BISHOP CHULAPARAMBIL MEMORIAL COLLEGE, KOTTAYAM

M.Sc. MATHEMATICS PROGRAMME(2019 ONWARDS)

COURSE OUTCOMES

COURSE DESCRIPTIONS

SYLLABUS

BOARD OF STUDIES

1. **Dr. Varghese Mathew**
   Associate Professor
   Department of Mathematics
   Govt. College, Nattakom
2. **Mr. Manesh Jacob**
   Assistant Professor
   Department of Mathematics
   Marthoma College, Thiruvalla
3. **Mrs. Sosamma Mathew**
   Associate Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
4. **Mrs. Salma Mary K Abraham**
   Associate Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
5. **Dr. Stephy Thomas**
   Assistant Professor
   Department of Statistics
   Bishop Chulaparambil Memorial College, Kottayam
6. **Mrs. Ann Johns**
   Assistant Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
7. **Mrs. Anu Varghese**
   Assistant Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
8. **Mr. Liju Alex**
   Assistant Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam

GPO No.	Graduate Programme Outcomes
GPO No. 1	**Disciplinary Knowledge & Critical Thinking:** Articulate knowledge of one or more disciplines that form a part of UG programme. Critically think, analyse, apply and evaluate various information and follow scientific approach to the development of knowledge.
GPO No. 2	**Communication Skill:** Communicate thoughts and ideas clearly in writing and orally. Develop careful listening, logical thinking and proficiency in interpersonal communication.
GPO No. 3	**Environmental Awareness:** Sustainable approach to use of natural resources. Capable of addressing issues, promoting values and give up practices that harm the ecosystem and our planet.
GPO No. 4	**Ethical Awareness:** Uphold ethics/morals in all spheres of life. Identify and avoid unethical behaviour in all aspects of work.
GPO No. 5	**Social Commitment:** Be aware of individual roles in society as nation builders, contributing to the betterment of society. Foster social skills to value fellow beings and be aware of one's responsibilities as international citizens.
GPO No. 6	**Lifelong learners:** Equip students to be life long learners. Be flexible to take up the changing demands of work place as well as for personal spheres of activities.

PSO No:	Programme Specific Outcome	GPO No.
PSO1	Develop broad and balanced knowledge and understanding the concepts of Algebra, Analysis, Topology, Differential equations, Number Theory, Optimization Techniques, Probability theory and Discrete Mathematics in detail.	1,2
PSO 2	Familiarize the students with various mathematical tools of analysis to recognize, understand, interpret, model, solve practical problems and problems in mathematics related sciences.	1,3,5
PSO 3	To develop skills of mathematical abstraction, creativity, independent learning in understanding as well as interpreting different areas in Mathematics.	3,5
PSO 4	Enhance the ability to apply the mathematical knowledge and skills acquired to solve specific theoretical concepts/problems in Mathematics.	2,6
PSO 5	To enhance programming skills to understand different mathematical programming softwares and develop skills to solve problems using different programming packages.	1,4
PSO 6	Provide students sufficient knowledge and skills enabling them to undertake Independent multidisciplinary research and further studies in mathematics and its allied areas.	3,4,6
PSO 7	Acquire the knowledge and skills to engage and communicate the fundamental concepts of Mathematics and other allied areas to a wide spectrum of audience.	2,6
PSO 8	Encourage the students to develop a range of generic skills helpful in employment, internships and social activities.	4,5,6

COURSE OUTCOMES FI RST SEMESTER M.Sc MATHEMATICS

Course	Details
Code	**ME010101**
Title	**Abstract Algebra**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 1st Semester
Type	Core

ME010101 ABSTRACT ALGEBRA

CO NO.	COURSE OUTCOMES	Cognitive Level	PSO NO.
CO 1	To understand the finitely generated abelian group and its fundamental theorem and fundamental homomorphism theorem	Un	PSO 1
CO 2	To understand group action on a set and to apply G sets to counting	Un, Ap	PSO 1,2,4
CO 3	To understand isomorphism theorems and use them to verify that groups are isomorphic	Un,Ap	PSO 1,4
CO 4	To understand the concepts of Sylow p subgroup and the statement of Sylow theorems	Un	PSO 1,4
CO 5	To apply Sylow theorems to analyse the structure of groups of small order	Ap	PSO 1,2,4
CO 6	To understand and apply Fermat's Little theorem and Euler's theorem	Un,Ap	PSO 1,4
CO 7	To understand and apply division algorithm for polynomial rings	Un,Ap	PSO 1,4
CO 8	To understand and explain the structures of non commutative rings and strictly skew field	Un,An	PSO 1,.2,4
CO 9	To understand factor rings and prime and maximal ideal	Un	PSO 1,4

- Ap-Apply   Un-Understand   An- Analyze

COURSE DESCRIPTION

ME010101- ABSTRACT ALGEBRA

5 Hours/Week (Total Hours : 90) **4 Credits**

• Module		Course Description	Hrs.	Co No.
I	**1.0**	**Module I**	**25**	
	1.1	Direct products	2	1
	1.2	Finitely generated Abelian groups	2	1
	1.3	Fundamental theorem	2	1
	1.4	Applications	2	1
	1.5	Factor groups	3	1
	1.6	Fundamental homomorphism theorem	2	1
	1.7	Normal subgroups and inner automorphisms	3	1
	1.8	Group action on a set	3	2
	1.9	Isotropy subgroups	3	2
	1.10	Applications of G- sets to counting	3	2
II	**2.0**	**Module II**	**25**	
	2.1	Isomorphism theorems	9	3
	2.2	Sylow theorems	9	4
	2.3	Applications of the Sylow theory	7	5
III	**3.0**	**Module III**	**20**	
	3.1	Fermat's and Euler Theorems	5	6
	3.2	The field of quotients of an integral domain	5	7
	3.3	Rings of polynomials	5	7
	3.4	Factorisation of polynomials over a field.	5	7
IV	**4.0**	**Module IV**	**20**	
	4.1	Non commutative examples	5	8
	4.2	Homeomorphisms and factor rings	8	9
	4.3	Prime and Maximal Ideals	7	9

Syllabus

Textbooks:

John B. Fraleigh, A First Course in Abstract Algebra, 7th edition, Pearson Education.

Module 1:

Direct products and finitely generated Abelian groups, fundamental theorem, Applications Factor groups, Fundamental homomorphism theorem, normal subgroups and inner automorphisms .Group action on a set, Isotropy subgroups, Applications of G- sets to counting.

(Part II – Sections 11, 14, 16 & 17) **(25 hours)**

Module 2:

Isomorphism theorems, Sylow theorems , Applications of the Sylow theory.

(Part VII Sections34, 36 & 37) **(25 hours)**

Module 3:

Fermat's and Euler Theorems, The field of quotients of an integral domain, Rings of polynomials, Factorisation of polynomials over a field.

(Part IV – Sections 20, 21, 22 & 23) **(20 hours)**

Module 4:

Non commutative examples, Homeomorphisms and factor rings, Prime and Maximal Ideals

(Part V – Sections 24, 26 & 27) **(20 hours)**

References:-

1. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. Thomas W. Hungerfor, Algebra (Graduate texts in Mathematics), Springer
3. M. Artin, Algebra, Prentice -Hall of India, 1991
4. N. Jacobson, Basic Algebra Vol. I, Hindustan Publishing Corporation
5. P.B. Bhattacharya, S.K. Jain, S.R. Nagapaul, Basic Abstract Algebra, 2nd edition, Cambridge University Press, Indian Edition, 1997.
6. David S Dummit, Richard M Foote, Abstract Algebra, Third Edition, Wiley.

<u>COURSE OUTCOMES</u>

ME010102 Linear Algebra

Course	Details
Code	**ME010102**
Title	**Linear Algebra**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 1st Semester
Type	Core

CO NO.	COURSE OUTSOMES	COGNITIVE LEVEL	PSO NO.
CO 1	To understand Vector spaces, subspaces , basis dimension and related theorems	Un	PSO 1
CO 2	To understand more about Linear Transformations, isomorphism, linear functional and how to prove related theorems	Un,Ap	PSO 1,4
CO 3	To understand determinants and its properties	Un	PSO 1
CO 4	To apply various properties determinants for proving theorems	Ap	PSO 4
CO 5	To learn more about characteristic values , roots and apply it to solve related problems	Un,Ap	PSO 1,4
CO 6	To understand Annihilating polynomials, invariant subspaces ,direct sums and related theorems	Un	PSO 1

- Ap-Apply Un-Understand An- Analyze

ME010102 - LINEAR ALGEBRA

5 Hours/Week (Total Hours : 90) **4 Credits**

Module		**Course Description**	**Hrs.**	**Co No.**
I	**1.0**	**Module I**	**20**	
	1.1	Vector spaces	4	1
	1.2	Subspaces	4	1
	1.3	Basis and dimension Co-ordinates	4	1
	1.4	Summary of row-equivalence	4	1
	1.5	Computations concerning subspaces	4	1
II	**2.0**	**Module II**	**25**	
	2.1	Linear transformations	3	2
	2.2	The algebra of linear transformations	4	2
	2.3	Isomorphism	4	2
	2.4	Representation of transformations by matrices,	4	2
	2.5	Linear functional	4	2
	2.6	Double dual	3	2
	2.7	Transpose of a linear transformation.	3	2
III	**3.0**	**Module III**	**20**	
	3.1	Determinants	4	3,4
	3.2	Commutative Rings	4	3,4
	3.3	Determinant functions	4	3,4
	3.4	Permutation and uniqueness of determinants	4	3,4
	3.5	Additional properties of determinants.	4	3,4
Iv	**4.0**	**Module IV**	**25**	
	4.1	Introduction to elementary canonical forms	5	5
	4.2	Characteristic Values	5	5
	4.3	Annihilatory Polynomials	5	6
	4.4	Invariant subspaces	5	6
	4.5	Direct sum Decompositions	5	6

Syllabus

Textbook: Kenneth Hoffman / Ray Kunze (Second Edition), *Linear Algebra*,

Prentice-Hall of India Pvt. Ltd., New Delhi, 1992

Module 1:

Vector spaces, subspaces, basis and dimension
Co-ordinates, summary of row-equivalence, Computations concerning subspaces
(Chapter 2- 2.1, 2.2, 2.3,2.4 2.5& 2.6 of the text) **(20 hours)**

Module 2:

Linear transformations, the algebra of linear transformations, isomorphism, representation of transformations by matrices, linear functional, double dual, transpose of a linear transformation.
(Chapter 3 - 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 & 3.7 of the text) **(25 hours)**

Module 3:

Determinants: Commutative Rings, Determinant functions, Permutation and uniqueness of determinants, Additional properties of determinants.
(Chapter 5 - 5.1, 5.2, 5.3 & 5.4 of the text) **(20 hours)**

Module 4:

Introduction to elementary canonical forms, characteristic values, annihilatory Polynomials, invariant subspaces, Direct sum Decompositions
(Chapter 6 - 6.1, 6.2, 6.3, 6.4,6.6of the text) **(25 hours)**

COURSE OUTCOMES

ME010103 Basic Topology

Course	Details
Code	**ME010103**
Title	**Basic Topology**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 1st Semester
Type	Core

CO NO.	COURSE OUTCOMES	COGNITIVE LEVEL	PSO NO.
CO 1	To understand the concept of Topological spaces	Un	PSO 1,2
CO 2	To understand the generalization from metric spaces to Topological spaces	Un	PSO 1,2
CO 3	To understand the concept of Base, Sub base and Subspace	Un	PSO 2
CO 4	To learn the continuity of a function w.r.t the given topologies on its domain and codomain.	Un	PSO 1,2
CO 5	To identify whether a given property is topological	Un	PSO 2
CO 6	To understand the notion of connectivity and localise it	Un	PSO 2
CO 7	To understand and apply hierarchy of separation axioms	Un,Ap	PSO 2.4

Un: Understand, Ap: Apply

COURSE DESCRIPTION

Department : Mathematics

ME010103 BASIC TOPOLOGY

Module		Course Description	Hrs	Co.No.
1	1.1	Metric Topology	3	1
	1.2	Topological spaces and examples	5	2
	1.3	Bases and sub bases	12	3
	1.4	Subspace	5	3
2	2.1	Closed sets and closure	5	3
	2.2	Neighborhood	5	3
	2.3	Accumulation point	5	4
	2.4	Continuity	8	4
	2.5	Quotient space	2	5
3	3.1	Smallness condition	10	5
	3.2	Connectedness	10	5
4	4.1	Local connectedness	7	6
	4.2	Path	3	6
	4.3	Separation axioms	10	6

SYLLABUS

Text Book : K.D Joshi , Introduction to General Topology , Wiley Eastern Ltd, 1984

Module I : Topological Spaces: Definition of a topological space – Examples of topological spaces-Bases and subbases – subspaces.

