BISHOP CHULAPARAMBIL MEMORIAL COLLEGE, KOTTAYAM

M.Sc. MATHEMATICS PROGRAMME(2011 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. **Dr. George Mathew**
   Associate Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
4. **Mrs. Sosamma Mathew**
   Associate Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
5. **Mrs. Salma Mary K Abraham**
   Associate Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
6. **Dr. Stephy Thomas**
   Assistant Professor
   Department of Statistics
   Bishop Chulaparambil Memorial College, Kottayam
7. **Mrs. Ann Johns**
   Assistant Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
8. **Mrs. Anu Varghese**
   Assistant Professor
   Department of Mathematics
   Bishop Chulaparambil Memorial College, Kottayam
9. **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.

Programme Specific Outcome

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	Details
Code	**MT01C01**
Title	**Linear Algebra**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 1st Semester
Type	Core

COURSE OUTCOMES

MT0C01 Linear Algebra

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

C0URSE DESCRIPTION

MT01C01 - LINEAR ALGEBRA

Module		**Course Description**	**Hrs.**	**Co No.**
I	**1.0**	**Module I**	**15**	
	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	3	1
II	**2.0**	**Module II**	**30**	
	2.1	Linear transformations	4	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	4	2
	2.7	Transpose of a lineartransformation.	4	2
III	**3.0**	**Module III**	**18**	
	3.1	Determinants	3	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.	3	3,4
Iv	**4.0**	**Module IV**	**27**	
	4.1	Introduction to elementary canonical forms	3	5
	4.2	Characteristic Values	4	5
	4.3	Annihilatory Polynomials	4	6
	4.4	Invariant subspaces	4	6
	4.5	Simultaneous diagonalization	4	6
	4.6	Direct sum Decompositions	4	6
	4.7	Invariant direct sum	4	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,
(Chapter 2- 2.1, 2.2, 2.3,2.4, 2.5 of the text) (15 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) (30 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) (18 hours)

Module 4:

Introduction to elementary canonical forms, characteristic values, annihilatory Polynomials, invariant subspaces, simultaneous diagonalization, Direct sum Decompositions, invariant direct sum
(Chapter 6 - 6.1, 6.2, 6.3, 6.4,6.5,6.6of the text) (27 hours)

Course	Details
Code	**MT01C02**
Title	**Basic Topology**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 1st Semester
Type	Core

COURSE OUTCOMES

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

Ap-Apply Un-Understand

COURSE DESCRIPTION

MT01C02 BASIC TOPOLOGY

Module		Course Description	Hrs	Co.No.
1	**1.0**	Module I	**24**	
	1.1	Metric Topology	**4**	**1**
	1.2	Topological spaces and examples	**4**	**2**
	1.3	Bases and sub bases	**4**	**3**
	1.4	Subspace	**3**	**3**
	1.5	Closed sets and closure	**3**	**3**
	1.6	Neighborhood	**3**	**3**
	1.7	Accumulation point	**3**	**4**
2	**2.0**	Module II	**22**	
	2.1	Continuity	**8**	**4**
	2.2	Quotient space	**5**	**5**
	2.3	Smallness condition	**9**	**5**
3	**3.0**	Module III	**22**	**5**
	3.1	Connectedness	**8**	**5**
	3.2	Local connectedness	**7**	**6**
	3.3	Path	**7**	**6**
4	**4.0**	Module IV	**22**	
	4.1	Separation axioms	**12**	**6**
	4.2	Compactness and separation axioms	**10**	**6**

SYLLABUS

Text Book:

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

Module 1:
Definition of a topological space – examples of topological spaces, bases and sub bases – sub spaces.Basic concepts: closed sets and closure – neighborhood, interior and accumulation points
(Chapter 4 Section – 1, 2, 3, 4 - Chapter 5 Section -. 1 and 2 of the text.5.2.11 & 5.2.12 excluded.) (24 hours)

Module 2: Continuity and related concepts: making functions continuous, quotient spaces.Spaces with special properties: Smallness condition on a space
(Chapter 5. Section. 3 and 4 of the text, 5.3.2(4) excluded)
(Chapter 6 Sec. 1 of the text) (22 hours)

Module 3: Connectedness: Local connectedness and paths
(Chapter 6 Section. 2 & 3 of the text) (22 hours)

Module 4: Separation axioms: Hierarchy of separation axioms – compactness and separation axioms
(Chapter – 7 Section 1 & 2 of the text)(2.13 to 2.16 of section.2 excluded) (22 hours)

Course	Details
Code	**MT01C03**
Title	**Measure Theory and Integration**
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 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 1,2
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 understand how to integrate functions which are not Riemann integrable.	Un, Ap	PSO 1, 2,7
CO 6	To generalize the concept of measure, measurable set, measurable functions from the measure space on real numbers to a general measure space, integration.	Un	PSO 1
CO 7	To understand types of convergence of measurable functions.	Un	PSO 1

