems that are easily treated by applying manifold methods.	• 2 tutorial hour\week • Self-study	• Assignments • Short Quizzes
2.0	Skills		
2.1	To develop techniques of proof in the corresponding subject.	Deep problems	Short Quizzes
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	Self-study	Participations
2.3	To use Internet in searching for scientific information	Deep problems	Short Quizzes
2.4	To carry out deep and not short proofs.	Self-study	Participations

Code	Course Learning Outcomes	Teaching Strategies	Assessment Methods
3.0	Values		
3.1	To work individually.	Personal questions	Participation
3.2	To work in groups.	Team work	Homework and Mini-projects

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- **Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).**
- **The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.**
- **Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.**
- **A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.**

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	D. Barden, <i>An Introduction to Differential Manifolds</i>, World Scientific, 2003.
Essential References Materials	• J.M. Lee, <i>Introduction to Smooth Manifolds</i>, Springer, 2003. • W. Boothby, <i>An introduction to differentiable manifolds and Riemannian Geometry</i>, Academic Press, 1975.
Electronic Materials	None
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.

Item	Resources
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Topics in Pure Mathematics (1)
Course Code:	MAT 7281
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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E. Student Academic Counseling and Support	5
F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

Specific to each course of study.

2. Course Main Objective

This course is designed to enable students to study different special topics of interest, which are carefully selected from pure mathematics topics. The course covers selected topics in mathematics suggested by the student's supervisor and approved by the chairman and the department council each time this course is offered.

The main objective is to learn topics those are not formally offered by the program and receive appropriate academic credit.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	Course dependent.	K1, K2
2	Skills:	

CLOs		Aligned PLOs
	Course dependent	S1, S2, S3, S4
3	Values:	
	Course dependent	V1, V2, V3

C. Course Content

No	List of Topics	Contact Hours
1	Specific to each course of study.	72
Total		72

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		
	Course dependent	Course dependent	Course dependent
2.0	Skills		
	Course dependent	Course dependent	Course dependent
3.0	Values		
	Course dependent	Course dependent	Course dependent

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	Course dependent
Essential References Materials	Course dependent
Electronic Materials	Course dependent
Other Learning Materials	Course dependent

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Topics in Applied Mathematics (1)
Course Code:	MAT 7283
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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E. Student Academic Counseling and Support	5
F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

Specific to each course of study.

2. Course Main Objective

This course is designed to enable students to study different special topics of interest, which are carefully selected from applied mathematics topics. The course covers selected topics in mathematics suggested by the student's supervisor and approved by the chairman and the department council each time this course is offered.

The main objective is to learn topics those are not formally offered by the program and receive appropriate academic credit.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	Course dependent.	K1, K2
2	Skills:	

CLOs		Aligned PLOs
	Course dependent	S1, S2, S3, S4
3	Values:	
	Course dependent	V1, V2, V3

C. Course Content

No	List of Topics	Contact Hours
1	Specific to each course of study.	72
Total		72

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		
	Course dependent	Course dependent	Course dependent
2.0	Skills		
	Course dependent	Course dependent	Course dependent
3.0	Values		
	Course dependent	Course dependent	Course dependent

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	Course dependent
Essential References Materials	Course dependent
Electronic Materials	Course dependent
Other Learning Materials	Course dependent

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Topics in Pure Mathematics (2)
Course Code:	MAT 7285
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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E. Student Academic Counseling and Support	5
F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

Specific to each course of study.

2. Course Main Objective

This course is designed to enable students to study different special topics of interest, which are carefully selected from pure mathematics topics. The course covers selected topics in mathematics suggested by the student's supervisor and approved by the chairman and the department council each time this course is offered.

The main objective is to learn topics those are not formally offered by the program and receive appropriate academic credit.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	Course dependent.	K1, K2
2	Skills:	

CLOs		Aligned PLOs
	Course dependent	S1, S2, S3, S4
3	Values:	
	Course dependent	V1, V2, V3

C. Course Content

No	List of Topics	Contact Hours
1	Specific to each course of study.	72
Total		72

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		
	Course dependent	Course dependent	Course dependent
2.0	Skills		
	Course dependent	Course dependent	Course dependent
3.0	Values		
	Course dependent	Course dependent	Course dependent

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homeworks, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	Course dependent
Essential References Materials	Course dependent
Electronic Materials	Course dependent
Other Learning Materials	Course dependent

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Topics in Applied Mathematics (2)
Course Code:	MAT 7287
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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2. Assessment Tasks for Students	5
E. Student Academic Counseling and Support	5
F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	5 (4 Lectures, 0 Lab, 2 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☐ Elective ☒
3. Level/year at which this course is offered:	Level 3-4 / Year 1-2
4. Pre-requisites for this course (if any):	None
5. Co-requisites for this course (if any):	None

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	72	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	24
5	Others (specify)	0
Total		72

B. Course Objectives and Learning Outcomes

1. Course Description

Specific to each course of study.

2. Course Main Objective

This course is designed to enable students to study different special topics of interest, which are carefully selected from applied mathematics topics. The course covers selected topics in mathematics suggested by the student's supervisor and approved by the chairman and the department council each time this course is offered.

