CHRIST COLLEGE
(AUTONOMOUS) IRINJALAKUDA - KERALA

PG DEPARTMENT OF MATHEMATICS-AIDED

MASTER OF MATHEMATICS

COURSE PLAN

2020-2021

EVEN SEMESTER

HOD in Charge : Dr. SEENA V

LIST OF CONTENTS

M.Sc. MATHEMATICS
SEMESTER - 2

SI.NO	Course	Title	Contact Hours	Total Credits	Internal	External	Total Weightage
1	Core	MTH2C06 Algebra- II	5	4	20%	80%	30
2	Core	MTH2C07 Real Analysis	5	4	20%	80%	30
3	Core	MTH2C08 Topology	5	4	20%	80%	30
4	Core	MTH2C09 ODE & calculus of variations	5	4	20%	80%	30
5	Core	MTH2C10 Operations Research	5	4	20%	80%	30

MTH2C06: ALGEBRA II

Lecture Hours per week: 5, Credits: 3
Total weightage 30, Internal: 20%, External: 80%, Examination 3 Hours

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TEXT: John B. Fraleigh: A FIRST COURSE IN ABSTRACT ALGEBRA (7^{th} Edn.), Pearson Education Inc., 2003.

Module 1

Prime and Maximal Ideals, Introduction to Extension Fields, Algebraic Extensions (Omit Proof of the Existence of an Algebraic Closure), Geometric Constructions. [27, 29, 31, 32]

Module 2

Finite Fields, Automorphisms of Fields, The Isomorphism Extension Theorem, Split- ting Fields, Separable Extensions. [33, 48, 49, 50, 51]

Module 3

Galois Theory, Illustration of Galois Theory, Cyclotomic Extensions, Insolvability of the Quintic. [53, 54, 55, 56]

References

[1] **N. Bourbaki**: Elements of Mathematics: Algebra I, Springer; 1998

[2] **Dummit and Foote**: Abstract algebra (3rd edn.); Wiley India; 2011

[3] **M.H. Fenrick**: Introduction to the Galois correspondence (2Ndedn.); Birkhuser; 1998

[4] **P.A. Grillet**: Abstract algebra (2Nd edn.); Springer; 2007

[5] **I.N. Herstein**: Topics in Algebra (2Nd Edn); John Wiley & Sons, 2006.

[6] **T.W. Hungerford**: Algebra; Springer Verlag GTM 73(4th Printing); 1987

[7] **C. Lanski**: Concepts in Abstract Algebra; American Mathematical Society; 2010

[8] **R. Lidl and G. Pilz** Appli:ed abstract algebra(2Nd edn.); Springer; 1998

OBJECTIVES

1. To train the student in the domain of Abstract Algebra.
2. To give sufficient knowledge of the subject, which can be used by student for further applications in their respective domains of interest.

LESSON PLAN

Unit/ session/ hours (time Required)	Topics for student preparation (input)	Procedure (process) Student centric Method of teaching	Activity	Learning outcome (output)	Assessment
Module 1 Prime and Maximal Ideal, Field Extensions **(25 HOURS)**	Definition of Prime and Maximal Ideals , Finite and Algebraic extension,Simple Extensions and Geometric Constructions	• Lecture • Discussion • Participative learning	• Students Seminar on Preliminaries	To understand the concept of ideals, Maximal ideals, finite extensions, Geometric constructions	Evaluation Through Test Paper
Module-2 Finite Fields, Automorphism **(35HOURS)**	Finite fileds , Conjugation isomorphism theorem and the definition of G(E/F)	• Lecture • Discussion • Participative learning	• Student seminars for finding primitive nth root of unity and finding splitting field	To understand There exist a finite filed contating p^n elements for every prime p, Splitting fields, Separable extensions	Evaluation through test paper and MCQ
Module-3 Galois Theory and Cyclotomic Extensions **(40HOURS)**	Galois Theory and Theorems related to cyclotomic extension and insolvability of quintic	• Lecture • Discussion • Participative learning	• Assignment to find the Galois group of Given Field and Cyclotomic extensions	To understand Galois theory and Cyclotomic extensions	Evaluation Through MCQ

Course Outcomes

CO1	To learn the concepts of prime and maximal ideals
CO2	To gain knowledge about extension fields and their properties
CO3	To learn the concept of splitting fields
CO4	To get an idea of geometric construction of numbers
CO5	To gain knowledge in elements of Galois theory
CO6	To learn an idea of cyclotomic extensions

UNIT WISE BREAK UP

OBJECTIVE

- To develop skills and to acquire knowledge on some of the basic concepts in Ideals, Geometric Constructions
- To develop skills and to acquire knowledge of Algebraic Extensions, Splitting fields, Polynomials solvable by radicals.

Module Number	Topic	No. of Lecture Hours	Pre- class activity	Pedagogy (in class)	Out of class assignment
Module 1:	Prime and Maximal Ideal, Field Extensions	**25**			
Unit 1.	Ideals	**9**	Learn basic definition and results of Rings , Fundamental hommorphism theorems	Lecture, Discussion and Illustration	Find more examples and solve previous question papers.
Unit 2.	Extension Fields	11			
Unit 3	Geometric Constructions	5			
Module 2	Finite Fields, Automorphism	**35**			
Unit 1.	Finite Fields	8	Read about characteristic of a ring and Extension fields	Lecture, Discussion and Illustration	Find more examples and solve previous question papers
Unit 2.	Automorphism of Fields	8	Learn the definition of hommorphism, isomorphism		
Unit 3	Isomorphism Extn Theorem	7	Read definitions of algebraic extension and Fundamental homomorphism theorems		
Unit 4	Splitting Field and Separable Extensions	12	Learn the definition of algebraic closure and finite extensions		
Module 3	Galois Theory and Cyclotomic Extensions	**40**			
Unit 1	Galois theory and its illustration	25	Read Definition of Galois group, Finite extension and Splitting Field	Lecture, Discussion and Illustration	Find more examples and solve previous question papers
Unit 2	Cyclotomic Extensions	8	Read the definition of Splitting Field		
Unit 3	Insolvability of Quintic	7	Learn the definition of normal extension and splitting field		

Teacher in Charge: Dr. Seena V

qq **SECOND SEMESTER**
MTH2C07: REAL ANALYSIS II
No. of Credits: 4
No. Of hours of Lectures/week: 5

TEXT: H. L. Royden P. M. Fitzpatrick H.L. REAL ANAYLSIS (4th Edn.), Prentice Hall of India, 2000.