Un : Understand, Ap: Apply

Module	Course Description	Hours	CO No.
	Pre-requisites	**23**	
0.1	Lebesgue Measure: Introduction: Algebras of sets, the axiom of choice and infinite direct products, open and closed sets of real numbers.	5	CO 1,2
	Module 1		
1.1	Lebesgue outer measure, The sigma algebra of Lebesgue measurable sets	5	CO 1,2
1.2	Outer and inner approximation of Lebesgue measurable sets	5	CO 1,2,4
1.3	Countable additivity, continuity and Borel-Cantelli Lemma	4	CO 1,4
1.4	Non measureable sets , The Cantor set and Cantor Lebesgue function	4	CO 1
1.5	Lebesgue Measurable Functions		
	Module 2	**23**	
2.1	Lebesgue Integration: Sums, products and compositions	4	CO 1
2.2	Sequential pointwise limits and simple approximation	3	CO 1,3
2.3	The Riemann Integral – The Lebesgue integral of a bounded measurable function over a set of finite measure	5	CO 1,3,4
2.4	The Lebesgue integral of a measurable non-negative function	4	CO 1,3,4,5
2.5	The general Lebesgue integral	4	CO 1,3,4,5
2.6	Integration of monotone functions	3	CO 1,3,4
	Module 3	**20**	
3.1	General Measure Space and Measurable Functions	3	CO 6
3.2	Measures and measurable sets	2	CO 6
3.3	Signed Measures: The Hahn and Jordan decompositions	3	CO 6
3.4	The Caratheodory measure induced by an outer measure	2	CO 6
3.5	Measureable functions , Integration over General Measure Space and Product Measures	4	CO 6
3.6	Integration of non negative meaurable functions	3	CO 6
3.7	Integration of general measurable functions, The Radon Nikodym Theorem	3	CO 6
	Module 4	**18**	
4.1	Convergence: convergence in measure	4	CO 7
4.2	Almost uniform convergence	5	CO 7
4.3	Measurability in a product space	4	CO 7
4.4	Product measure: The theorems of Fubini and Tonelli	5	CO 7

Text Book

Text 1: H.L. Royden, Real Analysis, Third edition, Prentice Hall of India Private Limited.
Text 2: G. de Barra, Measure Theory and Integration, New Age International (P) Linnilect Publishers.

Pre-requisites: Algebras of sets, the axiom of choice and infinite direct products, open and closed sets of real numbers.
(Chapter 1 - section 4, 5, Chapter 2 - section 5 of Text 1) (5 hours)
(No questions shall be asked from this section)

Module 1: Lebesgue measure: introduction, outer measure, measurable sets and Lebesgue measure, & non-measurable sets, measurable functions.
(Chapter 3 - Sec. 1 to 5. of Text 1) (20 hours)

Module 2: Lebesgue integral: the Riemann integral, he Lebesgue integral of a bounded function over a set of finite measures, the integral of a non-negative function, the general Lebesgue integral, differentiation of monotone functions.
(Chapter 4 - Sec. 1 – 4. of Text 1, Chapter 5 - Sec. 1. of Text 1) (20 hours)

Module 3: Measure and integration: measure spaces, measurable functions, Integration, general convergence theorems, signed measures, the Radon-Nikodym theorem, outer measure and measurability, the extension theorem.
(Chapter 11 - Sec. 1 to 6 of Text 1, Chapter 12 - Sec. 1& 2 of Text 1) (20 hours)

Module 4: Convergence: convergence in measure, almost uniform convergence, measurability in a product space, the product measure and Fubini's theorem.
(Chapter 8 - Sec. 7.1 & 7.2 of Text 2, Chapter 10 - Sec. 10.1& 10.2 of Text 2) (25 hours)

Books for References :

1. Halmos P.R, Measure Theory, D.van Nostrand Co.
2. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age International (P) Ltd., New Delhi, 1986(Reprint 2000).
3. R.G. Bartle, The Elements of Integration, John Wiley & Sons, Inc New York, 1966.
4. Inder K Rana, An Introduction to Measure and Integration, Narosa Publishing House, 1997.

Course	Details
Code	**MT01C04**
Title	**Graph Theory**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	I[st] Year / 1[st] Semester
Type	Core

Course Outcomes

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 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	**20**	
1.1	Introduction and Basic concepts	2	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, Operations on graphs, Graph products	3	CO 1,2
1.5	Directed graphs , Connectivity- Introduction,vertex cuts and edge cuts	3	CO 1
1.6	Connectivity and edge connectivity	2	CO 1,2
1.7	Blocks, Cyclical edge connectivity of a graph	3	CO 1
	Module 2	**15**	
2.1	Trees- Introduction, Definition, characterization and simple properties, centres and centroids	7	CO 1
2.2	Counting the number of spanning trees, Cayley's Formula	4	CO 1
2.3	Applications	4	CO 1,5
	Module 3	**20**	
3.1	Eulerian and Hamiltonian graphs, Hamiltonian around the world game	7	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, Brook's theorem	3	CO 1,3,4
3.5	Triangle free graphs	3	CO 1,2
	Module 4	**20**	
4.1	Planar and non planar graphs	5	CO 1,4
4.2	Euler formula and its consequences	4	CO 1,4
4.3	K_5 and $K_{3,3}$ are Nonplanar Graphs, Dual of a graph	5	CO 1,4
4.4	The Four color theorem and the Heawood Five color theorem	6	CO 1,4