Chapter 4: Sections 1, 2, 3, and 4 of the text) (25 hours)

Module II : Basic concepts: Closed sets and Closures – Neighbourhoods, Interior and Accumulation points – Continuity and Related Concepts – Making functions continuous , Quotient spaces

Chapter 5: Section 1;1. To 1.7 , Section 2; 2.1 to 2.10 and 2.13, Section3; 3.1 to 3.11, Theorem 3.2 condition 4

(25 hours)

Module III : Spaces with special properties :- Smallness conditions on a space, Connectedness **Chapter 6 : Section 1; 1.1 to 1.16, Section 2; 2.1 to 2.15**

(20 hours)

Module IV : Spaces with special properties :- Local connectedness and Paths Separation axioms:- Hierarchy of separation axioms

Chapter6: Sections 3.1 to 3.8, Chapter 7 : Sections 1.1 to 1.17 (20 hours)

COURSE OUTCOMES

Course	Details
Code	**ME010104**
Title	**Real Analysis**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 1st Semester
Type	Core

COURSE OUTCOME NO.	COURSE OUTCOMES	Cognitive Level	PSO NO.
CO 1	To understand the fundamental concepts of bounded variation, total variation and their characterisation theorems.	Un	PSO 1
CO 2	To apply properties of bounded variation to characterise rectifiable curves.	Un,Ap	PSO 1,2,4
CO 4	To understand the basic concepts of Riemann-Stieltjes integrals and their properties.	Un	PSO 1
CO 5	To get an ability to check whether a function is Riemann-Stieltjes integrable or not.	Un,Ap	PSO 1,4
CO 6	To understand the fundamental concepts of Point wise convergence and uniform convergence of sequence of functions.	Un	PSO 1
CO 7	To apply various method to check the uniform continuity of a sequence of functions.	Un,Ap	PSO 1,4
CO 8	To understand the fundamental concepts of power series expansion and apply to define exponential and logarithmic functions and their properties.	Un,Ap	PSO 1,.2,4
CO 9	To understand fundamental concepts of equicontinuous families of functions.	Un	PSO 1

- Ap-Apply Un-Understand

COURSE DESCRIPTION

ME010104- REAL ANALYSIS

5 Hours/Week (Total Hours: 90) **4 Credits**

Module		**Course Description**	**Hrs.**	**Co No.**
I	**1.0**	**Module I**	**20**	
	1.1	Preliminaries	1	1
	1.2	Properties of monotonic functions	1	1
	1.3	Functions of bounded variation	2	1
	1.4	Total variation	1	1
	1.5	Additive property of total variation	2	1
	1.6	Total variation on (a,x) as a functions of x	2	1
	1.7	Functions of bounded variation expressed as the difference of increasing functions	2	1
	1.8	Continuous functions of bounded variation	2	1
	1.9	Curves and paths	2	2
	1.10	Rectifiable path and arc length	2	2
	1.11	Additive and continuity properties of arc length	2	2
	1.12	Change of parameter	1	2
II	**2.0**	**Module II**	**20**	
	2.1	Definition and existence of the integral	5	4
	2.2	Properties of integral	5	4
	2.3	Integration and differentiation	5	5
	2.4	Integration of vector valued functions	5	5
III	**3.0**	**Module III**	**25**	
	3.1	Discussions of main problem	5	6
	3.2	Uniform convergence	5	6
	3.3	Uniform convergence and continuity	5	6
	3.4	Uniform convergence and integration	5	7
	3.5	Uniform convergence and differentiation	5	7
Iv	**4.0**	**Module IV**	**25**	
	4.1	Equi continuous families of function	5	9
	4.2	The Stone Weierstrass theorem	5	9
	4.3	Power series	4	8
	4.4	The exponential and logarithmic functions	5	8
	4.5	The trigonometric functions	6	8
	4.6	The algebraic completeness of the complex field	5	8

Syllabus

Textbooks:

1. Tom Apostol, Mathematical Analysis (2^{nd} edition) , Narosa Publishing house.

2. Walter Rudin, Principles of Mathematical Analysis (3^{rd} edition), McGraw Hill Book Company, International Editions.

Module 1:

Functions of bounded variation and rectifiable curves

Introduction, properties of monotonic functions, functions of bounded variation, total variation, additive property of total variation, total variation on(a, x) as a functions of x, functions of bounded variation expressed as the difference of increasing functions, continuous functions of bounded variation, curves and paths, rectifiable path and arc length, additive and continuity properties of arc length, equivalence of paths, change of parameter.

(Chapter 6, Section: 6.1 - 6.12. of Text 1) (20 hours.)

Module 2:

The Riemann-Stieltjes Integral

Definition and existence of the integral, properties of the integral, integration and differentiation, integration of vector valued functions.

(Chapter 6 - Section 6.1 to 6.25 of Text 2) (20 hours.)

Module 3:

Sequence and Series of Functions

Discussion of main problem, Uniform convergence, Uniform convergence and Continuity, Uniform convergence and Integration, Uniform convergence and Differentiation.

(Chapter 7 Section. 7.1 to 7.18 of Text 2) (25 hours.)

Module 4:

Weierstrass Approximation &Some Special Functions

Equicontinuous families of functions, the Stone - Weierstrass theorem, Power series, the exponential and logarithmic functions, the trigonometric functions, the algebraic completeness of complex field.

(Chapter 7 – Sections 7.19 to 7.27, Chapter 8 - Section 8.1 to 8.8 of Text 2)

(25 hours.)

References:-

1. Robert G. Bartle Donald R. Sherbert, Introduction to Real Analysis, 4th Edition, John Wiley and Sons, New York.

2. Gerald B. Folland, Real Analysis: Modern Techniques and Their Applications, 2nd Edition, WeilyInterscience Publication, John Wiley and Sons, New York.

3. Royden H.L, Real Analysis, 2nd edition, Macmillan, New York.

4. Kenneth A. Ross, Elementary Analysis - The Theory of Calculus Second Edition, Springer International

5. Shanti Narayan & M.D. Raisinghania, Elements of Real Analysis, 7th Edition, S. Chand Publishing, New Delhi

Course	Details
Code	**ME010105**
Title	**Graph Theory**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	I st Year / 1 st Semester
Type	Core

CO NO.	COURSE OUTCOMES	Cognitive Level	PSO NO.
CO1	To understand graphs and directed graphs in detail, to prove basic theorems and to find its basic applications in real world.	Un	PSO 1, 4
CO 2	To understand the basic graph classes, graph operators, associated matrices etc.	Un	PSO 1,2
CO 3	To understand various parameters associated with graphs and to prove the relations between them.	Un	PSO 1
CO 4	To understand planar graphs, graph colouring and to prove related famous theorems .	Un	PSO 1,2
CO 5	To understand how graph theory is used to solve optimization problems, communication networks, puzzles, games etc.	Un, Ap	PSO 1,2

- Ap-Apply Un-Understand

Module	Course Description	Hours	CO No.
	Module 1	**19**	
1.1	Introduction and Basic concepts	4	CO 1,2
1.2	Subgraphs, Degree of vertices	3	CO 1,3
1.3	Path and connectedness, Automorphism of simple graphs	4	CO 1
1.4	Line graphs	3	CO 1
1.5	Operations on graphs, Graph products	3	CO 1,2
1.6	Directed graphs	2	CO 1
	Module 2	**19**	
2.1	Connectivity- Introduction,vertex cuts and edge cuts	4	CO 1
2.2	Connectivity and edge connectivity	3	CO 1,3
2.3	Blocks, Cyclical edge connectivity of a graph	2	CO 1
2.4	Trees- Introduction, Definition, characterization and simple properties, centres and centroids	4	CO 1
2.5	Counting the number of spanning trees, Cayley's Formula	4	CO 1
2.6	Applications	2	CO 1,5
	Module 3	**18**	
3.1	Eulerian and Hamiltonian graphs, Hamiltonian around the world game	5	CO 1,5
3.2	Graph coloring-vertex coloring	4	CO 1,3,4
3.3	Applications of graph coloring	3	CO 1,4
3.4	Critical graphs	3	CO 1,3,4
3.5	Brook's theorem	3	CO 1,4
	Module 4	**20**	
4.1	Planar and non planar graphs	4	CO 1,4
4.2	Euler formula and its consequences	3	CO 1,4
4.3	K_5 and $K_{3,3}$ are Nonplanar Graphs, Dual of a graph	4	CO 1,4
4.4	The Four color theorem and the Heawood Five color theorem	5	CO 1,4
4.5	Spectral properties of graph	4	CO 1,2

Text Book

R. Balakrishnan and K. Ranganathan , A Text book of Graph Theory, Second edition Springer.

Module I: Introduction, Basic concepts. Sub graphs. Degrees of vertices. Paths and Connectedness, Automorphism of a simple graph, line graphs, Operations on graphs, Graph Products.
Directed Graphs : Introduction, basic concepts and tournaments.
(Chapter 1 Sections 1.1 – 1.7(Upto 1.7.3 including) 1.8, 1.9)
(Chapter 1 Sections 2.1, 2.2, 2.3) (20Hours)

Module II: Connectivity : Introduction, Vertex cuts and edge cuts, connectivity and edge connectivity, blocks, Cyclical edge Connectivity of a graph.
Trees; Introduction, Definition, characterization and simple properties, centres and cancroids, counting the number of spanning trees, Cayley's formula. Applications
(Chapter 3 Sections 3.1, 3.2 , 3.3, 3.4 and 3.5)
(Chapter 4 Sections4.1, 4.2, 4.3, 4.4 (Up to 4.4.3 including) and 4.5, 4.7) (25Hours)

Module III: Eulerian and Hamiltonian Graphs: Introduction, Eulereian graphs, Hamiltonian Graphs, Hamiltonian around' the world' game
Graph Colorings: Introduction, Vertex Colorings, Applications of Graph Coloring, Critical Graphs, Brooks' Theorem
(Chapter 6 Sections 6.1, 6.2 and 6.3)
(Chapter 7 Sections 7.1, 7.2 and7.3(Up to 7.3.1 including) (20Hours)

Module IV: Planarity: Introduction, Planar and Nonplanar Graphs, Euler Formula and Its Consequences, K_5 and $K_{3,3}$ are Nonplanar Graphs, Dual of a Plane Graph, The Four-Color Theorem and the Heawood Five-Color Theorem .
Spectral Properties of Graphs: Introduction, The Spectrum of a Graph, Spectrum of the Complete Graph Kn, Spectrum of the Cycle Cn,
(Chapter 8 Sections 8.1, 8.2 , 8.3, 8.4, 8.5 and 8.6)
(Chapter 11 Sections 11.1, 11.2 , 11.3 and 11.4) (25Hours)

Books for References :

1. John Clark and Derek Allan Holton, A First Look at Graph Theory, Allied Publishers.
2. Douglas B West, Introduction to Graph Theory, Prentice Hall of India.
3. Sheldon Axler, Linear algebra done right, Second edition ,Springer.