Module 1

The Real Numbers: Sets, Sequences and Functions
Chapter 1: Sigma Algebra, Borel sets Section 1.4: Proposition13
Lebesgue Measure Chapter 2: Sections 2.1, 2.2 ,2.3 ,2.4 ,2.5 ,2.6,2.7 up-to preposition19.
Lebesgue Measurable Functions Chapter 3: Sections 3.1, 3.2, 3.3

Module 2

Lebesgue Integration Chapter 4: Sections 4.1, 4.2, 4.3, 4.4, 4.5, 4.6
Lebesgue Integration: Further Topics Chapter 5: Sections: 5.1, 5.2, 5.3

Module 3

Differentiation and Integration Chapter 6: Sections 6.1, 6.2, 6.3 6.4, 6.5,6.6 The L^pspaces: Completeness and Approximation Chapter 7: Sections 7.1 ,7.2 ,7.3

References

[1] **K B. Athreya and S N Lahiri:** Measure theory, Hindustan Book Agency, New Delhi, (2006).

[2] **R G Bartle:** The Elements of Integration and Lebasque Measure, Wiley (1995).

[3] **S K Berberian:** measure theory and Integration, The Mc Millan Company, New York, (1965).

[4] **L M Graves:** The Theory of Functions of Real Variable Tata McGraw-Hill Book Co (1978)

[5] **P R Halmos:** Measure Theory, GTM, Springer Verlag

[6] W Rudin: Real and Complex Analysis, Tata McGraw Hill, New Delhi,2006

[7] **I K Rana:** An Introduction to Measure and Integration, Narosa Publishing Company, New York.

[8] **Terence Tao:** An Introduction to Measure Theory, Graduate Studies in Mathematics, Vol 126 AMS

Objectives

- To familiarize students the concept of Lebesgue measurable sets and Lebesgue measurable functions.
- To create a deep knowledge about Lebesgue integration.
- To understand the properties of L^p spaces.

Lesson Plan

Unit/ session/ hours (time Required)	Topics for student preparation (input)	Procedure (process) Student centric Method of teaching	Activity	Learning outcome (output)	Assessment
Module 1 Lebesgue measure and Lebesgue measurable functions	Basics of Borel sets, σ −algebra, convergence.	• Lecture • Discussion • Participative learning • Assignment	Peer group discussion on measurable sets and measurable functions; Assignments to solve some exercise questions	To understand the concept of Lebesgue measurable functions	Viva and Test paper
Module 2 Lebesgue integration	Riemann integral, step function, measurable functions	• Lecture • Seminar • Participative learning	• Student seminars to explain Riemann integrals and some basic properties of Lebesgue integration • Group discussion	To understand properties of Lebesgue integration	Viva and Test paper
Module-3 Differentiation and integration; L^p spaces	Continuity, monotone functions, L^p spaces	• Lecture • Participative learning • Seminar	• Student seminars on L^p spaces	To understand the relation between integration and measure.	Test paper

Course Outcomes:

CO1	**To understand the concepts of Lebesgue measure of subsets of real numbers**
CO2	**To create a knowledge of Lebesgue measurable functions**
CO3	**To develop concepts of general Lebesgue integral**
CO4	**To discuss about uniform integrability and prove Vitali theorem**
CO5	**To study about functions of bounded variation**
CO6	**To create an idea about L^p- spaces**

UNIT WISE BREAK UP

LECTURE HOURS: 90 hrs

Module Number	Topic	No. of Lecture Hours	Pre- class activity	Pedagogy (in class)	Out of class assignment
Module 1:		**35**			
Unit 1.	The Real Numbers	**2**	Read the basics of Borel sets, countability, σ −algebra, and convergence.	Lecture, Group discussion and Illustration	Assignment on Lebesgue measurable sets
Unit 2.	Lebesgue measure	**19**			
Unit 3	Lebesgue measurable functions	**14**			
Module 2		**30**			
Unit 1.	Lebesgue integration	18	Familiar with the concepts of Lebesgue measure and Lebesgue measurable functions	Lecture, Discussion	Discussion of results in PLG
Unit 2.	Further topics in Lebesgue integration	12			
Module 3		**25**			
Unit 1	Differentiation and Integration	15	Learn the basics of continuity, monotone functions and L^p spaces from Real Analysis I	Lecture, Discussion	Discussion in PLG on properties of L^p spaces
Unit 2	L^p spaces	10			

Teacher in charge: Naveen V V

MTH2C08: TOPLOGY

Lecture Hours per week: 5, Credits: 4

Examination 3 Hours

Objectives

To develop a basic ideas in geometric objects that are preserved under continuous deformation

Module I : A Quick Revision of Chapter 1,2 and 3. Topological Spaces, Basic Concepts [Chapter 4 and Chapter 5 Sections 1, Section 2 (excluding 2.11 and 2.12) and Section 3 only]

Module II : Making Functions Continuous, Quotient Spaces, Spaces with Special Properties [Chap- ter 5 Section 4 and Chapter 6]

Module III : Separation Axioms: Hierarchy of Separation Axioms, Compactness and Separation Axioms, The Urysohn Characterization of Normality, Tietze Characterization of Normality. [Chapter 7: Sections 1 to 3 and Section 4 (up to and including 4.6)]

Textbook :

JOSHI, K.D: INTRODUCTION TO GENERAL TOPOLOGY (Revised Edn.),

New Age International(P) Ltd., New Delhi, 1983.