Text Book

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

Module: -1 Basic results and directed graphs
Basic concepts. sub graphs. degrees of vertices. Paths and connectedness , automorphism of a simple graph, line graphs, basic concepts and tournaments. Connectivity- Vertex cuts and edge cuts. connectivity and edge connectivity, blocks.
(Chapter 1 Sections 1.1 to 1.5 and 1.6 (Up to 1.6.3), Chapter 2 Sections 2.1 and 2.2, Chapter 3 Sections 3.1 to 3.3 of the text) (20 hours)

Module:- 2 Trees:
Definition, characterization and simple properties, centres and cenroids, counting the number of spanning trees, Cayley's formula, applications.
(Chapter 4 Sections 4.1 to 4.4, Chapter 10 Sections 10.1 to 10.4 of the text) (20 hours)

Module:- 3
Independent Sets, Eulerian Graphs; Hamiltonian Graphs and Vertex Colouring, Vertex independent sets and vertex coverings. edge independent sets, Eulerian graphs, Hamiltonian graphs, vertex colourings, critical graphs, triangle free graphs.
(Chapter 5 Sections 5.1 and 5.2, Chapter 6 Sections 6.1 and 6.2, Chapter 7 Sections 7.1 to 7.3 of the text) (25 hours)

Module:- 4 :
Edge colouring and planarity- Edge colouring of graphs, planar and non planar graphs, Euler formula and its consequences, K5 and K3,3 are non planar graphs, dual of a plane graph. the four colour theorem and Heawood five colour theorem.
(Chapter 7 Section 7.4, Chapter 8 Sections 8.1 to 8.5 of the text) (25 hours)

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. F.Harary, Graph Theory, Addison-Wesley, 1969.

Course	**Details**
Code	**MT01C05**
Title	**COMPLEX ANALYSIS**
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 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 and Linear transformations.	Un	PSO1,2,4
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, Ap	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	PSO 1,2,3,4
CO 7	To introduce the concepts of chains and cycles and express Cauchy's theorems on homological aspects.	Un	PSO 1,2,4
CO 8	To get an idea of residues and by using this find the definite integrals.	Un	PSO 1,3,4
CO 9	To understand harmonic functions and Mean value property	Un	PSO 1

- Ap: Apply Un:Understand

Module		Course Description	Hrs	CO.No.
1	1.0	**Module I**	**20**	
	1.1	Analytic functions as mappings.	4	2
	1.2	Conformality: arcs and closed curves, analytic functions in regions, conformal mapping, length and area.	5	2
	1.3	Linear transformations: linear group, the cross ratio, symmetry, oriented circles, family of circles.	6	2
	1.4	Elementary conformal mappings: the use of level curves, a survey of elementary mappings, elementary Riemann surfaces.	5	2
2	2.0	**Module II**	**19**	
	2.1	Fundamental theorem: line integrals, rectifiable arcs, line integrals as functions of arcs.	4	3
	2.2	Cauchy's theorem for a rectangle, Cauchy's theorem in a disk.	8	3,5
	2.3	Cauchy's integral formula: the index of a point with respect to a closed curve, the integral formula, higher derivatives	7	3,4,5
3	3.0	**Module III**	**25**	
	3.1	Local properties of analytical functions: removable singularities.	1	6
	3.2	Taylor's theorem, zeroes and poles, the local mapping, the maximum principle.	1	6
	3.3	The general form of Cauchy's theorem: chains and cycles, simple connectivity	2	7
	3.4	Homology, general statement of Cauchy's theorem, proof of Cauchy's theorem	2	7
	3.5	Locally exact differentiation, multiply connected regions.	2	5
4	4.0	**Module IV**	**22**	
	4.1	Calculus of Residues: the residue theorem, the argument principle, evaluation of definite integrals.	8	8
	4.2	Harmonic functions: definition and basic properties, the mean value property,	7	9
	4.3	Poisson's formula, Schwarz theorem, the reflection principle.	7	9

Text Book :

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

Module 1: Analytic functions as mappings. Conformality: arcs and closed curves, analytic functions in regions, conformal mapping, length and area. Linear transformations: linear group, the cross ratio, symmetry, oriented circles, family of circles. Elementary conformal mappings: the use of level curves, a survey of elementary mappings, elementary Riemann surfaces.
(Chapter 3 – sections 2, 3 and 4. of the text) (20 hours.)

Module 2: Complex Integration
Fundamental theorem: 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, higher derivatives.
(Chapter 4 – Sections 1 and 2. of the text.) (20 hours.)

Module 3: Local properties of analytical functions: removable singularities, Taylor's theorem, zeroes and poles, the local mapping, the maximum principle. 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.
(Chapter 4 – Sections 3 and 4. of the text) (25 hours.)

Module 4: Calculus of Residues: the residue theorem, the argument principle, evaluation of definite integrals. Harmonic functions: definition and basic properties, the mean value property, Poisson's formula, Schwarz theorem, the reflection principle.
(Chapter 4 – Sections 5 and 6 of the text) (25 hours.)