COURSE OUTCOMES

ME010201 : ADVANCED ABSTRACT ALGEBRA

Course	**Details**
Code	**ME010201**
Title	**ADVANCED ABSTRACT ALGEBRA**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	I[st] Year / 2[nd] Semester
Type	Core

COURSE OUTCOME NO.	**COURSE OUTCOMES**	**Cognitive Level**	**PSO NO.**
CO 1	To get an idea about extension of finite fields, Unique Factorisation Domain and Euclidean domain.	Un	PSO 1,2,4
CO 2	To understand basic concepts of Gaussian integers and multiplicative norms.	Un	PSO 1,2
CO 3	To understand fundamental concepts of automorphism of fields and splitting fields.	Un	PSO 1,2
CO 4	To understand fundamental concepts of Galois Theory and its illustration.	Un	PSO 1,2
CO 5	To get an idea about cyclotomic extension.	Un	PSO 1,2

- Un-Understand

M.Sc MATHEMATICS SECOND SEMESTER

COURSE DESCRIPTION

ME010201- ADVANCED ABSTRACT ALGEBRA

5 Hours/Week (Total Hours : 90) **4 Credits**

Module		Course Description	Hrs.	Co No.
I	**1.0**	**Module I**	**20**	
	1.1	Introduction to extension fields	6	1
	1.2	Algebraic extensions	7	1
	1.3	Geometric Constructions Finite fields	7	1
II	**2.0**	**Module II**	**20**	
	2.1	Unique factorization domains	7	1
	2.2	Euclidean domains	7	1
	2.3	Gaussian integers and multiplicative norms	6	2
III	**3.0**	**Module III**	**25**	
	3.1	Automorphism of fields	8	3
	3.2	The isomorphism extension theorem	8	3
	3.3	Splitting fields	9	3
IV	**4.0**	**Module IV**	**25**	
	4.1	Separable extensions	6	4
	4.2	Galois Theory	7	4
	4.3	Illustrations of Galois Theory	6	4
	4.4	Cyclotomic Extensions.	6	5

Syllabus

Textbooks:

John B. Fraleigh, A First Course in Abstract Algebra, 7th edition, Pearson Education.

Module 1

Introduction to extension fields, algebraic extensions, Geometric Constructions Finite fields.

(Part VI – Section 29, 31 – 31.1 to 31.18, 32, 33 of the text) (20 hours)

Module 2

Unique factorization domains, Euclidean domains. Gaussian integers and multiplicative norms

(Part IX – Sections 45,46 & 47 of the text) (20 hours)

Module 3

Automorphism of fields, the isomorphism extension theorem , Splitting fields.

(Part X – Sections 48 & 49, 50 of the text) (25 hours)

Module 4

Separable extensions, Galois Theory, Illustrations of Galois Theory, Cyclotomic Extensions. (mention the insolvability of the quintic)

(Sections 51, 53, 54, 55 - 55.1 to 55.6 of the text) (25 hours)

References:-

1. David S Dummit, Richard M Foote, Abstract Algebra, Third Edition, Wiley.
2. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. M. Artin, Algebra, Prentice -Hall of India, 1991.
4. Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, 2004.
5. Klaus Jonich. Linear Algebra, Springer Verlag.
6. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.
7. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.
8. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
9. Roger A. Horn, Charles R. Johnson, Matrix Analysis, Second Edition, Cambridge University press.

COURSE OUTCOMES

Course	Details
Code	**ME010202**
Title	**Advanced Topology**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	I st Year / 2 nd Semester
Type	Core

CO NO.	COURSE OUTCOMES	COGNITIVE LEVEL	PSO NO.
CO 1	To apply the basic ideas of separation axioms	Ap	PSO 4
CO 2	To understand apply Urysohn's lemma	Un,Ap	PSO 1,4
CO 3	To understand basic concepts related to product topology.	UN	PSO 1,2
CO 4	To learn the concept of evaluation function	Un	PSO 1
CO 5	To identify whether a given property is productive	Un	PSO 1,2
CO 6	To understand the notion of Nets and it's convergence	Un	PSO 1,2
CO 7	To understand and apply fundamental theorems .	Un,App	PSO 1,4

COURSE DESCRIPTION

Department : Mathematics

ME010202 ADVANCED TOPOLOGY

Module		**Course Description**	**Hrs**	**Co. No.**
1	**1.1**	Compactness and Separation Axioms	**10**	**1**
	1.2	Urysohn Characterisation of normality	**4**	**2**
	1.3	Tietze Characterisation of normality	**4**	**7**
2	**2.1**	Cartesian Products	**5**	**3**
	2.2	Product Topology	**10**	**3**
	2.3	Productive properties	**10**	**5**
3	**3.1**	Evaluation Functions	**8**	**4**
	3.2	Embedding Lemma and Tychonoff Embedding	**8**	**7**
	3.3	Urysohn Metrisation Theorem	**6**	**7**
4	**4.1**	Definition and Convergence of Nets	**7**	**6**
	4.2	Homotopy of paths	**10**	**7**

SYLLABUS

Text Books

1. K.D Joshi , Introduction to General Topology , Wiley Eastern Ltd, 1984
2. James R. Munkres , Topology(second edition) , Pearson

Module I :
Separation axioms:- Compactness and Separation axioms , The Urysohn Characterisation of normality –Tietze Characterisation of normality .
(Chapter 7: Sections 2; 2.1 to 2.10 Section 3; 3.1 to 3.6 – Proof of Lemma 3.4 excluded Section 4; 4.1 to 4.7 of text 1)
(20hours)

Module II : Products and Co-products:- Cartesian products of families of sets – The product topology -Productive properties.
(Chapter 8 : Section 1; 1.1 to 1.9 Section 2; 2.1 to 2.8 , Section 3 – 3.1 to 3.6 of text 1)
(25hours)

Module III : Embedding and Metrisation;- Evaluation functions into products – Embedding lemma and Tychonoff Embedding – The Urysohn Metrisation Theorem
(Chapter 9: Section 1; 1.1 1.5, Section 2; 2.1 to 2.5 Section, 3; 3.1 to 3.4 Variation of compactness **(Chapter 11:Sections 1.1 to 1.11 of text 1) (25 hours**)

Module IV : Definition and convergence of nets, Homotopy of paths.
(Chapter 10: Section 1 of text 1; Chapter 9 : Section 1 of text 2)
(20hours)

COURSE OUTCOMES

NAME OF THE COURSE : ME010203 NUMERICAL ANALYSIS WITH PYTHON

Course	Details
Code	**ME010203**
Title	**NUMERICAL ANALYSIS WITH PYTHON**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	Ist Year / 2nd Semester
Type	Core

Course Outcomes No.	Course Outcomes	Cognitive Level	PSO No.
CO 1	To Introduce the basics of Python 3 software. To familiarise different mathematical functions, parameters , operations in Python 3.	Un,	PSO 1, 2
CO 2	To understand symbols, symbolic operations, expression, Solving expressions.	Un ,Ap	PSO 2,3
CO 3	To introduce curve plotting using SymPy.	Un	PSO 2
CO 4	To apply python 3 to solve problems on factor finder, summing a series, solving single variable inequalities.	Ap	PSO 2,5
CO 5	To apply python 3 to find the continuity, differentiability of a function at a point, Maxima and minima of a function, area between the curves.	Ap	PSO 2,5
CO 6	To develop programmes to check the continuity of a function, area under the curve, length of a curve etc..	Cr	PSO 7
CO 7	To understand the concept of Interpolation, polynomial Interpolation, various methods.	Un	PSO 4,5
CO 8	Tounderstand different methods of finding the roots of an algebraic or transcendental expressions	Un	PSO 3,5
CO 9	To apply different numerical methods to find the roots of various algebraic as well s transcendental expressions.	Ap	PSO 1,4
CO 10	To apply python 3 to check the approximation of solutions using different numerical methods.	Ap	PSO 4,7

Un- Understand, Ap- Apply, Cr- Create,

COURSE DESCRIPTION				
COURSE: NUMERICAL METHODS WITH PYTHON				
MODULE	**SECTION**	**DESCRIPTION**		**CO NO.**
0	0.1	Introduction and Basics of python	5	1
	MODULE I		20	
1	1.1	Defining Symbols and Symbolic Operations	2	2
	1.2	Working with expressions	3	2
	1.3	Solving Equations using SymPy	2	3
	1.3	Plotting Curves using SymPy	2	3
	1.4	Problems on Factor Finder	2	4
	1.5	Summing a Series	2	4
	1.5	Solving Single variable inequalities	2	4
	MODULE II		20	
2	2.1	Finding Limit of a Function	3	4
	2.1	Finding the derivative of a function	3	4
	2.2	Higher order Derivatives	3	4
	2.2	Finding Maxima and Minima of a function	4	5
	2.3	Finding Integral of a function	1	5
	2.4	Verify the continuity of a function at a point	3	6
	2.4	Area between two curves and arc length	3	6
	MODULE III		20	
3	3.1	Module 3 : Outline	1	7
	3.1	Interpolation Basic Concepts	3	7
	3.1	Curve Fitting	3	7
	3.2	Polynomial Interpolation	2	7
	3.3	Lagrange's Method	2	7
	3.3	Newton's Method	2	7
	3.4	Limitation of Polynomial Approximation	2	7
	3.5	Roots of the equation	1	8
	3.5	Method of Bisection	2	8
	3.5	Newton-Raphson Method	2	8

	MODULE IV		20	
4	4	Module 4 : Outline	1	9
	4.1	Gauss Elimination Method	3	9
	4.1	Doolittle's Decomposition Method	3	9
	4.2	Numerical Integration	3	9
	4.2	Newton- Coates Formulas	2	8,10
	4.2	Trapezoidal Rule	33	9,10
	4.2	Simpsons Rule	2	9,10
	4.3	Simpsons 3/8 Rule	2	9,10

ME010203 Numerical Analysis with Python3

5 Hours/Week (Total Hours : 90) 4 Credits

Text 1 Jason R Brigs , Python for kids – a playful introduction to programming, No Starch Press

Text 2 Amit Saha, Doing Math with Python, No Starch Press, 2015.

Text 3 Jaan Kiusalaas, Numerical Methods in Engineering with Python3, Cambridge University Press.

Though any distribution of Python 3 software can be used for practical sessions, to avoid difficulty in getting and installing required modules like numpy, scipy etc, and for uniformity, the Python3 package Anaconda 2018.x (https://www.anaconda.com/distribution/#download-section) may be installed and used for the practical sessions. However, a brief introduction on how to use Python IDLE 3 also should be given.

BASICS OF PYTHON

Before going into mathematics programming part, an introduction to Python should be given.No questions should be included in the end semester examination from this unit. Internal examinations may test the knowledge of concepts from this section.

From Text 1, Chapter 2 full – calculations and variables,

Chapter 3 – creating strings, lists are more powerful than strings, tuples,

Chapter 5- If statements, if-then-else statements, if and elif statements, combining conditions, the difference between strings and numbers,

Chapter 6 – using for loops, while we are talking about looping,

Chapter 7 – using functions, parts of a function, using modules

Chapter 9 – The functions abs, float, int, len, max, min, range, sum

From Text 2 Chapter 1 - section complex numbers

Unit I -

Module I : Defining Symbols and Symbolic Operations, Working with Expressions, Solving Equations and Plotting Using SymPy, problems on factor finder, summing a series and solving single variable inequalities

Chapter 4 - From text 2

Unit II

Module II : Finding the limit of functions, finding the derivative of functions, higher-order derivatives and finding the maxima and minima and finding the integrals of functions are to be done. in the section programming challenges, the following problems - verify the continuity of a function at a point, area between two curves and finding the length of a curve

Chapter 7 from text 2

Unit III

Module III : Interpolation and Curve Fitting - Polynomial Interpolation - Lagrange's Method, Newton's Method and Limitations of Polynomial Interpolation,

Roots of Equations - Method of Bisection and Newton-Raphson Method.