Reference Books:

1. **M.A. Armstrong**: Basic Topology; Springer- Verlag New York; 1983
2. **J. Dugundji**: Topology; Prentice Hall of India; 1975
3. **M. Gemignani**: Elementary Topology; Addison Wesley Pub Co Reading Mass; 1971
4. **M.G. Murdeshwar**: General Topology (2nd Edn.); Wiley Eastern Ltd; 1990
5. **G.F. Simmons**: Introduction to Topology and Modern Analysis; McGraw-Hill Inter- national Student Edn.; 1963
6. **S. Willard**: General Topology; Addison Wesley Pub Co., Reading Mass; 197

OBJECTIVES

a) ***To develop basic ideas of topological spaces and its properties***

b) ***To recognise spaces having some special characteristics***

c) ***To develop the ideas of quotient spaces***

d) ***To classify spaces using separation axioms.***

e) ***To develop the concept and characterisation of normality with its properties.***

LESSON PLAN

Unit/ session/ hours (time Required)	**Topics for student preparation (input)**	**Procedure (process) Student centric Method of teaching**	**Activity**	**Learning outcome (output)**	**Assessment**
Module 1: Topological Spaces	Definitions and basics concepts of sets and functions with additional structure, Geometry and metric spaces.	• Lecture • Discussion • Participative learning • Problem solving	• Peer group discussion and presentation on concepts of metric spaces with properties	• To visualize, from geometry to metric space To understand • More ideas about topological spaces and its basic concepts.	Evaluation Through MCQ and Test Paper

Module 2: Quotient Space	Study the properties of continuity and connectedness in metric space	• Lecture • Discussion • Participative learning • Problem solving	• Student seminars to explain the properties of continuity and connectedness	To understand: • Compare the results studied in topology with the results studied in Analysis.	Evaluation Through test paper and MCQ
Module3: Seperation Axiom	Basic concepts of compact and separation in Analysis	• Lecture • Discussion • Participative learning • Problem solving	• Seminar and Assignment to find the different spaces using separation axioms.	To understand: • More about the spaces. • Hierarchy of separation axioms thought progressively stronger conditions imposed upon a topological space to make it resemble a metric space.	Evaluation Through MCQ and Test Paper

Course Outcomes

CO1	To develop basic concepts of topological spaces and its properties
CO2	To understand the concept of quotient spaces
CO3	To identify spaces having special properties
CO4	To classify spaces using separation axioms
CO5	For utilization of Urysohn characterization of normality and Tietze characterization of normality

UNIT WISE BREAK UP

LECTURE HOURS: 90

OBJECTIVE

a) To familiarize student with the importance of Topological Spaces

b) To enable student the results obtained in Topological Spaces to apply in both physical and logical aspects of the network.

Module Number	Topic	No. of Lecture Hours	Pre-class activity	Pedagogy (in class)	Out of class assignment
Module 1:	**Topological Spaces**	**30**			
Unit 1.	Definitions and Examples of Topological Spaces	8	Learn basic properties of metric spaces, convergent.	Lecture, Discussion, Seminars and Illustration	Identification of more examples for the topological space and more examples for Continuity
Unit 2.	Bases,Sub-bases and Subspaces in Topological Space	10			
Unit 3	Basic Concepts in Topological Space	12	Read basic properties of elementary functions of real analysis		
Module 2	**Quotient Space**				
Unit 1.	Quotient Space		Read basic	Lecture,	Problems of

Unit 2.	Connectedness		properties of real analysis	Discussion, Seminars and Illustration	connectedness
Unit 3	Local connectedness and Paths			Lecture, seminars and Discussions	Discussion of results in Paths
Module 3	**Seperation Axioms**				
Unit 1	Hierarchy of Separation Axioms		Basics concepts and properties in compactness of analysis	Lecture, Discussion, Seminars and Illustration	Problems of Separation axioms and compactness
Unit 2	Compactness				
Unit 3	Characterisation of normality			Lecture, Discussion and Illustration	Discussion of results in characterisation of normality

Teacher in Charge: Dr.V.Vibitha Kochamani

SECOND SEMESTER
MTH2C09: ODE AND CALCULUS OF VARIATIONS
No. of Credits: 4
No. Of hours of Lectures/week: 5

TEXT: SIMMONS, G.F., DIFFERENTIAL EQUATIONS WITH APPLICATIONS AND HISTORICAL NOTES, New Delhi, 1974.

Module 1

Power Series Solutions and Special functions; Some Special Functions of Mathematical Physics. [Chapter 5: Sections 26, 27, 28, 29, 30, 31; Chapter 6: Sections 32, 33]

Module 2

Some special functions of Mathematical Physics (continued), Systems of First Order Equations; Non linear Equations [Chapter 6: Sections 34, 35: Chapter 7: Sections 37, 38, Chapter 8 : Sections 40, 41, 42, 43, 44]

Module 3

Oscillation Theory of Boundary Value Problems, The Existence and Uniqueness of Solutions, The Calculus of Variations. [Chapter 4: Sections 22, 23 & Appendix A. (Omit Section 24) ; Chapter 11 : Sections 55, 56,57: Chapter 9 : Sections 47, 48, 49]

References

[1] G. Birkhoff and G.C. Rota: Ordinary Differential Equations (3rd Edn.); Edn. Wiley & Sons; 1978

[2] W.E. Boyce and R.C. Diprima: Elementary Differential Equations and boundary value problems (2nd Edn.); John Wiley & Sons, NY; 1969