References:

1. Chaudhary. B, The elements of Complex Analysis, Wiley Eastern.
2. Cartan. H (1973), Elementary theory of Analytic functions of one or several variable, Addison Wesley.
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.

M.Sc MATHEMATICS SECOND SEMESTER

Course	Details
Code	**MT02C06**
Title	**ABSTRACT ALGEBRA**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 1st Semester
Type	Core

COURSE OUTCOMES

MT02C05 : ABSTRACT ALGEBRA

COURSE OUTCOME 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 1,4
CO 2	To understand and apply factorization of polynomials over a fields	Un,Ap	PSO 1,2,4
CO 3	To get an idea about extension of finite fields, Unique Factorisation Domain and Euclidean domain.	Un	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	Un,Ap	PSO 1,2,4
CO 6	To understand fundamental concepts of automorphism of fields and splitting fields.	Un	PSO 1,2,4
CO 7	To understand fundamental concepts of Galois Theory and its illustration.	Un	PSO 1,4

- Un-Understand, Ap- Apply

COURSE DESCRIPTION

Module		Course Description	Hrs.	Co No.
I	**1.0**	**Module I**	**25**	
	1.1	Direct products	3	1
	1.2	Finitely generated Abelian groups	4	1
	1.3	Fundamental theorem	4	1
	1.4	Applications	5	1
	1.5	Rings of polynomials	4	2
	1.6	Factorisation of polynomials over a field.	5	2
II	**2.0**	**Module II**	**25**	
	2.1	Introduction to extension fields	3	3
	2.2	Algebraic extensions	7	3
	2.3	Geometric Constructions	8	3
	2.4	Finite fields	7	3
III	**3.0**	**Module III**	**20**	
	3.1	Sylow’s theorems	5	4,5
	3.2	Applications of sylow theory	5	4,5
	3.3	Automorphism of fields	5	6
	3.4	the isomorphism extension theorem	5	6
IV	**4.0**	**Module IV**	**20**	
	4.1	Splitting fields	6	6
	4.2	Separable extensions	7	6
	4.3	Galois theory	7	7

MT02C05 ABSTRACT ALGEBRA

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

<u>Syllabus</u>

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 (without proof), Applications, Rings of polynomials, Factorisation of polynomials over a field.
(Part II – Section 11) & (Part IV – Sections 22 & 23) (25 hours)

Module 2: Introduction to extension fields, algebraic extensions, Geometric Constructions, Finite fields.
(Part VI – Section 29, 31 – 31.1 to 31.18, 32, 33) (25 hours)

Module 3: Sylow's theorems (without proof), Applications of Sylow theory, Automorphism of fields, the isomorphism extension theorem
(proof of the theorem excluded)
(Part VII Sections 36 & 37) (Part X – Sections 48 & 49, (49.1 to 49.5) (20 hours)

Module 4: Splitting fields, separable extensions, Galois theory
(Part X – Sections 50, 51, 53 -53.1 to 53.6) (20 hours)

Course	Details
Code	**MT02C07**
Title	Advanced Topology
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 1st Semester
Type	Core

COURSE OUTCOMES

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,Ap	PSO 1,4

Ap-Apply Un-Understand

COURSE DESCRIPTION

MT02C07 ADVANCED TOPOLOGY

Module		**Course Description**	**Hrs**	**Co.No.**
1	**1.1**	UrysohnCharacterisation of normality	**3**	**1**
	1.2	TietzeCharacterisation of normality	**3**	**2**
	1.3	Cartesian Products	**4**	**3**
	1.4	Product Topology	**7**	**3**
	1.5	Productive properties	**7**	**5**
2	**2.1**	Evaluation Functions	**5**	**3**
	2.2	Embedding Lemma and Tychonoff Embedding	**7**	**4**
	2.3	UrysohnMetrisation Theorem	**3**	**4**
3	**3.1**	Definition and Convergence of Nets	**7**	**5**
	3.2	Topology and Convergence of Nets	**8**	**5**
	3.3	Filters and convergence	**5**	**6**
	3.4	Ultra filters and compactness	**5**	**6**
4	**4.1**	Variation of Compactness	**8**	**6**
	4.2	Local Compactness	**8**	**7**
	4.3	Compactifications	**8**	**7**

SYLLABUS

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

Module 1: – Urysohn Characterisation of Normality –Tietze Characterisation of Normality. (Chapter 7 Section-.3 and 4 of the text.Proof of 3.4, 4.4, and 4.5 excluded)
Products and co-products: Cartesian products of families of sets– Product Topology – Productive properties.
(Chapter 8 Section. 1, 2 & 3 of the text) (proof of 1.6 &1.7 excluded) (25 hours)

Module 2: Embedding and Metrisation – Evaluation Functions in to Products,Embedding Lemma and Tychnoff Embedding, The UrysohnMetrisationTheorem.
(Chapter 9. Sec. 1, 2 & 3 of the text) (15 hours)

Module 3: Nets and Filters: Definition and Convergence of Nets, Topology and Convergence of Nets, Filters and their Convergence, Ultra filters and Compactness.
(Chapter – 10 Sections -1, 2, 3 & 4 of the text) (25 hours)