Chapter 3, sections 3.1, 3.2 Chapter 4, sections 4.1, 4.3, 4.5 From Text 3, -

Unit IV-

Module III : Gauss Elimination Method (excluding Multiple Sets of Equations), Doolittle's Decomposition Method only from LU Decomposition Methods

Numerical Integration, Newton-Cotes Formulas, Trapezoidal rule, Simpson's rule and Simpson's 3/8 rule.

Chapter 2, sections 2.2, 2.3 , Chapter 6, sections 6.1, 6.2 From Text 3.

1. Instead of assignments, a practical record book should be maintained by the students. Atleast 15 programmes should be included in this record book.

2. Internal assessment examinations should be conducted as practical lab examinations by the faculty handling the paper.

3. End semester examination should focus on questions including concepts from theory and programming. However, more importance should be given to theory in the end semester examinations as internal examinations will be giving more focus on programming sessions.

Course	Details
Code	**ME010204**
Title	**COMPLEX ANALYSIS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	I^{st} Year / 2^{nd} Semester
Type	Core

CO NO.	COURSE OUTSOMES	COGNITIVE LEVEL	PSO NO.
CO 1	To understand the concept of Riemann Sphere and stereographic projections.	Un	PSO 1,2,3
CO 2	To get an idea of conformal mapping and its properties.	Un	PSO 1,2,4
CO 3	To understand the fundamental theorems on complex integration.	Un	PSO 1,2,4
CO 4	To get an idea of index point and also express it by using Cauchy's integral formula.	Un	PSO 1,3,4
CO 5	To demonstrate differentiation under the sign of integration.	Un	PSO 1,3,4
CO 6	To get an idea of singularities.	Un, Ap	PSO 1,2,3,4
CO 7	To introduce the concepts of chains and cycles and express Cauchy's theorems on homological aspects.	Un, Ap	PSO 1,2,4
CO 8	To get an idea of residues and by using this find the definite integrals.	Un,Ap	PSO 1,3,4

- Ap: Apply Un:Understand

COURSE DESCRIPTION

ME010204:COMPLEX ANALYSIS

Module		Course Description	Hrs	CO.No.
1	1.0	Module I	25	1
	1.1	Riemann Sphere	1	1
	1.2	Stereographic projection	2	1
	1.3	Distance between Stereographic projection	2	1
	1.4	Power series	2	1
	1.5	Abel's theorem	2	1
	1.6	Hadamard's formula	1	1
	1.7	Abel's limit theorem	1	1
	1.8	Arcs and Closed curves	2	1
	1.9	Analytic functions in regions	2	1
	1.10	Conformal mappings	2	2
	1.11	Linear transformations	2	2
	1.12	Cross ratio	2	2
	1.13	Symmetry	2	2
	1.14	Families of Circles	2	2
2	2.0	Module II	20	
	2.1	Line integrals	3	3,4
	2.2	Rectifiable arcs	3	3,4
	2.3	Line integrals as functions of arcs	3	3,4
	2.4	Cauchy's theorem for a rectangle	3	3,4
	2.5	Cauchy's theorem in a disc	3	3,4
	2.6	Cauchy's integral formula	3	3,4
	2.7	Index of a point	2	3,4
3	3.0	Module III	20	
	3.1	Higher derivatives	1	3,5
	3.2	Morera's theorem	1	3,5
	3.3	Liouville's theorem	2	3,5
	3.4	Fundamental theorem	2	3,5
	3.5	Cauchy's estimate	2	3,5
	3.6	Removable singularity	2	3,5
	3.7	Taylor's theorem	2	3,5
	3.8	Zeroes and poles	2	3,5
	3.9	Weistrass theorem	2	3,5
	3.10	Maximum principle	2	3,5
	3.11	Schwarz lemma	2	3,5
4	4.0	Module IV	25	
	4.1	Chains and cycles	1	6,7,8
	4.2	Simple connectivity	3	6,7,8
	4.3	Homology	3	6,7,8
	4.4	Cauchy's theorem	3	6,7,8
	4.5	Locally exact differentiation	3	6,7,8
	4.6	Multiply connected regions	3	6,7,8
	4.7	Residue theorem	3	6,7,8
	4.8	Argument principle	3	6,7,8
	4.9	Evaluation of definite integrals	3	6,7,8

Text Book :
Lars V. Ahlfors, Complex Analysis, Third edition, McGraw Hill Internationals

Module-1
The spherical representation of complex numbers , Riemann Sphere, Stereographic projection, Distance between the stereographic projections
Elementary Theory of power series,Abel's Theorem on convergence of the power series, Hadamard's formula, Abel's limit Theorem
Arcs and closed curves, Analytic functions in regions, Conformal mappings, Length and area ,Linear transformations , The cross ratio, Symmetry, Oriented circles, Families of circles.
Chapter – 1
Chapter – 2 Sections.2.1 to 2.5,
Chapter – 3 Sections 2.1, 2.2, 2.3,2.4 and 3.1 to 3.4 of the text (25 hours)

Module-2
Fundamental theorems on complex integration: line integrals, rectifiable arcs, line integrals as functions of arcs, Cauchy's theorem for a rectangle, Cauchy's theorem in a disk,
Cauchy's integral formula: the index of a point with respect to a cloud curve, the integral formula.
Chapter 4 – Sections1, 2.1 and 2.2 of the text (20 hours)

Module-3
Higher derivatives. Differentiation under the sign of integration, Morera's Theorem, Liouville's Theorem, Fundamental Theorem, Cauchy's estimate
Local properties of analytical functions: removable singularities, Taylor's theorem, zeroes and poles,Weirstrass Theorem on essential singularity, the local mapping, the maximum principle, Schwarz lemma
Chapter-4 sections 2.3, 3.1,3.2, 3.3, and 3.4 of the text (20 hours)

Module-4
The general form of Cauchy's theorem: chains and cycles, simple connectivity, homology, general statement of Cauchy's theorem, proof of Cauchy's theorem, locally exact differentiation, multiply connected regions
Calculus of Residues: the residue theorem, the argument principle, evaluation of definite integrals.
Chapter-4 Sections 4 and 5 of the text (25 hours)

Course	Details
Code	**ME010205**
Title	**Measure Theory and Integration**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 2nd Semester
Type	Core

COURSE OUTCOME NO.	COURSE OUTCOMES	Cognitive Level	PSO NO.
CO 1	To understand drawback of Riemann integration and how to overcome this drawback using Lebesgue integration.	Un	PSO 1
CO 2	To implement the new concept “measure” of a set for doing Lebesgue integration.	Un	PSO 1
CO 3	To evaluate Lebesgue integral of functions by approximating the known Riemann integrals of the same functions.	Un	PSO 1,4
CO 4	To prove various equalities and inequalities of Lebesgue integrals as generalisations of Riemann integrals	Un	PSO 1
CO 5	To integrate functions which are not Riemann integrable.	Un	PSO 1, 7

Un: Understand, Ap: Apply

Module	Course Description	Hours	CO No.
	Module 1	**23**	
1.1	Lebesgue Measure: Introduction	5	CO 1,2
1.2	Lebesgue outer measure, The sigma algebra of Lebesgue measurable sets	5	CO 1,2
1.3	Outer and inner approximation of Lebesgue measurable sets	5	CO 1,2,4
1.4	Countable additivity, continuity and Borel-Cantelli Lemma	4	CO 1,4
1.5	Non measureable sets , The Cantor set and Cantor Lebesgue function	4	CO 1
	Module 2	**23**	
2.1	Lebesgue Measurable Functions	4	CO 1
2.2	Lebesgue Integration: Sums, products and compositions	3	CO 1,3
2.3	Sequential pointwise limits and simple approximation	5	CO 1,3,4
2.4	The Riemann Integral – The Lebesgue integral of a bounded measurable function over a set of finite measure	4	CO 1,3,4,5
2.5	The Lebesgue integral of a measurable non-negative function	4	CO 1,3,4,5
2.6	The general Lebesgue integral	3	CO 1,3,4
	Module 3	**18**	
3.1	General Measure Space and Measureable Functions	3	CO 1
3.2	Measures and measurable sets	4	CO 1
3.3	Signed Measures: The Hahn and Jordan decompositions	4	CO 1,4
3.4	The Caratheodory measure induced by an outer measure	3	CO 1,4
3.5	Measureable functions	4	CO 1
	Module 4	**18**	
4.1	Integration over General Measure Space and Product Measures	4	CO 1
4.2	Integration of non negative meaurable functions	3	CO 1
4.3	Integration of general measurable functions	4	CO 1
4.4	The Radon Nikodym Theorem	3	CO 1
4.5	Product measure: The theorems of Fubini and Tonelli	4	CO 1

Text Book

H. L. Royden, P.M. Fitzpatrick, Real Analysis Fourth Edition, Pearson Education

Module 1: Lebesgue Measure: Introduction, Lebesgue outer measure, The sigma algebra of Lebesgue mesurable sets, Outer and inner approximation of Lebesgue measurable sets , Countable additivity, continuity and Borel-Cantelli Lemma - Non measureable sets - The Canter set and Canter Lebesgue function
Chapter 2; Sections 2.1 to 2.7 **(25 Hours)**

Module 2: Lebesgue Measurable Functions and Lebesgue Integration: Sums, products and compositions – Sequential pointwise limits and simple approximation – The Riemann Integral – The Lebesgue integral of a bounded measurable function over a set of finite measure – The Lebesgue integral of a measurable non negative function – The general Lebesgue integral.
Chapter 3; Sections 3.1 to 3.2, Chapter 4; Sections 4.1 to 4.4 **(25 Hours)**

Module 3: General Measure Space and Measureable Functions: Measures and measurable sets – Signed Measures: The Hanh and Jordan decompositions – The Caratheodory measure induced by an outer measure – Measureable functions
Chapter 17; Sections 17.1 to 17.3, Chapter 18; Section 18.1 upto corollory 7 (20 Hours)

Module 4: Integration over General Measure Space and Product Measures: Integration of non negative meaurable functions – Integration of general mesurable functions – The Radon Nikodym Theorem – Product measure: The theorems of Fubini and Tonelli
Chapter 18; Sections 18.2 to 18.4, Chapter 20; Section 20.1 **(20 Hours)**

Books for References :

1. G. de Barra : Measure Theory and integration , New Age International (P) Ltd., New Delhi,.
2.Halmos P.R, Measure Theory, D.vanNostrand Co.
3. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age International (P) Ltd., New Delhi, 1986(Reprint 2000).
4. R.G. Bartle, The Elements of Integration, John Wiley & Sons, Inc New York, 1966.