The main objective is to learn topics those are not formally offered by the program and receive appropriate academic credit.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	Course dependent.	K1, K2
2	Skills:	

CLOs		Aligned PLOs
	Course dependent	S1, S2, S3, S4
3	Values:	
	Course dependent	V1, V2, V3

C. Course Content

No	List of Topics	Contact Hours
1	Specific to each course of study.	72
Total		72

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		
	Course dependent	Course dependent	Course dependent
2.0	Skills		
	Course dependent	Course dependent	Course dependent
3.0	Values		
	Course dependent	Course dependent	Course dependent

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	Homework's, Quizzes, Mini-projects	During the semester	30%
2	Midterm	Week 6-7	30%
4	Final Exam	Week 13	40%

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	Course dependent
Essential References Materials	Course dependent
Electronic Materials	Course dependent
Other Learning Materials	Course dependent

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	- Each class room should be equipped with a whiteboard and a projector. - Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Reading and Research (1)
Course Code:	MAT 7291
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	4 (4 Lectures, 0 Lab, 0 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered:	Level 5 / Year 2
4. Pre-requisites for this course (if any): None	
5. Co-requisites for this course (if any): None	

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	48	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	0
5	Others (specify)	0
Total		48

B. Course Objectives and Learning Outcomes

1. Course Description

This course introduces the student in reading and understanding research methods relevant to areas of future research works. The student reads very specialized articles and books and learns how to analyze research results. By the end of the course, the student should be able to present talks on the subject studied. Reading and research course is selected with the consent of supervisor or the graduate committee.

2. Course Main Objective

This course allows the student to work on a material not covered by any other PhD course. In addition, the course enables the student to be more acquainted with some new research topics in a specific field. The topic of the course is suggested by a supervisor in order for a qualified graduate student is prepared for his/her PhD research subject.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	Research subject dependent.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in the corresponding subject.	S1, S2
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	S4
2.3	To use Internet in searching for scientific information	S5
2.4	To carry out deep and not short proofs.	S3
3	Values:	
3.1	To work with independence and responsibility.	V1, V3
3.2	To collaborate with team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Independent research or course of study under the direction of a member of the faculty, which may include research for and preparation of a thesis.	48
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	Research subject dependent.	• 4 lecture hours/week • Self-study	Assignments
2.0	Skills		
2.1	To develop techniques of proof in the corresponding subject.	Deep problems	Presentations
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	Self-study	Participations
2.3	To use Internet in searching for scientific information	Self-study	Presentations
2.4	To carry out deep and not short proofs.	Deep problems	Participations
3.0	Values		
3.1	To work with independence and responsibility.	Personal questions	Presentations and discussions
3.2	To collaborate with team works.	Team work	Collaborations

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	None		

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	On the recommendation of supervisor or graduate committee.
Essential References Materials	On the recommendation of supervisor or graduate committee.
Electronic Materials	On the recommendation of supervisor or graduate committee.
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
		Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	Reading and Research (2)
Course Code:	MAT 7292
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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F. Learning Resources and Facilities.....	6
1.Learning Resources	6
2. Facilities Required.....	6
G. Course Quality Evaluation	6
H. Specification Approval Data	7

A. Course Identification

1. Credit hours:	4 (4 Lectures, 0 Lab, 0 Tutorial)
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered:	Level 6 / Year 2
4. Pre-requisites for this course (if any): None	
5. Co-requisites for this course (if any): None	

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	48	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	48
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	0
5	Others (specify)	0
Total		48

B. Course Objectives and Learning Outcomes

1. Course Description

This course introduces the student in reading and understanding research methods relevant to areas of future research works. The student reads very specialized articles and books and learns how to analyze research results. By the end of the course, the student should be able to present talks on the studied subject. Reading and research course is selected with the consent of supervisor or the graduate committee.

2. Course Main Objective

This course allows the student to work on a material not covered by any other PhD course. In addition, the course enables the student to be more acquainted with some new research topics in a specific field. The topic of the course is suggested by a supervisor in order for a qualified graduate student is prepared for his/her PhD research subject.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	Research subject dependent.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in the corresponding subject.	S1, S2
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	S4
2.3	To use Internet in searching for scientific information	S5
2.4	To carry out deep and not short proofs.	S3
3	Values:	
3.1	To work with independence and responsibility.	V1, V3
3.2	To collaborate with team works.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Independent research or course of study under the direction of a member of the faculty, which may include research for and preparation of a thesis.	48
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	Research subject dependent.	• 4 lecture hours/week • Self-study	Assignments
2.0	Skills		
2.1	To develop techniques of proof in the corresponding subject.	Deep problems	Presentations
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	Self-study	Participations
2.3	To use Internet in searching for scientific information	Self-study	Presentations
2.4	To carry out deep and not short proofs.	Deep problems	Participations
3.0	Values		
3.1	To work with independence and responsibility.	Personal questions	Presentations and discussions
3.2	To collaborate with team works.	Team work	Collaborations

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	None		

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses is given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	On the recommendation of supervisor or graduate committee.
Essential References Materials	On the recommendation of supervisor or graduate committee.
Electronic Materials	On the recommendation of supervisor or graduate committee.
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)	None.