Module 4: Compactness: Variations of compactness – local compactness –compactification.
Chapter 11. Section 1 (Proof of theorem 1.4 & 1.12 excluded),Section 3,Section 4(from 4.1 to 4.7) of the text (25 hours)

Course	Details
Code	**MT02C08**
Title	**ADVANCED COMPLEX ANALYSIS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 2nd 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 infinite products and its convergence, Riemann Zeta function, its product development and its zeroes	Un	PSO 1
CO 5	To understand the Entire functions, 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 and Weierstrass theory of functions	Un	PSO 1
CO 8	To understand doubly periodic functions and its properties	Un	PSO 1,7
CO 9	To understand the theory of analytic continuation of functions and the Riemann surface	Un	PSO 1

Un-Understand

Module	Course Description	Hours	CO No.
	Module 1	**20**	
1.1	Power Series Expansions – Weierstrass's theorem	6	CO 3
1.2	The Taylor Series, The Laurent Series, Partial Fractions and Factorization – Partial Fractions	5	CO 3
1.3	Infinite Products, Canonical Products, The Gamma Function.	9	CO 4
	Module 2	**21**	
2.1	Entire Functions – Jensen's Formula, Hadamard's Theorem - proof excluded)	4	CO 5
2.2	The Riemann Zeta Function – The Product Development	4	CO 4
2.3	The Extension of Riemann Zeta Function to the Whole Plane,	5	CO 4
2.4	The Functional Equation, The Zeroes of the Zeta Function	4	CO 4
2.5	Normal Families – Normality and Compactness, Arzela's Theorem	4	CO 5
	Module 3	**20**	
3.1	The Riemann Mapping Theorem – Statement and Proof	4	CO 6
3.2	Boundary Behaviour, Use of the Reflection Principle	6	CO 6,7
3.3	Harmonic Functions – Definitions and Basic Properties	2	CO 1
3.4	The Mean-Value Property, Poisson's Formula, Schwarz's Theorem, The Reflection Principle.	3	CO 1
3.5	A closer look at Harmonic Functions – Functions with Mean Value Property, Harnack's Principle.	3	CO 1
3.6	The Dirichlet's Problem – Subharmonic Functions, Solution of Dirichlet's Problem without proof	2	CO 1,2
	Module 4	**17**	
4.1	Elliptic functions: simply periodic functions, functions of finite order.	4	CO 8
4.2	Doubly periodic functions: The period module, unimodular transformations, the canonical basis, general properties of elliptic functions.	5	CO 8
4.3	The Weirstrass theory: the Weierstrass function, the functions x (y) and s (y), the differential equation.	4	CO 7
4.4	Analytic continuation: the Weierstrass theorem, Germs and Sheaves, sections and Riemann surfaces, analytic continuation along arcs, homotopic curves.	4	CO 7,8

Text Book

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

Module 1: Elementary theory of power series: sequences, series, uniform convergence, power series, Abel's limit theorem. Power series expansions: Weierstrass' theorem, the Taylor's series, the Laurent's series, Partial fractions and factorisation: partial fractions, infinite products, canonical products, the gamma functions.
(Chapter 2, Section 2 - Chapter 5, Sections 1, 2.1 to 2.4 of the text) (25 hours)

Module 2: Entire functions: Jenson's formula, Hadamard's theorem (without proof) the Riemann zeta function: the product development, extension of x to the whole plane, the functional equation, the zeroes of zeta function. Normal families: Equi continuity, normality and compactness, Arzela's theorem (without proof).
(Chapter 5 - Sections 3, 4, 5.1,5.2, and 5.3 of the text) (25 hours)

Module 3: The Riemann mapping theorem: statement and proof, boundary behavior, use of reflection principle, analytic arcs. Conformal mappings of polygons: the behavior of an angle, the Schwarz- Christoffel formulaI (Statement only). A closer look at harmonic functions: functions with mean value property, Harnack's principle. The Dirichlet problem: sub harmonic functions, solution of Dirichlet problem (statement only).
(Chapter 6 Section 1, 2.1, 2.2, 3, 4.1 & 4.2 of the text) (20 hours)

Module 4: Elliptic functions: simply periodic functions, representation of exponentials, the Fourier development, functions of finite order, Doubly periodic functions: The period module, unimodular transformations, the canonical basis, general properties of elliptic functions. The Weirstrass theory: the Weierstrass function, the functions x (y) and s (y), the differential equation. Analytic continuation: the Weierstrass theorem, Germs and Sheaves, sections and Riemann surfaces, analytic continuation along arcs, homotopic curves.
(Chapter 7 Sections 1, 2, 3.1, 3.2, 3.3, Chapter 8 Sections 1.1 to 1.5 of the text) (20 hours)

Books for References :

1. Chaudhary. B, The elements of Complex Analysis, Wiley Eastern.
2. Cartan. H (1973), Elementary theory of Analytic functions of one or several variable, Addison Wesley.
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

Course	Details
Code	**MT02C09**
Title	**PARTIAL DIFFERENTIAL EQUATIONS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 2nd Semester
Type	Core