Course	Details
Code	**ME010301**
Title	**ADVANCED COMPLEX ANALYSIS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 3rd Semester
Type	Core

CO No.	COURSE OUTCOMES	COGNITIVE LEVEL	PSO NO.
CO 1	To understand the harmonic functions, subharmonic functions and to prove the famous theorems related to these functions	Un	PSO 1
CO 2	To understand the Dirichlet's problem and its solution briefly	Un	PSO 1
CO 3	To understand the concept of power series and its convergence, absolute convergence and uniform convergence	Un	PSO 1,7
CO 4	To understand the Riemann Zeta function, its product development and its zeroes	Un	PSO 1
CO 5	To understand the Normal families of functions and its relations to a compact set	Un	PSO 1
CO 6	To understand that any simply connected region is topologically equivalent to an open unit disk - Riemann mapping theorem	Un	PSO 1
CO 7	To learn how to extend Riemann mapping to the boundary of a simply connected domain using polygons	Un	PSO 1

Module	Course Description	Hours	CO No.
	Module 1	**23**	
1.1	Harmonic Functions – Definitions and Basic Properties	5	CO 1
1.2	The Mean-Value Property, Poisson’s Formula, Schwarz’s Theorem, The Reflection Principle.	5	CO 1
1.3	A closer look at Harmonic Functions – Functions with Mean Value Property, Harnack’s Principle.	6	CO 1
1.4	The Dirichlet’s Problem – Subharmonic Functions, Solution of Dirichlet’s Problem without proof	7	CO 1,2
	Module 2	**17**	
2.1	Power Series Expansions – Weierstrass’s theorem	4	CO 3
2.2	The Taylor Series, The Laurent Series Partial Fractions and Factorization – Partial Fractions,	4	CO 3
2.3	Infinite Products, Canonical Products, The Gamma Function.	5	CO 4
2.4	Entire Functions – Jensen’s Formula, Hadamard’s Theorem - proof excluded)	4	CO 5
	Module 3	**20**	
3.1	The Riemann Zeta Function – The Product Development	6	CO 4
3.2	The Extension of Riemann Zeta Function to the Whole Plane,	4	CO 4
3.3	The Functional Equation, The Zeroes of the Zeta Function	5	CO 4
3.4	Normal Families – Normality and Compactness, Arzela’s Theorem	5	CO 5
	Module 4	**16**	
4.1	The Riemann Mapping Theorem – Statement and Proof	4	CO 6
4.2	Boundary Behaviour, Use of the Reflection Principle	6	CO 7
4.3	The Weierstrass’s Theory – The Weierstrass’s P - function, The Differential Equation	6	CO 7

Text Book

Complex Analysis – Lars V. Ahlfors (Third Edition), McGraw Hill Book Company

Module 1: Harmonic Functions – Definitions and Basic Properties, The Mean-Value Property, Poisson's Formula, Schwarz's Theorem, The Reflection Principle. A closer look at Harmonic Functions – Functions with Mean Value Property, Harnack's Principle. The Dirichlet's Problem – Subharmonic Functions, Solution of Dirichlet's Problem (Proof of Dirichlet's Problem and Proofs of Lemma 1 and 2 excluded).
(Chapter 4 : Section 6: 6.1 - 6.5, Chapter 6 : Section 3 : 3.1 - 3.2 , Section 4 : 4.1 - 4.2)

Module 2: Power Series Expansions – Weierstrass's theorem, The Taylor Series, The Laurent Series Partial Fractions and Factorization – Partial Fractions, Infinite Products, Canonical Products, The Gamma Function. Entire Functions – Jensen's Formula, Hadamard's Theorem (Hadamard's theorem – proof excluded).
(Chapter 5 : Section 1 : 1.1 - 1.3, Section 2 : 2.1 – 2.4, Section 3 : 3.1 – 3.2)

Module 3: The Riemann Zeta Function – The Product Development, The Extension of □□(s) to the Whole Plane, The Functional Equation, The Zeroes of the Zeta Function. Normal Families – Normality and Compactness, Arzela's Theorem.
(Chapter 5 : Section 4 : 4.1 – 4.4, Section 5 : 5.2 - 5.3)

Module 4: The Riemann Mapping Theorem – Statement and Proof, Boundary Behaviour, Use of the Reflection Principle. The Weierstrass's Theory – The Weierstrass's □□- function, The functions □□and □□, The Differential Equation.
(Chapter 6 : Section 1: 1.1-1.3, Chapter 7 : Section 3 : 3.1 – 3.3)

Books for References :

1. Chaudhary B., The Elements of Complex Analysis, Wiley Eastern.
2. Cartan H., Elementary theory of Analytic Functions of one or several variable, Addison Wesley, 1973.
3. Conway J. B., Functions of one complex variable, Narosa publishing.
4. Lang S., Complex Analysis, Springer.
5. H. A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
6. Ponnuswamy S., Silverman H., Complex Variables with Applications

COURSE OUTCOMES

ME010302 PARTIAL DIFFERENTIAL EQUATIONS

Course	**Details**
Code	**ME010302**
Title	**PARTIAL DIFFERENTIAL EQUATIONS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 3rd Semester
Type	Core

Course Outcomes No.	**Course Outcomes**	**Cognitive Level**	**PSO No.**
CO 1	To understand the solutions of first order partial differential equations and orthogonal trajectories of a system of curves on a surface.	Un	PSO 1,4
CO 2	To apply various methods to solve first order linear differential equations, pfaffian differential forms.	Ap	PSO 1,2
CO 3	To apply methods to solve non linear partial differential equations of first order.	Ap	PSO 1,2,4
CO 4	To understand Charpit's method, Jacobi's method	Un	PSO 1
CO 5	To understand the origin of second order equations	Un	PSO 1
CO 6	To apply various methods to solve equations with variable coefficients .	Ap	PSO 1,2,4
CO 7	To solve the non linear equations of second order and find elementary solutions of Laplace equations.	Ap	PSO 1,4

Un- Understand, Ap- Apply, Cr- Create

COURSE DESCRIPTION

ME010302: PARTIAL DIFFERENTIAL EQUATIONS

Module		Course Description	Hrs	CO.No.
1		**MODULE I**	**20**	
	1.1	Methods of solutions of dx/P = dy/Q = dz/R.	4	**1,2**
	1.2	Orthogonal trajectories of asystem of curves on a surface.	3	**1**
	1.3	Pfaffian differential forms and equations.	4	**2**
	1.4	Solution of Pfaffian differential equations in three variables	4	**2**
	1.5	Partial differential equations.	3	**3**
	1.6	Orgins of first order partial differential equation	2	**3**
2		**MODULE II**	**25**	
	2.1	Linear equations of first order	3	**2**
	2.2	Integral surfaces passing through a given curve	3	**3**
	2.3	Surfaces orthogonal to a given system of surfaces	3	**3**
	2.4	Nonlinear partial differential equation of the first order .	3	**3**
	2.5	Compatible systems of first order equations	3	3
	2.6	Charpits Method	3	4
	2.7	Special types of first order equations.	3	4
	2.8	Solutions satisfying given conditions	3	4
3		**MODULE III**	**20**	
	3.1	Jacobi's method	5	4
	3.2	The origin of second order equations.	5	5
	3.3	Linear partial differential equations with constant coefficients.	5	5,6
	3.4	Equations with variable coefficients	5	5,6
4		**MODULE IV**	**25**	
	4.1	Separation of variables.	4	**7**
	4.2	Non linear equations of the second order .	4	**7**
	4.3	Elementary solutions of Laplace equation.	4	**7**
	4.4	Families of equipotential surfaces	4	**7**
	4.5	The two dimensional Laplace equation.	4	**7**
	4.6	Relation of Logarithmic potential to the theory of functions	4	**7**

SYLLABUS

Textbooks:
Ian Sneddon, Elements of partial differential equations, Mc Graw Hill Book Company.

Module:-1
Methods of solutions of dx/P = dy/Q = dz/R. Orthogonal trajectories of a system of curves on a surface. Pfaffian differential forms and equations.Solution of Pfaffian differential equations in three variables. Partial differential equations. Orgins of first order partial differential equation .
(Sections 1.3 to 1.6 & 2.1, 2.2 of the text) (20 hours)

Module:-2
Linear equations of first order. Integral surfaces passing through a given curve. Surfaces orthogonal to a given system of surfaces.Non linear partial differential equation of the first order . Compatible systems of first order equations .Charpits Method. Special types of first order equations. Solutions satisfying given conditions
(Section 2.4 to2.7, 2.9 to 2.12 of the text) (25 hours)

Module:-3
Jacobi's method.The origin of second order equations. Linear partial differential equations with constant coefficients. Equations with variable coefficients.
(Section 2.13, 3.1, 3.4, 3.5 of the text) (20 hours)

Module:-4
Separation of variables. Non linear equations of the second order . Elementary solutions of Laplace equation. Families of equipotential surfaces. The two dimensional Laplace equation. Relation of Logarithmic potential to the theory of functions
(Section 3.9,3.10,4.2, 4.3 ,4.11,4.12 of the text) (25 hours)

COURSE OUTCOME

ME010303 : MULTIVARIATE CALCULUS AND INTEGRAL TRANSFORMS

Course	**Details**
Code	**ME010303**
Title	**MULTIVARIATE CALCULUS AND INTEGRAL TRANSFORMS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2^{nd} Year / 3^{rd} Semester
Type	Core

CO NO.	**COURSE OUTCOMES**	**COGNITIVE LEVEL**	**PSO NO.**
CO 1	To learn Weirstrass theorem, Fourier integral theorem more theorems regarding integral transforms.	Un	PSO 1,2
CO 2	To get an idea about multivariate differential calculus.	Un	PSO 1,4
CO 3	To understand different types of derivatives & Jacobian matrix.	Un	PSO 1,2
CO 4	To understand more about implicit functions.	Un	PSO 1,5
CO 5	To learn Mean value theorem for differentials, proof of Stokes theorem.	Un, Ap	PSO 1,4
CO 6	To understand primitive mapping,partitions and change of variables	Un	PSO 1,4

Un – Understand, Ap – Apply

ME010303 : MULTIVARIATE CALCULUS AND INTEGRAL TRANSFORMS

COURSE DESCRIPTION

Module		Course Description	Hrs	CO.No.
1		**MODULE I**	**20**	
	1.1	The Weirstrass theorem	2	**1**
	1.2	Other forms of Fourier series	3	**1**
	1.3	The Fourier integral theorem	2	**1**
	1.4	The exponential form of the Fourier integral theorem	2	**1**
	1.5	Integral transforms and convolutions	5	**1**
	1.6	The convolution theorem for Fourier transforms	6	**1**
2		**MODULE II**	**22**	
	2.01	The directional derivative	2	**2**
	2.02	Directional derivatives and continuity	2	**2**
	2.03	The total derivative	2	**2**
	2.04	The total derivative expressed in terms of partial derivatives	2	**2**
	2.05	An application of complex- valued functions	2	**2**
	2.06	The matrix of a linear function	2	**2**
	2.07	The Jacobian matrix	2	**3**
	2.08	The chain rate matrix form of the chain rule	2	**3**
	2.09	Implicit functions and extremum problems	2	**4**
	2.10	The mean value theorem for differentiable functions	2	**5**
3		**MODULE III**	**28**	
	3.1	A sufficient condition for differentiability	4	**5**
	3.2	A sufficientcondition for equality of mixed partial derivatives	4	**5**
	3.3	Functions with non-zeroJacobian determinant	4	**5**
	3.4	The inverse function theorem (without proof)	4	**5**
	3.5	The implicit function theorem (without proof)	4	**5**
	3.6	Extrema of real- valued functions of one variable	4	**5**
	3.7	Extrema of real- valued functions of several variables	4	**5**
4		**MODULE IV**	**20**	
	4.1	Integration of Differential Forms	4	**6**
	4.2	Primitive mappings	4	**6**
	4.3	Partitions of unity	4	**6**
	4.4	Change of variables	4	**6**
	4.5	Differential forms	4	**6**

SYLLABUS

Textbooks:

1. Tom APOSTOL, Mathematical Analysis, Second edition, Narosa Publishing House.
2. WALTER RUDIN, Principles of Mathematical Analysis, Third edition –International Student Edition.