G. Course Quality Evaluation

Evaluation Areas/Issues	Evaluators	Evaluation Methods
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio.

Evaluation Areas/Issues	Evaluators	Evaluation Methods
		Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)

Course Title:	PhD Dissertation
Course Code:	MAT 7399
Program:	Doctor of Philosophy in Mathematics
Department:	Mathematics and Statistics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University

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A. Course Identification

1. Credit hours:	18
2. Course type	
a.	University ☐ College ☐ Department ☒ Others ☐
b.	Required ☒ Elective ☐
3. Level/year at which this course is offered: Levels 7-12 / Years 3-4	
4. Pre-requisites for this course (if any): Passing the comprehensive exam	
5. Co-requisites for this course (if any): None	

6. Mode of Instruction (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	288	100 %
2	Blended		
3	E-learning		
4	Distance learning		
5	Other		

7. Contact Hours (based on academic semester)

No	Activity	Learning Hours
1	Lecture	0
2	Laboratory/Studio	0
3	Seminars	0
4	Tutorials	0
5	Other (Recommendations of supervisor and discussions with him)	288
Total		288

B. Course Objectives and Learning Outcomes

1. Course Description Depend on research area.
2. Course Main Objective The objective of this course is to enable students to learn skills of research including reviewing the literature, writing research, thinking critically and evaluating works. The student, as well, should master investigating previous known results and attempt seriously to invent, generalize, improve, or focus on special cases to come up eventually with original and valuable results. The course is aimed also to mastering the language of proof and uses it to practice applied and theoretical aspects of research, accessing all resources such as papers, electronic materials, and data base to comprehend the topic and avoiding redundant efforts. Finally, one important goal for the course is to elaborate scientific writing up and publishing in respected journals in the field.

3. Course Learning Outcomes

CLOs		Aligned PLOs
1	Knowledge and Understanding	
1.1	Research subject dependent.	K1, K2
2	Skills:	
2.1	To develop techniques of proof in the corresponding subject.	S1, S2
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	S4
2.3	To use Internet in searching for scientific information	S5
2.4	To carry out deep and not short proofs.	S3
3	Values:	
3.1	To work individually.	V1, V3
3.2	To work in groups.	V1, V2

C. Course Content

No	List of Topics	Contact Hours
1	Independent research under the direction of a member of the faculty, which may include research and writing a thesis.	-
Total		-

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	Research subject dependent.	• 30 work hours\week • Self-study	• Assignments
2.0	Skills		
2.1	To develop techniques of proof in the corresponding subject.	Deep problems	Presentations
2.2	To develop oral communication and technical writing skills through writing and oral presentation.	Self-study	Participations
2.3	To use Internet in searching for scientific information	Self-study	Participations
2.4	To carry out deep and not short proofs.	Deep problems	Presentations
3.0	Values		
3.1	To work individually.	Personal questions	• Presentations and discussions • Writing a thesis
3.2	To work in groups.	Team work	Collaborations

2. Assessment Tasks for Students

#	Assessment task*	Week Due	Percentage of Total Assessment Score
1	First year report	Last week in the first year (year 3)	Pass or fail
2	Second year report	Last week in the second year (year 4)	Pass or fail
4	Defense	Upon defense committee approval	Pass or fail

*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 :

- Students admitted to the PhD program will receive the appropriate academic counseling and support from the mathematics graduate committee (MGC).
- The lecturer for each course allocates 6 office hours per week advertised on his /her own timetable, and reserved as part of his/her teaching schedule to help the students on any academic problems/difficulties.
- Student is able to get individual consultation and academic advice appointment with teaching staff via e-mail or phone calls.
- A list of teaching staff members with their room numbers, their phone numbers and their e-mail addresses are given in the Department website.

F. Learning Resources and Facilities

1. Learning Resources

Required Textbooks	On the recommendation of supervisor.
Essential References Materials	On the recommendation of supervisor.
Electronic Materials	On the recommendation of supervisor.
Other Learning Materials	None

2. Facilities Required

Item	Resources
Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology Resources (AV, data show, Smart Board, software, etc.)	The rooms are equipped with data show and Smart Board.
Other Resources	None.

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
Effectiveness of teaching	Students	Direct: Questionnaire.
	Course Responsible	Direct: Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Peer Reviewer	Direct: Questionnaire. Indirect: External assessor report.
Effectiveness of assessment	Program Leaders	Direct: Course e-Portfolio. Indirect: Course report.
Extent of achievement of course learning outcomes	Course Responsible	Direct: Exams - Course e-Portfolio. Indirect: Second examiner checklist-Course report.
	Program Leaders	Indirect: Exams.
Quality of learning resources	Students	Indirect: Second examiner checklist-Course report.
	Faculty (Academic Advisory- GCC)	Direct: course Entrance/Exit. Indirect: Observations - Accreditation review.
	Program Leaders	Direct: Course e-Portfolio.
	Course Responsible	Indirect: Course evaluation survey- Observations- Syllabus review- Accreditation review.

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	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
Reference No.	11/1444
Date	22/04/1444 (16/11/2022)