COURSE OUTCOMES

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 Cauchy's method , 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 and characteristic curves of second order equations.	Ap	PSO 1,2,4
CO 7	To understand the solution of linear hyperbolic equations and separation of variables.	Un	PSO 1,4
CO 8	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

MT02C09: PARTIAL DIFFERENTIAL EQUATIONS

Module		Course Description	Hrs	CO.No.
1		**MODULE I**	**25**	
	1.1	Methods of solutions of dx/P = dy/Q = dz/R.	3	**1,2**
	1.2	Orthogonal trajectories of a system of curves on a surface.	3	**1**
	1.3	Pfaffian differential forms and equations.	3	**2**
	1.4	Solution of Pfaffian differential equations in three variables	4	**2**
	1.5	Partial differential equations.	2	**3**
	1.6	Origins of first order partial differential equation	1	**3**
	1.7	Cauchy's problem for first order equation	3	**4**
	1.8	Linear equations of first order	2	**4**
	1.9	Integral surfaces passing through a given curve	2	**3**
	1.10	Surfaces orthogonal to a given system of surfaces	2	**3**
2		**MODULE II**	**25**	
	2.1	Nonlinear partial differential equation of the first order .	4	**3**
	2.2	Cauchy'smethod of characteristics.	3	4
	2.3	Compatible systems of first order equations	4	4
	2.4	CharpitsMethod	4	4
	2.5	Special types of first order equations.	3	2,4
	2.6	Solutions satisfying given conditions	3	2,4
	2.7	Jacobi's method	4	4
3		**MODULE III**	**20**	
	3.1	The origin of second order equations.	5	**5**
	3.2	Linear partial differential equations with constant coefficients.	5	**5,6**
	3.3	Equations with variable coefficients	5	**5,6**
	3.4	Characteristic curves of second order equations	5	**5,6**
4		**MODULE IV**	**20**	
	4.1	The solution of linear Hyperbolic equations.	4	**7**
	4.2	Separation of variables.	4	**7**
	4.3	Non linearequations of the second order .	3	**8**
	4.4	Elementary solutions of Laplace equation.	3	**8**
	4.5	Familiesof equipotential surfaces	3	**8**
	4.6	Boundary value problems	3	**8**

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 differentialequations. Orgins of first order partial differential equation . Cauchy's problem for first order equation. Linear equations of first order. Integral surfaces passing through a given curve. Surfaces orthogonal to a given system of surfaces.
(Sections 1.3 to 1.6 & 2.1 to 2.6 of the text) (25 hours)

Module:-2

Nonlinear partial differential equation of the first order .Cauchy's method of characteristics. Compatible systems of first order equations .CharpitsMethod. Special types of first order equations. Solutions satisfying given conditions. Jacobi's method.
(Section 2.7 to 2.13 of the text) (25 hours)

Module:-3

The origin of second order equations. Linear partial differential equations with constant coefficients. Equations with variable coefficients.Characteristic curves of second order equations .
(Section 3.1, 3.4, 3.5, 3.6 of the text) (20 hours)

Module:-4

The solution of linear Hyperbolic equations. Separation of variables. Non linearequations of the second order . Elementary solutions of Laplace equation. Families of equipotential surfaces. Boundary value problems.
(Section 3.8, 3.9 ,3.11 ,4.2, 4.3,4.4 of the text) (20 hours)

Course	**Details**
Code	**MT02C10**
Title	**REAL ANALYSIS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	1st Year / 2nd Semester
Type	Core

COURSE OUTCOMES

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 learn about Stone Weierstrass theorem	Un	PSO1.4
CO 9	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 10	To understand the fundamental concept of Fourier series	Un	PSO 1,4

Un: Understand, Ap: Apply

COURSE DESCRIPTION

MT02C10- 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
	3.5	The Stone-Weierstrass theorem (without proof).	5	8
IV	**4.0**	**Module IV**	**20**	
	4.1	Power series	4	9
	4.2	The exponential and logarithmic functions	4	9
	4.3	The trigonometric functions	4	9
	4.4	The algebraic completeness of the complex field	4	9
	4.5	Fourier series.	4	10

Syllabus

Textbooks:

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

2. Walter Rudin, Principles of Mathematical Analysis (3rd 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, the Stone-Weierstrass theorem (without proof).

(Chapter 7 Section. 7.7 to 7.18 of Text 2) (25 hours.)

Module 4:

Some Special Functions

Power series, the exponential and logarithmic functions, the trigonometric functions, the algebraic completeness of complex field, Fourier series.

(Chapter 8 - Section 8.1 to 8.16 of Text 2) (20 hours.)