Module 1:
The Weirstrass theorem, other forms of Fourier series, the Fourier integral theorem, the exponential form of the Fourier integral theorem, integral transforms and convolutions, the convolution theorem for Fourier transforms.
(Chapter 11 Sections 11.15 to 11.21 of Text 1) (20 hours)

Module 2: Multivariable Differential Calculus
The directional derivative, directional derivatives and continuity, the totalderivative, the total derivative expressed in terms of partial derivatives, An application of complex- valued functions, the matrix of a linear function, the Jacobian matrix, the chain rate matrix form of the chain rule, Implicit functions and extremum problems, the mean value theorem for differentiable functions.
(Chapter 12 Sections. 12.1 to 12.11 of Text 1) (22 hours)

Module 3: A sufficient condition for differentiability, a sufficientcondition for equality of mixed partial derivatives, functions with non-zeroJacobian determinant, the inverse function theorem (without proof), theimplicit function theorem (without proof), extrema of real-valued functions ofone variable, extrema of real- valued functions of several variables.
Chapter 12 Sections-. 12.12 to 12.13. of Text 1
Chapter 13 Sections-. 13.1 to 13.6 of Text 1 (28 hours)

Module 4: Integration of Differential Forms, Integration, primitive mappings, partitions of unity, change of variables, differential forms.
Chapter 10 Sections. 10.1 to 10.14 Text 2 (20 hours)

COURSE OUTCOMES

ME010304 - FUNCTIONAL ANALYSIS

Course	**Details**
Code	**ME010304**
Title	**FUNCTIONAL ANALYSIS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 3rd Semester
Type	Core

CO NO.	**COURSE OUTCOMES**	**COGNITIVE LEVEL**	**PSO NO.**
CO 1	To understand the basic ideas of of the theory of Normed space ,Banach Space.	Un	PSO 1,2
CO 2	To understand the basic ideas of of the theory Inner product space, Hilbert Space.	Un	PSO 1,2
CO 3	To Understand the concept of Linear Operators Defined On Banach space and inner product space.	Un	PSO 2
CO 4	To apply the ideas from linear algebra and the theory of metric space in functional analysis.	Ap	PSO 4
CO 5	To understand and apply fundamental theorems in Banach space including Hahn-Banach theorem	Un, Ap	PSO 2,4
CO 6	To understand the basic theory of bounded linear operators.	Un	PSO 2
CO 7	To apply Zorn's lemma in the theory of Hilbert space.	Ap	PSO 4

COURSE DESCRIPTION

Department : Mathematics

ME010304 - FUNCTIONAL ANALYSIS

Module		**Course Description**	**Hrs**	**Co.No.**
1	**1.1**	Preliminary	**3**	**1**
	1.2	Vector space	**2**	**2**
	1.3	Banach space	**5**	**2**
	1.4	Finite dimension	**5**	**3**
	1.5	Linear operators	**5**	**3**
2	**2..1**	Linear Functional	**4**	**3**
	2.2	Dual space	**6**	**4**
	2.3	Inner product space	**10**	**4**
3	**3.1**	Orthonormal sets	**15**	**5**
	3.2	Hilbert adjoint operators	**10**	**5**
4	**4.1**	Hahn BanachTheorem	**5**	**5**
	4.2	Adjoint operators	**10**	**6**
	4.3	Reflexive spaces	**7**	**6**

<u>SYLLABUS</u>

Text Book: Erwin Kreyszig, Introductory Functional Analysis with applications, John Wiley and sons, New York

<u>Module 1:</u>

Examples, Completeness proofs, Completion of Metric Spaces, Vector Space, Normed Space, Banach space, Further Properties of Normed Spaces, Finite Dimensional Normed spaces and Subspaces, Compactness and Finite Dimension

(Chapter 1 – Sections 1.5, 1.6; Chapter 2 - Sections 2.1 to 2.5)

<u>Module 2:</u>

Linear Operators, Bounded and Continuous Linear Operators, Linear Functionals, Linear Operators and Functionals on Finite dimensional spaces, Normed spaces of operators, Dual space

(Chapter 2 - Section 2.6 to 2.10)

<u>Module 3:</u>

Inner Product Space, Hilbert space, Further properties of Inner Product Space, Orthogonal Complements and Direct Sums, Orthonormal sets and sequences, Series related to Orthonormal sequences and sets, Total Orthonormal sets and sequences, Representation of Functionals on Hilbert Spaces

(Chapter 3 - Sections 3.1 to 3.6, 3.8)

<u>Module 4:</u>

Hilbert-Adjoint Operator, Self-Adjoint, Unitary and Normal Operators, Zorn's lemma, Hahn-Banach theorem, Hahn- Banach theorem for Complex Vector Spaces and Normed Spaces, Adjoint Operators

(Chapter 3 - Sections 3.9, 3.10; Chapter 4 - Sections 4.1 to 4.3, 4.5)

Course	Details
Course Code	ME010305
Name of the Course	Optimization Techniques
Hourse Per Week	5
Credit	4

CO No	**Course Outcome**	**Cognitive Level**	**PSO No**
CO 01	Describe the basic concepts of Linear, Integer Programing Problem	Un	PSO 1
CO 02	Apply the basic methods of IPP for solving IPP	Ap	PSO 2, PSO 5
CO 03	Use sensitivity analysis to study the effect of changes in solved LP Problems	Ap	PSO 2, PSO 5
CO 04	Analyze the basic flow and potential problems using algorithms	An	PSO 2
CO 05	Describe the importance of iterative procedures in solving the Non-linear programing methods	C	PSO 4
CO 06	Solve the basics of the Game theoretic problems	Ap	PSO 2, PSO 5

Re – Remember, Un – Understand, Ap – Apply, An – Analyze

ME010305 OPTIMIZATION TECHNIQUES

1.0	LINEAR PROGRAMMING	**24**	
1.01	Basics of LPP	5	CO 01
1.02	Simplex method of solving LPP	6	CO 01
1.03	Cannonical form	2	CO 01
1.04	Simplex method for LPP with equality constraints	3	CO 01
1.05	Simplex multipliers	1	CO 01
1.06	Revised simplex method	2	CO 01
1.07	Duality of LPP and associated theorems	3	CO 01
1.08	Dual Simplex Procedure	2	CO 01
2	**INTEGER PROGRAMMING**	**14**	
2.01	Introduction to Integer Programming Problem	1	CO 02
2.02	Comparison of IPP and LPP		CO 02
2.03	Theorems comparing the solution of LPP and corresponding IPP	2	CO 02
2.04	Branch and Bound Algorithm – Procedure	4	CO 02
2.05	Problems based on Branch and Bound algorithm		CO 02
2.06	Cutting plane algorithm – Procedure	4	CO 02
2.07	Two problems using cutting plane algorithm		CO 02
2.08	0-1 Problems		CO 02
2.09	Either- or problems with an example	1	CO 02
2.10	Fixed cost problems with an example	1	CO 02
2.11	Integer valued problems with an example	1	CO 02
3.00	**GOAL PROGRAMMING , FLOW AND POTENTIALS IN NETWORKS**	**20**	
3.01	Introduction to goal programing	3	CO 03
3.02	Example problem of goal programming		CO 03
3.03	Introduction and basic definitions of Network Flows	1	CO 03
3.04	Minimum path problem with non negative coefficients	2	CO 03
3.05	Minimum path problem with negative coefficients	1	CO 03
3.06	Spanning tree of minimum length	4	CO 03
3.07	Problem of minimum potential difference	1	CO 03
3.08	Critical path method	2	CO 03
3.09	Project Evaluation and Review technique	1	CO 03
3.10	Maximum Flow Problems	2	CO 03
3.11	Generalized maximum flow problems	2	CO 03
3.12	Duality of maximum flow problems	1	CO 03
4.00	**NON- LINEAR PROGRAMMING**	**29**	
4.01	Basic Concepts	1	CO 04

4.02	Taylor’s series expansion and conditions for optimality	2	CO 04
4.03	Fibonacci Search	2	CO 04
4.04	Golden Section Search	1	CO 04
4.05	Hooke Jeevs Algorithm	2	CO 04
4.06	Gradient projection search	2	CO 04
4.07	Scaling and Oscillation	1	CO 04
4.08	Newton’s Method of Gradient Projection	2	CO 04
4.09	Lagragian multiplier	2	CO 04
4.10	Constrained Derivative	3	CO 04
4.11	Project Gradient method with equality constraints	3	CO 04
4.12	Kuhn-Tucker Consitions	2	CO 04
4.13	Quadriatic Programming	1	CO 04
4.14	Complementary pivot problem	2	CO 04
4.15	LPP as Complementary Pivot Problem		CO 04
4.16	QPP as complementary pivot problem		CO 04
4.17	Complementary pivot Algorithm and Problems	3	CO 04

<u>SYLLABUS</u>

Text Books

1. K.V. Mital and C. Mohan, Optimization Methods in Operation Research and Systems Analysis, 3rd edition.
2. Ravindran, Philips and Solberg. Operations Research Principle and Practice, 2nd edition, John Wiley and Sons.

Module I: LINEAR PROGRAMMING

Simplex Method, Canonical form of equations, Simplex Method (Numerical Example), Simplex Tableau, Finding the first BFS and artificial variables, Degeneracy, Simplex multipliers, Revised simplex method, Duality in LPP, Duality theorems, Applications of Duality, Dual simplex method, Summery of simplex methods.

(Chapter 3; sections: 9 – 21 of text – 1) (25 hours)

Module II: INTEGER PROGRAMMING

I.L.P in two dimensional space – General I.L.P. and M.I.L.P problems – cutting planes – remarks on cutting plane methods – branch and bound method – examples –general description – the 0 – 1 variable.

(Chapter 6; sections: 6.1 – 6.10 of text – 1) (25 hours)

Module III: GOAL PROGRAMMING , FLOW AND POTENTIALS IN NETWORKS

Goal programming. Graphs- definitions and notation – minimum path problem – spanning tree of minimum length – problem of minimum potential difference – scheduling of sequential activities – maximum flow problem – duality in the maximum flow problem – generalized problem of maximum flow.

(Chapter – 5 & 7 Sections 5.9 & 7.1 to 7.9, 7.15 of text - 1) (15 hours)

Module IV: NON- LINEAR PROGRAMMING

Basic concepts – Taylor's series expansion – Fibonacci Search - golden section search– Hooke and Jeeves search algorithm – gradient projection search – Lagrange multipliers – equality constraint optimization, constrained derivatives – non-linear optimization: Kuhn-Tucker conditions – complimentary Pivot algorithms.

(Chapter 11; Sections: 11.1 – 11.7, 11.9- 11.11 of text – 2) (25 hours)

Course	Details
Code	**ME010401**
Title	**SPECTRAL THEORY**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 4th Semester
Type	Core

COURSE OUTCOME NO.	COURSE OUTCOMES	Cognitive Level	PSO NO.
CO 1	To understand the reflexive spaces and the Category theorem	Un	PSO 1
CO 2	To understand various types of convergence and the relation between them.	Un	PSO 1
CO 3	To understand the important theorems in operator theory and to prove them.	Un	PSO 1
CO 4	To understand self adjoint and compact linear operators and their properties	Un	PSO 1,7
CO 5	To understand the spectrum of bounded and closed linear operators.	Un	PSO 1
CO 6	To understand the spectral properties in a Banach Algebra.	Un	PSO 1

Un: Understand, Ap: Apply

Module	Course Description	Hours	CO No.
	Module 1	**19**	
1.1	Reflexive Spaces, Category theorem(statement only), Uniform Boundedness theorem (applications excluded)	6	CO 1,3
1.2	Strong and Weak Convergence, Convergence of Sequences of Operators and Functionals	7	CO 2
1.3	Open Mapping Theorem, Closed Linear Operators, Closed Graph Theorem	6	CO 3,5
	Module 2	**21**	
2.1	Banach Fixed point theorem	3	CO 3
2.2	Spectral theory in Finite Dimensional Normed Spaces, Basic Concepts	6	CO 3
2.3	Spectral Properties of Bounded Linear Operators, Further Properties of Resolvent and Spectrum	7	CO 3,5
2.4	Use of Complex Analysis in Spectral Theory	5	CO 5
	Module 3	**22**	
3.1	Banach Algebras, Further Properties of Banach Algebras	4	CO 6
3.2	Compact Linear Operators on Normed spaces, Further Properties of Compact Linear Operators	6	CO 3,4
3.3	Spectral Properties of compact Linear Operators on Normed spaces	5	CO 3,4
3.4	Further Spectral Properties of Compact Linear Operators	7	CO 4,5
	Module 4	**18**	
4.1	Spectral Properties of Bounded Self adjoint linear operators	6	CO 3,4,5
4.2	Further Spectral Properties of Bounded Self Adjoint Linear Operators	5	CO 3,4,5
4.3	Positive Operators, Projection Operators, Further Properties of Projections	7	CO 3,4