[3] A. Chakrabarti: Elements of ordinary Differential Equations and special functions; Wiley Eastern Ltd., New Delhi; 1990

[4] E.A. Coddington: An Introduction to Ordinary Differential Equations; Printice Hall of India, New Delhi; 1974

[5] R.Courant and D. Hilbert: Methods of Mathematical Physics- vol I; Wiley Eastern Reprint; 1975

[6] P. Hartman: Ordinary Differential Equations; John Wiley & Sons; 1964

[7] L.S. Pontriyagin: A course in ordinary Differential Equations Hindustan Pub. Corporation, Delhi; 1967

[8] I. Sneddon: Elements of Partial Differential Equations; McGraw-Hill International Edn.; 1957

MTH2C09: ODE AND CALCULUS OF VARIATIONS
No. of Credits: 4
No. Of hours of Lectures/week: 5

Unit/ session/ hours (time Required)	Topics for student preparation (input)	Procedure (process) Student centric Method of teaching	Activity	Learning outcome (output)	Assessment
Module 1 Power series solutions and special functions	Basics of power series	• Lecture • Participative learning • Problem Solving	• Group discussion • Assignment	To understand method of solving ODE in terms of power series	Assignments and Test paper
Module 2 Some special functions in Mathematical Physics	Method of solving linear ODE of first and second order	• Lecture • Assignment • Problem solving	• Group discussion • Assignment	To understand properties of some special function in mathematical physics To solve non linear ODE	Test paper
Module-3 Calculus of Variations	Basics of ODE and boundary value problem	• Lecture • Discussion	• Assignment	To understand the basics of Calculus of Variation	Assignment Seminar

Course Outcomes:

CO1	**To develop an idea of power series solutions**
CO2	**To analyze the concept of Bessel functions and Legendre Polynomials**
CO3	**To understand the concept of systems of first order differential equation**
CO4	**To gain the knowledge of boundary value problems**
CO5	**To get the knowledge of calculus of variations**

UNIT WISE BREAK UP

LECTURE HOURS: 90 hrs

OBJECTIVE

- To understand the methods to find Power series solutions
- To solve the system of first order differential equations
- To understand methods to solve boundary value problems
- To get the knowledge of calculus of variations

Module Number	Topic	No. of Lecture Hours	Pre- class activity	Pedagogy (in class)	Out of class assignment
Module 1:		**25**			
Unit 1.	Power series solutions and Special Functions	**12**	Learn the basics of Power series	Lecture, Group discussion	Assignment on problems on power series solution of ODE
Unit 2.	Special Functions of Mathematical Physics	**13**			
Module 2		**30**			
Unit 1.	Special Functions of Mathematical Physics	9	Learn methods to solve first order differential equations	Lecture, Discussion	Assignment on the problems system of first order DE
Unit 2.	System of first order equations	11			
Unit 3	Non-linear equations	10			
Module 3		**35**			
Unit 1	Oscillation Theory of Boundary Value Problems	12	Learn the basics Boundary value problems	Lecture, Discussion	Discussion in PLG Assignment on problems of boundary value problems
Unit 2	Existence of Uniqueness of Solutions	11			
Unit 3	Calculus of variations	12			

Teacher in Charge: Aravind Krishna

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MTH2C10: OPERATION RESEARCH

Lecture Hours per week: 5, Credits: 4

TEXT : K.V MITAL; C.MOHAN., OPTIMISATION METHODS IN OPERATION RESEARCH AND SYSTEMS ANALYSIS.

Module 1: Convex Functions; Linear Programming.

Module 2: Linear Programming(contd); Transportation Problem.

Module 3: Integer Programming; Sensitivity Analysis, Flow and Potential in Networks; Theory of Games.

References

[1] **R.L. Ackoff and M.W Sasioni**: Fundamentals of Operation Research; Wiley Eastern Ltd. New Delhi; 1991

[2] **G. Hadley**: Linear Programming; Addison-Wesley Pub Co Reading, Mass; 1975

[3] **G. Hadley**: Non-linear and Dynamic Programming; Wiley Eastern Pub Co. Reading, Mass; 1964

OBJECTIVE

To use Operation Research as an essential in real life.

LESSON PLAN

Unit/ session/ hours (time Required)	Topics for student preparation (input)	Procedure (process) Student centric Method of teaching	Activity	Learning outcome (output)	Assessment
Module 1 Convex Functions; Linear Programming **(20 HOURS)**	Definitions of. Convex Functions; Linear Programming	• Lecture • Discussion • **Participative learning**	• Students presentation competition.	To understand the concept of Convex Functions; Linear Programming	Evaluation Through MCQ
Module-2 : Linear Programming(contd); Transportation Problem **(35 HOURS)**	Transportation Problem	• Lecture • Discussion • **Participative learning**	• Student seminars to explain Transportation Problem	To understand Transportation Problem	Evaluation through test paper
Module-3 Ineger Programming; Sensitivity Analysis, Flow and Potential in Networks; Theory of Games. **(35HOURS)**	Integral dependence and valuation, Chain conditions, Noetherian Rings, Artinian Rings	• Lecture • Discussion • **Participative learning**	• Assignment	To understand Ineger Programming; Sensitivity Analysis, Flow and Potential in Networks; Theory of Games	Evaluation Through MCQ

Course Outcomes

CO1	To formulate a real-life problem as a mathematical programming model in general, standard and canonical forms
CO2	. To optimize the linear programming problem using various method
CO3	To solve integer programming problems
CO4	To analyse the concepts of scheduling of sequential activities and flow in network analysis
CO5	To acquaint with the knowledge regarding the theory of games and treat the rectangular game as a linear programming problem

UNIT WISE BREAK UP

OBJECTIVE

- To familiarize students with the importance of Linear Programming.
- To understand Transportation Problem.
- To know Theory of Games