References:-

1. Royden H.L, Real Analysis, 2nd edition, Macmillan, New York.2.
2. Bartle R.G, The Elements of Real Analysis, John Wiley and Sons.
3. S.C. Malik, Savitha Arora, Mathematical Analysis, New Age International Ltd.
4. Edwin Hewitt, Karl Stromberg, Real and Abstract Analysis, Springer International,1978.Chand Publishing, New Delhi

THIRD SEMESTER M.Sc MATHEMATICS

Course	Details
Code	**MT03C11**
Title	**Multivariate Calculus and Integral Transforms**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 3rd 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

MT03C11: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**	**20**	
	2.1	The directional derivative	1	**2**
	2.2	Directional derivatives and continuity	3	**2**
	2.3	The total derivative	1	**2**
	2.4	The total derivative expressed in terms of partial derivatives	3	**2**
	2.5	An application of complex- valued functions	3	**2**
	2.6	The matrix of a linear function	3	**2**
	2.7	The Jacobian matrix	3	**3**
	2.8	The chain rate matrix form of the chain rule	3	**3**
3		**MODULE III**	**25**	
	3.1	Implicit functions and extremum problems	3	**4**
	3.2	The mean value theorem for differentiable functions	2	**5**
	3.3	A sufficient condition for differentiability	2	**5**
	3.4	A sufficient condition for equality of mixed partial derivatives	5	**5**
	3.5	Functions with non-zero Jacobian determinant	3	**5**
	3.6	The inverse function theorem (without proof)	1	**5**
	3.7	The implicit function theorem (without proof)	1	**5**
	3.8	Extrema of real- valued functions of one variable	4	**5**
	3.9	Extrema of real- valued functions of several variables	4	**5**
4		**MODULE IV**	**25**	
	4.1	Integration of Differential Forms	3	**6**
	4.2	Primitive mappings	3	**6**
	4.3	Partitions of unity	5	**6**
	4.4	Change of variables	4	**6**
	4.5	Differential forms	5	**6**
	4.6	Stokes theorem (without proof)	5	**5**

SYLLABUS

Textbooks:

1. Tom APOSTOL, Mathematical Analysis, Second edition, NarosaPublishing 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, integraltransforms 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, theJacobian matrix, the chain rate matrix form of the chain rule.
(Chapter 12 Sections. 12.1 to 12.10 of Text 1) (20 hours)

Module 3: Implicit functions and extremum problems, the mean value theorem fordifferentiable functions, 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-. 12.11 to 12.13. of Text 1
Chapter 13 Sections-. 13.1 to 13.6 of Text 1 (25 hours)

Module 4: Integration of Differential Forms
Integration, primitive mappings, partitions of unity, change of variables,differential forms, Stokes theorem (without proof)
Chapter 10 Sections. 10.1 to 10.25, 10.33 of Text 2 (25 hours)

Course	Details
Code	**MT03C12**
Title	**FUNCTIONAL ANALYSIS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 3rd Semester
Type	Core

COURSE OUTCOMES

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

Ap-Apply Un-Understand

COURSE DESCRIPTION

MT03C12 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**
	2.4	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**
	4.4	Uniform boundedness theorem	**3**	**7**

<u>SYLLABUS</u>
Text Book: Erwin Kreyszig, Introductory Functional Analysis with applications, John Wiley and sons, New York

Module 1
Vector Space, normed space. Banach space, further properties of normed spaces,finite dimensional normed spaces and subspaces, compactness and finite dimension,linear Operators, bounded and continuous linear operators.
(Chapter 2 - Sections 2.1 – 2.7 of the text)
(20 hours)

Module 2
Linear functionals, linear operators and functionals on finite dimensional spaces,normed spaces of operators. dual space, inner product space. Hilbert space, furtherproperties of inner product space.
(Chapter 2 - Section 2.8 to 2.10, chapter 3 - Sections 3.1 to 3.2 of the text)
(20 hours)

Module 3
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, Hilbert adjoint operators, Self adjoint unitary and normal operators.
(Chapter 3 - Sections 3.3 to 3.6, 3.8 to 3.10 of the text) (25 hours)

Module 4
Zorn's lemma, Hahn- Banach theorem, Hahn- Banach theorem for complex vector spaces and normed spaces, adjoint operators, reflexive spaces, category theorem (Statement only), uniform boundedness theorem
(Chapter 4 – Sections 4.1 to 4.3, 4.5 to 4.7 of the text) (25 hours)

Course	**Details**
Code	**MT03C13**
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: MT03C13 DIFFERENTIAL GEOMETRY			
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	Details
Code	**MT03C14**
Title	**NUMBER THEORY AND CRYPTOGRAPHY**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 3rd Semester
Type	Core

CO NO.	COURSE OUTSOMES	COGNITIVE LEVEL	PSO NO.
CO 1	To get an idea about time estimates	Un	PSO 1
CO 2	To understand the Euclidean algorithm and congruences and by using this properties easily solve problems.	Un, Ap	PSO1, 2,4
CO 3	To understand the concepts of finite fields and introduce the construction of polynomial fields.	Un	PSO 1,2,3,4
CO 4	To get an idea about quadratic residues and reciprocity	Un	PSO 1,3
CO 5	To demonstrate the cryptosystem.	Un	PSO 1,2,4
CO 6	To get an idea about index calculus algorithm and Pohlig Helman algorithm for finding discrete log problems.	Un, Ap	PSO 1,2, 4
CO 7	To introduce the simple iterative techniques for factorization of large numbers and by using this find whether a number is prime or composite.	Un, Ap	PSO 1, 3, 4
CO 8	To understand the concepts of quadratic sieve method.	Un	PSO 1