Text Book

Erwin Kreyszig, Introductory Functional Analysis with applications, John Wiley and sons, New York

Module I: Reflexive Spaces, Category theorem(statement only), Uniform Boundedness theorem (applications excluded), Strong and Weak Convergence, Convergence of Sequences of Operators and Functionals, Open Mapping Theorem, Closed Linear Operators, Closed Graph Theorem .
(Chapter 4 - Sections 4.6 to 4.9, 4.12, 4.13) (20 Hours)

Module 2: Banach Fixed point theorem, Spectral theory in Finite Dimensional Normed Spaces, Basic Concepts, Spectral Properties of Bounded Linear Operators, Further Properties of Resolvent and Spectrum, Use of Complex Analysis in Spectral Theory.
(Chapter5 – Section 5.1; Chapter 7 - Sections 7.1 to 7.5) (25 Hours)

Module 3: Banach Algebras, Further Properties of Banach Algebras, Compact Linear Operators on Normed spaces, Further Properties of Compact Linear Operators, Spectral Properties of compact Linear Operators on Normed spaces, Further Spectral Properties of Compact Linear Operators.
(Chapter 7 - Sections 7.6, 7.7; Chapter 8 - Sections 8.1 to 8.4) (25 Hours)

Module 4: Spectral Properties of Bounded Self adjoint linear operators, Further Spectral Properties of Bounded Self Adjoint Linear Operators, Positive Operators, Projection Operators, Further Properties of Projections .
(Chapter 9 - Sections 9.1 to 9.3, 9.5, 9.6) (20 Hours)

Books for References :

1. Limaye, B.V, Functional Analysis, New Age International (P) LTD, New Delhi, 2004

2. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York, 1963

3. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi, 1989

4. Somasundaram. D, Functional Analysis, S.Viswanathan Pvt. Ltd, Madras, 1994

5. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd, Meerut: 1995-96

6. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, 2008

7. Walter Rudin, Functional Analysis, TMH Edition, 1974.

<u>MSc Mathematics – Semester 4</u>

<u>COURSE OUTCOMES</u>

ME010402: ANALYTIC NUMBER THEORY

CO NO.	COURSE OUTCOMES	COGNITIVE LEVEL	PSO NO.
CO 1	To understand the various types of arithmetic functions.	Un	PSO 1
CO 2	To get the idea of Dirichlet multiplication and by using this find the Dirchlet product of arithmetical functions.	Un, Ap	PSO 1, 4
CO 3	To understand the averages of arithmetical functions.	Un	PSO 1
CO 4	To get the idea of Chebyshev's functions, using this derive prime number theorem.	Un	PSO 1
CO 5	To understand the concepts of congruences and by using this find the inverses of field elements.	Un, Ap	PSO 1, 4
CO 6	To learn the Chinese remainder theorem and find its application.	Un	PSO 1
CO 7	To get an idea of primitive roots and reduced residue systems.	Un	PSO 1
CO 8	To understand the geometric representation of partitions and derive the Euler's pentagonal - number theorems	Un	PSO 1

Un: Understand, Ap: Apply

COURSE DESCRIPTION

Module		Course Description	Hrs	Co. No.
I	1.0	**Module I : Arithmetic Functions Dirchlet Multiplication and Averages of Arithmetical functions**	**30**	
	1.1	Mobius function & Euler totient function	2	1
	1.2	Dirchlet product of arithmetical functions	2	1
	1.3	Dirchlet inverse and Mobius inversion formula	2	1
	1.4	Mangoldt function &Liovilles function	3	1
	1.5	Multiplicative functions & Dirchlet multiplication	3	1,2
	1.6	Inverse of completely multiplicative functions	3	1,2
	1.7	Divisor function & generalised convolutions	3	1,2
	1.8	Formal power series & Bell series	3	1,2
	1.9	Assymptotic equality of functions	3	1,2
	1.10	Euler's summation formula	3	1,2
	1.11	Average order of arithmetic functions	3	1,3
	1.12	Application of distribution of lattice points visible from origin	3	1,3
	1.13	Partial sums of a Dirchlet product	3	1,3
II	2.0	**Module II : Some Elementary Theorems on the Distribution of prime numbers**	**15**	
	2.1	Chebyshev's functions	3	1,4
	2.2	Some equivalent forms of prime number theorem	3	1,4
	2.3	Shapiro's Tauberian theorem	3	1,4
	2.4	Applications of Shapiro's theorem	3	1,4
	2.5	Assymptotic formula for the partial sum	3	1,4
III	3.0	**Module III : Congruences**	**30**	
	3.1	Definition & Basic properties of congruences	3	5
	3.2	Residue classes & complete residue systems	3	5
	3.3	Linear congruences	4	5
	3.4	Reduced residue systems & Euler Fermat theorem	4	5
	3.5	Polynomial congruences	4	5
	3.6	Langrange's theorem& its applications	4	5
	3.7	Chinese remainder theorem & its applications	4	6
	3.8	Polynomial congruences with prime power moduli	4	6
IV	4.0	**Module IV : Primitive roots & partitions**	**15**	
	4.1	The exponent of a number mod m	2	7
	4.2	Primitive roots & reduced systems	2	7
	4.3	The non existence of primitive roots mod 2^{α} for $\alpha \geq 3$	2	7
	4.4	The existence of primitive roots mod p for odd primes p	3	7
	4.5	Partitions & generating functions for partitions	3	7
	4.6	Euler's pentagonal number theorem	3	7

Syllabus

Text book: Tom M Apostol, Introduction to Analytic number theory, Springer International Student Edition, Narosa Publishing House.

Module I:

Arithmetic Functions, Dirichlet Multiplication and Averages of Arithmetical functions Arithmetic Functions, Dirichlet Multiplication:Introduction,The Möbius function μ(n),The Euler totient function ϕ(n), a relation connecting μ and ϕ, a product formula for ϕ(n),The Dirichlet product of arithmetical functions, Dirichlet inverse sand the Möbius inversion formula, The Mangoldt function ∧(n),Multiplicative functions, Multiplicative functions and DirichletMultiplication, The inverse of a completely multiplicative function, The Liouville's function λ(n),The divisor function $\sigma\alpha$(n),Generalized convolutions

Averages of Arithmetical functions:Introduction,The big oh notation, Asymptotic equality of functions,Eulers summation formula, Some elementary asymptotic formulas, The average order of d(n),The average order of the divisor functions $\sigma\alpha$(n),The average order of ϕ(n),An application to the distribution of lattice points visible from the origin, The average order of μ(n) and of ∧(n),The partial sums of a Dirichlet product, Applications to μ(n) and of ∧(n).

(Chapter 2: sections 2.1 to 2.14, Chapter 3:3.1 to 3.11) (30 hours)

Module II: Some Elementary Theorems on the Distribution of Prime Numbers Introduction,Chebyshev's functions ψ(x) and ϑ(x),Relation connecting ϑ(x) and π(x),Some equivalent forms of the prime number theorem,Inequalities for π(n) and Pn ,Shapiro's tauberiantheorem,Applications of Shapiro's theorem,An asymptotic formula for the partial sum $\Sigma 1 pp \leq x$. (chapter 4: sections 4.1 to 4.8) (15 hours)

Module III: Congruences: Definitions and basic properties of congruences, Residue classes and complete residue system, Linear congruences,Reduced residue systems and Euler-Fermat theorem,Polynomialcongruences modulo p,Lagrange's theorem, Applications of Lagrange's theorem,Simultaneous linear congruences,The Chinese remainder theorem, Applications of the Chinese remainder theorem.

(chapter 5: 5.1 to 5.8) (25 hours)

Module IV: Quadratic Residues,The Quadratic Reciprocity Law and Primitive Roots, Quadratic Residues,The Quadratic Reciprocity Law:Quadraticresidues,Legendre's symbol and its properties,evaluation of (-1|p) and (2|p),Gauss' Lemma,The quadratic reciprocity law,Applications of the reciprocity law.(Chapter 9; 9.1 to 9.6)

Primitive Roots:The exponent of a number mod m, Primitive roots, Primitive roots and reduced residue systems, The nonexistence of primitive roots mod 2α for $\alpha \geq 3$,The existence of primitive root mod p for odd primes p, Primitive roots and quadratic residues.

(chapter 10: 10.1 to 10.5) (20 hours)

Course	Details
Code	**ME800401**
Title	**DIFFERENTIAL GEOMETRY**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 3rd Semester
Type	Core

COURSE OUTCOMES

Course Outcomes No.	**Course Outcomes**	**Cognitive Level**	**PSO No.**
CO 1	To understand the concept of graph, level sets, orientable surfaces in R^{n+1} and sketch different level sets, graphs, vector fields.	Un, App	PSO 1, 2, 7
CO 2	To understand different types of vector fields and to find the maximal integral curve of a smooth vector fields.	Un ,App	PSO 2,4
CO 3	To understand the Gauss map, Geodesics, Parallel transport of a vector fields defined on a surface.	Un	PSO 3,4
CO 4	To categorize the different forms of derivatives of a vector field and to characterise compact oriented n surface using gauss maps.	App, An	PSO 2,3
CO 5	To understand the Weingarten map, curvature of a plane curve, Arc length of a plane curve and 1 forms.	Un	PSO 1,4
CO 6	To generalize the curvature of a plane curve to the curvature of an arbitrary surface.	Ap	PSO 3,4
CO 7	To understand different forms of curvature on an n surface and interrelate them.	Un	PSO 3,7
CO 8	To understand different forms of surfaces and explain the local equivalence of different forms of surfaces and establish the inverse function theorem on n surfaces.	Un	PSO 2, 7

Ap-Apply Un-Understand

MODULE	SECTION	DESCRIPTION	HOURS	CO NO.
	COURSE DESCRIPTION			
	COURSE: ME800401 DIFFERENTIAL GEOMETRY			
MODULE	**SECTION**	**DESCRIPTION**	**HOURS**	**CO NO.**
I	MODULE I		16	
	1.1	Module 1 : Introduction and Basic Concepts about Differential equation , Geometry in Hyper surfaces	1	1
	1.1	Level sets, Graph of a function	2	1
	1.1	Geometry of Level sets	1	1
	1.1	Problems in Level sets and Graph of a function	1	1
	1.2	Vector fields- definition and Geometry	1	1
	1.2	Integral Curves - Definition and Explanations	1	1
	1.2	Existence and Uniqueness of Integral Curves	2	1
	1.3	Tangent Space - basic Concepts	1	2
	1.3	Existence and Uniqueness of Tangent Space	1	2
	1.3	Problems in Vector Fields, Tangent Space	1	2
	1.4	Introduction to surfaces	1	2
	1.4	Surfaces – Definitions	1	2
	1.4	Examples of various surfaces	1	2
	1.5	Smooth Surfaces - Vector Fields on a a surface	1	2
	1.5	Orientable surfaces, Unorientable surfaces	1	2
	MODULE II		24	
2	2	Module 2 : Outline	1	3
	2.1	Gauss Map : Definition and basic concepts	1	3
	2.1	Existence of a smooth map on a connected surfaces	4	3
	2.2	Geodesics – Definition	1	3,4
	2.2	Geodesics - Some Properties	3	3,4
	2.3	Various types of Derivatives	2	3,4
	2.3	Parallel transport- definition	1	3,4
	2.3	Properties of various types derivatives	2	3,4
	2.3	Problems in various types of derivatives, Gauss Map	2	3,4
	2.3	Problems in parallel Transport	2	3,4
	MODULE III		23	
	3	Module 3 : Outline	1	5,6
	3.1	Weingarten Map – Definitions	2	5,6

	3.1	Properties of Weingarten Map	2	5,6
	3.2	Plane Curves – Definitions	1	5,6
	3.2	Global Parametrization - Definitions	2	5,6
	3.2	Existence of Global parametrzation	1	5,6
	3.2	Problems in Global Parametrization	2	5,6
	3.3	Arc length : Definition,properties	1	5,6
	3.3	Line Integrals : Definitions,Properties,related theorems	4	5,6
	3.3	One form – Definition	2	5,6
	3.3	Properties and results regarding One form	3	5,6
	3.3	Problems in arc length, Arc Length of various curves	2	5,6
	MODULE IV		22	
	4	Outline of Module IV	1	7,8
	4.1	Curavture : Basic concepts	2	7,8
	4.1	Curvature of various surfaces	3	7,8
	4.2	Parametrization - Basic Concepts	2	7,8
	4.2	Parametrized surfaces- Definition	2	7,8
	4.2	Various Parametrized surfaces	3	7,8
	4.3	Inverse Function theorem on N Surfaces	2	7,8
	4.3	Local equivalence of surface and parametrized n surfaces	3	7,8
	4.3	Inverse function theorem on n surfaces	2	7,8

DIFFERENTIAL GEOMETRY

Text Book: John A. Thorpe, Elementary Topics in Differential Geometry

Module 1: Graphs and level sets, vector fields, the tangent space, surfaces, vector fields on surfaces, orientation.