Module Number	Topic	No. of Lecture Hours	Pre- class activity	Pedagogy (in class)	Out of class assignment
Module 1:	Convex Functions; Linear Programming	**20**			
Unit 1.	Convex Functions	**10**	Learn basic definition and results of Convex Functions; Linear Programming	Lecture, Discussion and Illustration	Find more examples and solve previous question papers.
Unit 2.	Linear Programming	10			
Module 2	Linear Programming(contd); Transportation Problem	**35**			
Unit 1.	Linear Programming(contd)	17	Read basic properties of Transportation Problem	Lecture, Discussion and Illustration	Find more examples and solve previous question papers
Unit 2.	Transportation Problem	18			
Module 3	Ineger Programming; Sensitivity Analysis, Flow and Potential in Networks; Theory of Games	**35**			
Unit 1	Ineger Programming	10	Read basic properties of Ineger Programming, Sensitivity Analysis and Theory of Games	Lecture, Discussion and Illustration	Find more examples and solve previous question papers
Unit 2	Sensitivity Analysis, Flow and Potential in Networks,	13			
Unit 3	Theory of Games	12			

Teacher in Charge: Fr. Dr. Vincent N.S.

M.Sc. MATHEMATICS
SEMESTER - 4

SI.NO	Course	Title	Contact Hours	Total Credits	Internal	External	Total Weightage
1	Core	MTH4C15- Advanced Functional Analysis	5	4	20%	80%	30
2	Elective	MTH4E0-5 Advanced Complex Analysis	5	3	20%	80%	30
3	Elective	MTH4E08 -Commutative Algebra	5	3	20%	80%	30
4	Elective	MTH4E09- Differential Geometry	5	3	20%	80%	30

MTH4C15: Advanced Functional Analysis

Lecture Hours per week: 5, Credits: 4
Total weightage 30, Internal: 20%, External: 80%, Examination 3 Hours

Text: YULI EIDELMAN, VITALI MILMAN & ANTONIS TSOLOMITIS; FUNCTIONAL ANALYSIS AN INTRODUCTION; AMS, Providence, Rhode Island, 2004.

Module 1

Spectrum, Fredholm Theory of Compact operators; Classification of spectrum, Fred- holm Theory of Compact operators. Self-adjoint operators; General properties, Self-adjoint compact operators, spectral theory, Minimax principle, Applications to integral operators. [Chapter5; Sections 5.1, 5.2; Chapter 6; Sections 6.1, 6.2]

Module 2

Order in the space of self-adjoint operators, properties of the ordering; Projection operators; properties of projection in linear spaces, Ortho projections. Functions of Operators spectral decomposition; Spectral decomposition, The main inequality, Construction of the spectral integral, Hilbert Theorem [Chapter6; Sections6.3- 6.4, Chapter7, sections 7.1, 7.2 up-to and including statement of Theorem 7.2.1]

Module 3

The fundamental theorems and the basic methods; Auxiliary results, The Banach open mapping Theorem, The closed graph Theorem, The Banach- Steinhaus theorem, Bases in Banach spaces, Linear functionals; the Hahn Banach theorem, Separation of Convex sets. Banach Algebras; Preliminaries, Gelfand's theorem on maximal ideals [Chapter9 Sections9.1- 9.7; Chapter10, Section 10.1, 10.2]

References

[1] B. V. Limaye: Functional Analysis, New Age International Ltd, New Delhi, 1996.
[2] R. Bhatia: Notes on Functional Analysis TRIM series, Hindustan Book Agency
[3] Kesavan S: Functional Analysis TRIM series, Hindustan Book Agency
[4] S David Promislow: A First Course in Functional Analysis, John wiley & Sons, INC., (2008)
[5] Sunder V.S: Functional Analysis TRIM Series, Hindustan Book Agency
[6] George Bachman & Lawrence Narici: Functional Analysis Academic Press, NY (1970)
[7] Kolmogorov and Fomin S.V: Elements of the Theory of Functions and Functional Analysis. English Translation, Graylock, Press Rochaster NY (1972)
[1] W. Dunfordand J. Schwartz: Linear Operators Part1, General Theory John Wiley & Sons (1958)
[2] E. Kreyszig: Introductory Functional Analysis with Applications John Wiley & Sons (1978)
[3] F. Riesz and B. Nagy: Functional Analysis Frederick Unger NY (1955)
[4] J.B.Conway: Functional Analysis Narosa Pub House New Delhi (1978)
[5] Walter Rudin: Functional Analysis TMH edition (1978)
[6] Walter Rudin: Introduction to Real and Complex Analysis TMH edition (1975)
[7] J.Dieudonne: Foundations of Modern Analysis Academic Press (1969)

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OBJECTIVES

- To study certain topological-algebraical structures and the methods by which the knowledge of these methods can be applied to analytic problems.
- The objectives of the course is the study of spectrum,self adjoint operators, Fundamental theorems in functional analysis and Banach Algebra.

LESSON PLAN

Unit/ session/ hours (time Required)	Topics for student preparation (input)	Procedure (process) Student centric Method of teaching	Activity	Learning outcome (output)	Assessment
Module 1 Spectrum and Self adjoint operators **(25 HOURS)**	Classification of spectrum, Fedholm theory of compact operators, Properties of self adjoint operators	• Lecture • Discussion • Participative learning	• Students Seminar on Preliminaries	To understand Classification of spectrum, Fedholm theory of compact operators, Properties and of self adjoint operators	Evaluation Through Test Paper
Module-2 Self adjoint operators and spectral decomposition **(25HOURS)**	Order in the self adjoint operators, projection operator and spectral decomposition	• Lecture • Discussion • Participative learning	• Student seminars on spectral decompostion	To understand Order in the self adjoint operators, projection operator and spectral decomposition	Evaluation through test paper and MCQ
Module-3 Fundamental Theorems and Banch Algebra **(40HOURS)**	Various fundamental theorems in functional analysis and learn about Banch Algebra	• Lecture • Discussion • Participative learning	• Seminar on the topic Banch Algebra	To understand Various fundamental theorems in functional analysis and learn about Banch Algebra	Evaluation Through Test paper