(Chapters 1 to 5 of the text) (15 hours)

Module 2: The Gauss map, geodesics, Parallel transport,

(Chapters 6, 7 & 8 of the text) (20 hours)

Module 3: The Weingarten map, curvature of plane curves, Arc length and line integrals

(Chapters 9, 10 & 11 of the text) (25 hours)

Module 4: Curvature of surfaces, Parametrized surfaces, local equivalence of surfaces and Parametrized surfaces.

(Chapters 12, 14 & 15 of the text). (30 hours)

Reference Texts

- **John A. Thorpe, Elementary Topics in Differential Geometry**
- **M. DoCarmo, Differential Geometry of curves and surfaces**
- **Serge Lang, Differential Manifolds**

COURSE OUTCOMES

ME800402 ALGORITHMIC GRAPH THEORY

Course	Details
Code	**ME800402**
Title	**ALGORITHMIC GRAPH THEORY**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 3rd Semester
Type	Core

CO No.	Course Outcomes	Cognitive level	PSO No.
CO 1	To understand the fundamentals of graphs and algorithms.	Un,Ap	PSO 1,7
CO 2	To remember sorting algorithms, greedy algorithms and representing graphs in a computer.	Re	PSO 2,4
CO 3	To understand the properties of trees, depth first search and breadth first search algorithms.	Un	PSO 3,4
CO 4	To get an idea of weighted graphs center and median of graphs.	Un	PSO 2,3
CO 5	To understand the concept of networks, maximum flow minimum cut theorem and algorithms.	Un	PSO 1,4
CO 6	To understand Menger's theorem.	Un	PSO 3,5
CO 7	To get an idea of matchings and block designs	Un	PSO 4,7

Re – Remember, Un – Understand, Ap – Apply, An – Analyze

COURSE DESCRIPTION

ME800402: ALGORITHMIC GRAPH THEORY

Module		**Course description**	**Hrs.**	**Co No.**
I	**1.0**	**MODULE I: Introduction to Graphs and Algorithms**	**24**	
	1.1	An introduction to graph	2	
	1.2	Definition of a graph	1	
	1.3	Vertex degrees, Degree Sequence	1	
	1.4	Isomorphic graphs.	2	
	1.5	Sub graphs	1	
	1.6	cutvertices and blocks.	2	
	1.7	connected graphs	1	
	1.7	special graphs	2	
	1.8	Digraphs.	2	
	1.9	algorithmic complexity	1	
	1.10	Search Algorithms	3	
	1.11	Sorting algorithms	3	
	1.11	Greedy algorithms	2	
	1.12	Representing graphs in a computer	1	
II	**2.0**	**MODULE II : Trees, paths and distances**	**22**	
	2.1	Trees	1	
	2.2	Definition and simple properties	2	
	2.3	Rooted trees.	2	
	2.4	Depth-first search	2	
	2.5	Breadth – first search	3	
	2.6	Minimum spanning tree problem	3	
	2.7	Distance in a graphs, distance in weighted graphs,	3	
	2.8	The centre and median of a graph	3	
	2.9	Activity digraphs and critical paths	3	
III	**3.0**	**MODULE III : Networks**	**22**	
	3.1	An introduction to networks	3	
	3.2	The max-flow min-cut theorem	5	
	3.3	The max-flow min-cut algorithm	4	
	3.4	Connectivity and edge connectivity	5	
	3.5	Mengers theorem	5	
IV	**4.0**	**MODULE IV: Matchings and Factorizations**	**22**	
	4.1	An introduction to matchings	6	
	4.2	Maximum matchings in a bipartite graph	6	
	4.3	Factorizations	5	
	4.4	Block Designs	5	

ME800402: ALGORITHMIC GRAPH THEORY

5 hours/week (Total Hours : 90) 3 credits

Text Book: Gray Chartrand and O.R Oellermann , Applied and Algorithmic Graph Theory, Tata McGraw- Hill Companies Inc

Module I : Introduction to Graphs and Algorithms

What is graph? The degree of a vertex. isomorphic graphs. subgraphs, degree

sequences. connected graphs. cutvertices and blocks. special graphs. digraphs.

algorithmic complexity. Search algorithms, sorting algorithms. greedy algorithms., representing graphs in a computer.

(Chapter 1 Sections 1.1 to 1.9, Chapter 2 Sections 2.1, 2.2 , 2.3, 2.5 and 2.6 of the text) (24 hours)

Module II: Trees, paths and distances

Properties of trees, rooted trees. Depth-first search,. breadth – first search, . the minimum spanning tree problem

Distance in a graphs, distance in weighted graphs, .the centre and median of a graph. Activity digraphs and critical paths.

(Chapter 3 sections 3.1 to 3.3.3.4 and 3.5 , Chapter 4 sections 4.1 to 4.4 of the text) (22 hours)

Module III: Networks

An introduction to networks. the max-flow min-cut theorem. the max-flow min-cut algorithm . Connectivity and edge connectivity . Mengers theorem.

(Chapter 5 sections 5.1 , 5.2 , 5.3 and 5.5 of the text) (22 hours)

Module IV: Matchings and Factorizations

An introduction to matchings . maximum matchings in a bipartite graph,.

Factorizations. Block Designs.

(Chapter 6 sections 6.1 , 6.2 , 6.4 and 6.5 of the text) (22 hours)

TEXTBOOKS :

1. **Gray Chartrand and O.R Oellermann , Applied and Algorithmic Graph Theory, Tata McGraw- Hill Companies Inc.**
2. **Alan Gibbons, Algorithmic Graph Theory, Cambridge University Press, 1985**
3. **Mchugh. J.A, Algorithmic Graph Theory, Prentice-Hall, 1990**
4. **Golumbic. M, Algorithmic Graph Theory and Perfect Graphs, Academic press**

Course	Details
Code	**MT04E02**
Title	**COMBINATORICS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 4th Semester
Type	Core

COURSE OUTCOMES

Course Outcomes No.	**Course Outcomes**	**Cognitive Level**	**PSO No.**
CO 1	To understand the concept of Permutation, Combination, Circular permutation, The injection and bijection principles.	Un,	PSO 1, 2,8
CO 2	To apply the concepts of permutation and combination to solve various types of problems.	Un ,Ap	PSO 2,4,8
CO 3	To understand Pigeonhole principle, Ramsey numbers.	Un	PSO 3,4
CO 4	To apply Pigeonhole principle and Ramsey numbers to solve different types of practical problems.	Ap	PSO 2,3
CO 5	To understand the principle of inclusion and exclusion , Sterling numbers, Derangements.	Un	PSO 1,4
CO 6	To categorize different types of sterling numbers and apply it to solve different problems .	Un,Ap	PSO 3,4,7
CO 7	To understand different generating functions and the concept of recurrence relations	Un	PSO 2,4
CO 8	To apply different generating functions to model problems and to solve recurrence relation problems.	Ap	PSO 2,3, 7

Ap-Apply Un-Understand

COURSE DESCRIPTION				
MT04E02 COMBINTORICS				
MODULE	**SECTION**	**DESCRIPTION**	**HOURS**	**CO NO.**
I	**MODULE I : Introduction to permutation and combination**		**20**	
1	1.1	Module 1 : Introduction to permutation and combination	2	1,2
	1.1	Two Counting principle	1	1,2
	1.2	Permutations	3	1,2
	1.2	Circular Permutations	3	1,2
	1.3	Combinations	2	1,2
	1.3	The Injection and bijection Principle	3	1,2
	1.4	Arrangement and selection with repetation	3	1,2
	1.5	Distribution Problems	3	1,2
II	**Module 2: The Pigeonhole Principle and Ramsey Numbers**		**20**	
2	2.1	Module 2: The Pigeonhole Principle and Ramsey Numbers : Introduction	2	3,4
	2.1	The Pigeonhole Principle	2	3,4
	2.2	Examples	4	3,4
	2.3	Ramsey Numbers	2	3,4
	2.3	Problems in Ramsey Numbers	5	3,4
	2.4	Bounds of Ramsey Numbers	5	3,4
III	**Module III The Principle of Inclusion and Exclusion**		25	
3	3.1	Module 3: The Principle of Inclusion and exclusion : Introduction	2	5,6
	3.1	The Principle of inclusion	2	5,6
	3.2	Generalisation	4	5,6
	3.3	Integer Solution and Shortest Routes	4	5,6
	3.4	Surjective Mappings and Sterling Numbers of Second Kind	3	5,6
	3.5	Derangements and generalisation	6	5,6
	3.6	The Sieve Of Erathosthanes	2	5,6
	3.6	Euler’s Phi Function	2	5,6

IV	**Module IV Generating Functions & Recurrence relations**		**25**	
	4.1	Module 4 : Generating Functions : Introduction	2	7,8
	4.2	Ordinary generating Functions	2	7,8
	4.3	Modelling Problems	3	7,8
	4.4	Partitions of Integers	2	7,8
	4.4	Exponential Generating Function	2	7,8
	4.5	Recurrence Relation: Introduction	2	7,8
	4.5	Some Examples	3	7,8
	4.6	Linear Homogeneous recurrence relation	4	7,8
	4.6	General linear recurrence relation	3	7,8
	4.6	Applications	2	7,8

COMBINATORICS

Text Book: Chen Chuan -Chong, Koh Khee Meng, Principles and Techniques in Combinatorics, World Scientific,1999.

Module I Permutations and Combinations

Two basic counting principles, Permutations, Circular permutations, Combinations,

The injection and bijection principles, Arrangements and selection with repetitions

,Distribution problems

(Chapter I of the text) (20 hours)

Module II The Piegeonhole Principle and Ramsey Numbers

Introduction, The piegeonhole principle, More examples, Ramsey type problems and

Ramsey numbers, Bounds for Ramsey numbers

(Chapter 3 of the text) (20 hours)

Module III Principle of Inclusion and Exclusion

Introduction, The principle, A generalization, Integer solutions and shortest routes

Surjective mappings and Sterling numbers of the second kind, Derangements and a

generalization,.

(Chapter -4 Sections 4.1 to 4.6 of the text) (25 hours)

Module IV Generating Functions

Ordinary generating functions, Some modelling problems, Partitions of integer,

Exponential generating functions, Recurrence Relations Introduction, Two examples, Linear homogeneous recurrence relations, General linear recurrence relations, (Chapter 5, 6 Sections 6.1 to 6.4) (25 hours)

Reference Texts

- **Chen Chuan Chong , Koh Khee Meng , Principles and Techniques in Combinatorics., World Scientific Publishing, 2007**
- **V Krishnamoorthy, Combinatorics theory and applications, E. Hoewood, 1986**
- **Hall, Jr, Combinatorial Theory, Wiley- Interscinice, 1998.**