Course Outcomes

CO1	To get a basic knowledge on the notions – Spectrum, self-adjoint operators, compact operators and some theories related to it
CO2	To know about Spectral theory, Minimax Principle and its applications on integral operators
CO3	To develop an understanding on projection operators, spectral decompositions and Hilbert theorem
CO4	To know the fundamental theorems applicable on Banach spaces-Open mapping theorem, Closed Graph Theorem and Banach -Steinhaus Theorem
CO5	To introduce the concept of Banach Algebras and some basic theorems related to it

UNIT WISE BREAK UP

OBJECTIVE

- To develop skills and to acquire knowledge on some of the basic concepts in spectrum, self adjoint operators
- To develop skills and to acquire knowledge of projection operators, various fundamental theorems and Banch algebra

Module Number	Topic	No. of Lecture Hours	Pre- class activity	Pedagogy (in class)	Out of class assignment
Module 1	Spectrum and Self adjoint operators	**25**			
Unit 1.	Classification of Spectrum	**3**	Learn basic definition bounded operators	Lecture, Discussion and Illustration	Find more examples and solve previous question papers.
Unit 2.	Fedholm theory of compact operators	8	Learn basic definition compact operators		
Unit 3	Self adjoint operators	6	Read the definition of Hilbert spaces, bounded operators		
Unit 4	Self adjoint compact operators	8	Read the definition of self adjoint operator		
Module 2	Self adjoint operators and spectral decomposition	**25**			
Unit 1.	Order in the space of self-adjoint operators	7	Read the definition of bounded operator and Cauchy Schwartz inequality	Lecture, Discussion and Illustration	Find more examples and solve previous question papers
Unit 2.	Projection operators	10	Learn basic definition bounded operators and definition of Kernel and Image		
Unit 3	Spectral Decomposition	8	Learn the definition of self adjoint operator and ortho projection		
Module 3	Fundamental Theorems and Banch Algebra	**40**			
Unit 1	Banach open mapping and closed graph thorems	12	Learn the definition of open set and bounded operators	Lecture, Discussion and Illustration	Find more examples and solve previous question papers
Unit 2	Banach-Steinhaus theorem and Hanh Banch theorems	18	Learn the definition of Banch space, convex sets and Dual space		
Unit 3	Banach Algebra	10	Learn the definition of Banch space Ideals, Maximal ideal		

Teacher in Charge: Dr. Seena V

MTH4E05: Advanced Complex Analysis

Lecture Hours per week: 5, Credits: 3

Total weightage 30, Internal: 20%, External: 80%, Examination 3 Hours

Objectives

To develop research areas in complex analysis by discussing the detailed properties of analytic functions and meromorphic functions

Module I : Compactness and convergence of analytic functions

The Space of continuous functions $C(G, \Omega)$, Spaces of Analytic functions, Spaces of meromorphic functions, The Riemann Mapping theorem, Weierstrass Factorization Theorem

(35 Hours)

Module II : Factorization, Gamma and Zeta functions

Factorization of the sine function, Gamma function, The Riemann Zeta function, Runge's theorem, Simple connectedness

(25 Hours)

Module III : Analytic continuation

Mittage–Leffler's Theorem, Schwarz reflexion principle, Analytic continuation along a path, Monotromy theorem, Jensen's formula, The Genus and order of an entire function, Statement of Hadamard's factorization theorem

(30 Hours)

Textbook :

JOHN B. CONWAY, FUNCTIONS OF ONE COMPLEX VARIABLE (2nd Edn.), Springer International Student Edition, 1973

Reference Books:

1. **Cartan H:** Elementary Theory of Analytic Functions of one or Several Variables, Addison-Wesley Pub. Co. (1973)
2. **Moore T.O. & Hadlock E.H:** Complex Analysis, Series in Pure Mathematics - Vol. 9. World Scientific, (1991) Murray R. Spiegel: Complex Variables, Schaum's Outline series, 2nd Edn, McGraw-Hill Education, 2009.
3. **Pennisi L:** Elements of Complex Variables, Holf, Rinehart & Winston, 2nd Edn. (1976)
4. J.M. Howie: Complex Analysis, 1st Edition, Springer India Reprint,2003
5. **Remmert R:** Theory of Complex Functions, UTM, Springer- verlag, NY, (1991)

OBJECTIVES

a) To discuss properties of analytic and meromorphic functions.

b) To represent entire functions as an infinite product.

c) To develop properties of entire functions

LESSON PLAN

Unit/ session/ hours (time Required)	**Topics for student preparation (input)**	**Procedure (process) Student centric Method of teaching**	**Activity**	**Learning outcome (output)**	**Assessment**
Module 1 Spaces of Analytic Function and Meromorphic functions 35 hours	Definition and properties of continuous functions, analytic functions and meromorphic functions	• Lecture • Discussion • Participative learning	• Peer group discussion on properties of analytic and meromorphic functions	To understand: • The space of continuous, analytic and meromorphic functions.	Evaluation Through class test
Module-2 Factorization, Gamma and Zeta functions **25 Hours**	Weierstrass factorization theorem discussion	• Lecture • Discussion • Participative learning	• Student seminars to explain the properties Gamma and Zeta functions	To understand: • Beta and Gamma functions	Evaluation Through test paper
Module-3 Analytic continuation **30 Hours**	Existence of meromorphic function with prescribed poles	• Lecture • Discussion • Participative learning	• Student seminar to discuss the properties of entire functions	To understand: • Theorems like Mittage–Leffler's, Schwarz reflexion principle etc.	Evaluation Through test paper

Course Outcomes

CO1	To discuss the space properties of continuous functions, analytic functions and meromorphic functions
CO2	The expression of certain functions as an infinite product.
CO3	To develop properties of Gamma and Zeta functions.
CO4	To discuss some advanced properties of entire functions.

UNIT WISE BREAK UP

LECTURE HOURS: 90

OBJECTIVE

a) To familiarize student with the importance of the space of continuous functions, analytic functions and meromorphic functions.

b) To motivate student to start research in the branch of complex analysis.

Module Number	Topic	No. of Lecture Hours	Pre- class activity	Pedagogy (in class)	Out of class assignment
Module 1:	**Space of functions**	**35**			
Unit 1.	Spaces of continuous functions, analytic functions and meromorphic functions	25	Basic properties of continuous, analytic and meromorphic functions	Lecture and Discussions	Discussion in PLG on the space properties of continuous functions, analytic functions and meromorphic functions
Unit 2.	The Riemann Mapping theorem	5			
Unit 3	Weierstrass Factorization Theorem	5	Learn elementary factors		
Module 2	**Factorization, Gamma and Zeta functions**	**25**			
Unit 1.	Factorization of sine function	5	Read real valued gamma and zeta functions	Lecture, Discussion and Illustration	Discussion of results in PLG
Unit 2.	Gamma function	8			
Unit 3	Zeta function	8			
Unit 4	Runge's theorem	4			
Module 3	**Analytic continuation**	**30**			
Unit 1	Mittag Lefler theorem	10	Read properties of meromorphic functions and entire functions	Lecture and Discussions	Discussion of properties and results in PLG
Unit 2	Schwarz reflexion principle	6			
Unit 3	Monodromy theorem	4			
Unit 4.	Jensen's formula	4			
Unit 5.	The Genus and order of an entire function	6			

Teacher in Charge: Dr Shinto K.G

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MTH4E08: COMMUTATIVE ALGEBRA

Lecture Hours per week: 5, Credits: 3

TEXT : ATIYAH M.F., MACKONALD I. G., INTRODUCTION TO COMMUTATIVE ALGEBRA.

Module 1: Rings and Ideals, Modules [Chapters 1 and 2 from the text]

Module 2: Rings and modules of fraction, Primary decomposition [Chapters 3 and 4 from the text]

Module 3: Integral dependence and valuation, Chain conditions, Noetherian Rings, Artinian Rings [Chapters 5, 6, 7 and 8 from the text]

References

[4] **N. Bourbaki**: Commutative Algebra; Paris - Hermann; 1961

[5] **D. Burton**: A First Course in Rings and Idials; Addison - Wesley; 1970

[6] **N. S. Gopalakrishnan**: Commutative Algebra; Oxonian Press; 1984

[7] **T.W. Hungerford**: Algebra; Springer Verlag GTM 73(4th Printing); 1987

[8] **D. G. Northcott**: Ideal Theory; Cambridge University Press; 1953

OBJECTIVES

To use commutative algebra as an essential tool to explore several other areas of mathematics, such as algebraic geometry, number theory, and non commutative algebra

LESSON PLAN

Unit/ session/ hours (time Required)	Topics for student preparation (input)	Procedure (process) Student centric Method of teaching	Activity	Learning outcome (output)	Assessment
Module 1 Rings and Ideals, Modules **(40 HOURS)**	Definitions of rings, ideals, and modules.	• Lecture • Discussion • **Participative learning**	• Students presentation competition.	To understand the concept of rings, ideals, and modules	Evaluation Through MCQ
Module-2 : Rings and modules of fraction, Primary decomposition **(25HOURS)**	modules of fraction, Primary decomposition	• Lecture • Discussion • **Participative learning**	• Student seminars to explain modules of fraction, Primary decomposition	To understand modules of fraction, Primary decomposition	Evaluation through test paper
Module-3 Integral dependence and valuation, Chain conditions, Noetherian Rings, Artinian Rings **(25 HOURS)**	Integral dependence and valuation, Chain conditions, Noetherian Rings, Artinian Rings	• Lecture • Discussion • **Participative learning**	• Assignment to find the examples of Noetherian Rings, Artinian Rings	To understand Noetherian Rings, Artinian Rings	Evaluation Through MCQ

Course Outcomes

CO1	To know definitions concerning elements in rings and ideals in commutative algebra
CO2	To discuss modules.
CO3	To focus on constructions like tensor product and localization and the basic theory for this
CO4	To demonstrate primary decomposition and integral dependence .
CO5	To compare Noetherian rings and Artinian rings.
CO6	To participates in scientific discussions and begin with own research in commutative algebra.

UNIT WISE BREAK UP

OBJECTIVE

- To familiarize students with the importance of Module.
- To compare Noetherian Rings, Artinian Rings

Module Number	Topic	No. of Lecture Hours	Pre- class activity	Pedagogy (in class)	Out of class assignment
Module 1:	**Rings and Ideals, Modules**	**40**			
Unit 1.	Rings	**10**	Learn basic definition and results of Rings and Ideals, Modules	Lecture, Discussion and Illustration	Find more examples and solve previous question papers.
Unit 2.	Ideals	12			
Unit 3	Modules	18			
Module 2	Modules of fraction, Primary decomposition	**25**			
Unit 1.	Modules of fraction	12	Read basic properties of Modules	Lecture, Discussion and Illustration	Find more examples and solve previous question papers
Unit 2.	Primary decomposition	13			
Module 3	Integral dependence and valuation, Chain conditions, Noetherian Rings, Artinian Rings	**25**			
Unit 1	Integral dependence and valuation	8	Read basic properties of Chain conditions, Noetherian Rings, Artinian Rings	Lecture, Discussion and Illustration	Find more examples and solve previous question papers
Unit 2	Chain conditions,	8			
Unit 3	Noetherian Rings, Artinian Rings	9			

Teacher in Charge: Jomesh Jose.

MTH4E09: DIFFERENTIAL GEOMETRY
Lecture Hours per week: 5, Credits: 3
Examination 3 Hours

Objectives

Differential Geometry is the mathematical discipline that uses the techniques of differential calculus,Integral calculus, linear algebra and multilinear algebra to study problems in geometry.

Module I : Graphs and Level Set, Vector fields, The Tangent Space, Surfaces, Vector Fields on Surfaces, Orientation. The Gauss Map. [Chapters: 1,2,3,4,5,6 from the text.]

Module II : Geodesics, Parallel Transport, The Weingarten Map, Curvature of Plane Curves, Arc Length and Line Integrals. [Chapters: 7,8,9,10,11 from the text].

Module III :Curvature of Surfaces, Parametrized Surfaces, Local Equivalence of Surfaces and Parametrized Surfaces. [Chapters 12,14,15 from the text]

Textbook :
J.A. THORPE: ELEMENTARY TOPICS IN DIFFERENTIAL GEOMETRY

Reference Books:

1.W.L. Burke: Applied Differential Geometry, Cambridge University Press (1985)

2. M. de Carmo: Differential Geometry of Curves and Surfaces, Prentice Hall Inc Englewood Cliffs NJ (1976)

3.V.Grilleman and A. Pollack: Differential Topology, Prentice Hall Inc Englewood Cliffs NJ (1974)

4.B. O'Neil: Elementary Differential Geometry, Academic Press NY (1966)

5.M. Spivak: A Comprehensive Introduction to Differential, Geometry, (Volumes 1 to 5), Publish or Perish, Boston (1970, 75)

6.R. Millmen and G. Parker: Elements of Differential Geometry, Prentice Hall Inc Englewood Cliffs NJ (1977)

7.I. Singer and J.A. Thorpe: Lecture Notes on Elementary Topology and Geometry, UTM, Springer Verlag, NY (1967)

OBJECTIVES

a) To be able to understand the fundamental theorem of plane curves.

b) To find geodesics on various surfaces.

c) To get introduced to the concept of a regular parametrised curve.

d) To visualise the concept of curvature of a space curve and signed curvature of a plane curve.

e) To discuss the fundamental theorem for regular surfaces.

LESSON PLAN

Unit/ session/ hours (time Required)	**Topics for student preparation (input)**	**Procedure (process) Student centric Method of teaching**	**Activity**	**Learning outcome (output)**	**Assessment**
Module 1 Surfaces	Definitions,Terminology of Graphs and Level set	• Lecture • Discussion • Participative learning • Problem solving	• Peer group discussion and Presentation on basic graphs, level sets and vector fields	To understand: • More about the basic ideas in geometry • To visualise and manipulate the different concepts in vector fields and its orientation	Evaluation Through MCQ and Test Paper

Module-2 Curvature of Plane Curves	Concept of Geodesics and understand the parametrised curve and arc length	• Lecture • Discussion • Participative learning • Problem solving	• Student seminars and presentation to explain the different concepts in Curvature of curves	To understand: • Different types of curves in n-surfaces have been studied. • And also learned the local behaviour of curvature in n-surfaces	Evaluation Through MCQ, discussion and Test paper
Module-3 Curvature of Surfaces	Learn about smooth surface, tangent vector ,geodesics curvature and parametrised surfaces	• Lecture • Discussion • Participative learning • Problem solving	• Student Seminars and presentation to explain the different concepts in Curvature of surfaces	To understand: • Example of global theorem in differential geometry. • Learned the concepts of locally n-surfaces and parametrised n-surfaces are the same.	Evaluation Through MCQ and Test Paper

Course Outcomes

CO1	To sketch level curves, graph of a function and vector fields
CO2	To find the tangent space at a point of a level curve
CO3	To explain surfaces of n-dimension and orientation
CO4	To explain geodesics
CO5	To discuss the concept parallel transport
CO6	To discuss Weingarten map and related theorems
CO7	To define curvature of a plane curve and explain local and global parameterizations
CO8	To discuss differential one form

UNIT WISE BREAK UP

LECTURE HOURS: 90

OBJECTIVE

a) To familiarize student with the importance of different types of vector-valued functions, curves and surfaces with its orientation.

b) To enable student to apply the concepts and results obtained in the differential geometry to the computer language to analyse shapes and data on non-flat surfaces.

Module Number	Topic	No. of Lecture Hours	Pre-class activity	Pedagogy (in class)	Out of class assignment
Module 1:	**Surfaces**	**25**			
Unit 1.	Graphs,Level sets and Vector fields	7	Learn basic definitions, terminology in graphs and vector fields with its orientation	Lecture, Discussion and Seminars	Identification of some more examples to check the validity of the concepts and results discussed in the class of vector fields on surfaces.
Unit 2.	Tangent space and Surfaces	8			
Unit 3	Vector fields on surfaces, Orientation,Gauss Map	10			

Module 2	**Curvature of Plane Curves**				
Unit 1.	Geodesics and parallel transport		Read basic concepts of planes and curves with its properties	Lecture, Discussion, Illustration, and Seminars	Problems regarding the geodesics and Weingarten map
Unit 2.	Weingarten map and Curvature of plane curves				
Unit 3	Curvature of plane curves, Arc length and Line integrals				Find out the application problems in Curvature of plane curves and Arc length.
Module 3	**Curvature of Surfaces**				
Unit 1	Curvature of Surfaces		Read some basic properties in surfaces	Lecture, Discussion, Seminars and Illustration	Problems of Curvature of Surfaces and Parameterised Surfaces.
Unit 2	Parametrised Surfaces				
Unit 3	Local equivalence of surfaces			Discussion and Illustration	Discussion of results and concepts in local equivalence of surface.

Teacher in Charge: Dr V.Vibitha Kochamani