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

COURSE DESCRIPTION

MT03C14: NUMBER THEORY AND CRYPTOGRAPHY

Module		Course Description	Hrs	CO.No.
1	**1.0**	Module I : Some topics in elementary number theory	**28**	
	1.1	Time estimates for doing arithmetic	**9**	**1**
	1.2	Divisibility and Euclidean algorithm	**9**	**2**
	1.3	Congruences & Some applications to factoring	**10**	**2**
2	**2.0**	Module II : Finite Fields and Quadratic Residues	**14**	
	2.1	Finite Fields	**7**	**3**
	2.2	Quadratic Residues and reciprocity	**7**	**4**
3	**3.0**	Module III :Public Key	**25**	
	3.1	The idea of public key cryptography	**11**	**5**
	3.2	RSA	**12**	**5,6**
	3.3	Discrete log	**12**	**5,6**
4	**4.0**	Module IV : Primality and factoring	**23**	
	4.1	Pseudo primes	**4**	**7**
	4.2	The rho method	**4**	**7**
	4.3	Fermat factorization	**5**	**7**
	4.4	Factor bases	**5**	**7**
	4.5	The quadratic sieve method	**5**	**8**

Text Book

Neal Koblitz, A **Course in Number Theory and Cryptography, 2nd edition, Springer Verlag.**

Module 1: Some topics in Elementary Number Theory

Time estimates for doing arithmetic, divisibility and the Euclidean algorithm, congruences, some applications to factoring.

(Chapter – I Sections 1, 2, 3 & 4 of the text) (28 hours)

Module 2: Finite Fields and Quadratic Residues

Finite fields, quadratic residues and reciprocity

(Chapter – II Sections 1 & 2 of the text) (14 hours)

Module 3: Public Key

The idea of public key cryptography, **RSA,** Discrete log.

(Chapter – IV Sections 1, 2 & 3 of the text) (25 hours)

Module 4: Primality and Factoring

Pseudo primes, The rho method, Fermat factorization and factor bases, the quadratic sieve method.

(Chapter – V Sections 1, 2, 3 & 5 of the text) (23 hours)

Course	Details
Course Code	MT03C15
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 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 2
CO 06	Solve the basics of the Game theoretic problems	Ap	PSO 2, PSO 5

Re – Remember, Un – Understand, Ap – Apply, An – Analyze, C - Create

MT03C15 OPTIMIZATION TECHNIQUES

1.0	**INTEGER PROGRAMMING**	**12**	
1.01	Introduction to Integer Programming Problem	1	CO 01
1.02	Comparison of IPP and LPP		CO 01, CO 02
1.03	Theorems comparing the solution of LPP and corresponding IPP	2	CO 01
1.04	Branch and Bound Algorithm – Procedure	3	CO 01
1.05	Problems based on Branch and Bound algorithm		CO 02
1.06	Cutting plane algorithm – Procedure	3	CO 01
1.07	Two problems using cutting plane algorithm		CO 02
1.08	0-1 Problems		
1.09	Either- or problems with an example	1	CO 02
1.10	Fixed cost problems with an example	1	CO 02
1.11	Integer valued problems with an example	1	CO 02
2	**SENSITIVITY ANALYSIS; FLOW AND POTENTIALS IN NETWORKS**	**33**	
2.01	Linear Programming problem basics	1	CO 03
2.02	Simplex method of solving LPP	3	CO 03
2.03	Dual Simplex Procedure	1	CO 03
2.04	Sensitivity analysis for changes in b_i	2	CO 03
2.05	Sensitivity analysis for changes in c_j	2	CO 03
2.06	Sensitivity analysis for changes in a_{ij}	2	CO 03
2.07	Sensitivity analysis – Introduction of Variables	2	CO 03
2.08	Sensitivity analysis – Introduction of new constraint	2	CO 03
2.09	Sensitivity analysis – Deletion of variables	1	CO 03
2.10	Sensitivity analysis – Deletion of constraint	2	CO 03
2.11	Introduction to goal programing	2	CO 03
2.12	Example problem of goal programming		CO 03
2.13	Introduction and basic definitions of Network Flows	1	CO 04
2.14	Minimum path problem with non negative coefficients	1	CO 04
2.15	Minimum path problem with negative coefficients	1	CO 04
2.16	Spanning tree of minimum length	1	CO 04
2.17	Problem of minimum potential difference	1	CO 04
2.18	Critical path method	2	CO 04
2.19	Project Evaluation and Review technique	1	CO 04
2.20	Maximum Flow Problems	2	CO 04
2.21	Generalized maximum flow problems	2	CO 04
2.22	Duality of maximum flow problems	1	CO 04

3.00	**THEORY OF GAMES**	**15**	
3.01	Introdution to theory of Games with basic definitions	1	CO 06
3.02	minmax rule and maxmin – Solving problems	1	CO 06
3.03	minimax theorem and other theorems of matrix games	4	CO 06
3.04	Solving 2X2 Games	2	CO 06
3.05	Analytic solution to 2X2 games		CO 06
3.06	Graphical method	2	CO 06
3.07	Notion of dominance	2	CO 06
3.08	Solving game theoretic problems using LPP	3	CO 06
4.00	**NON- LINEAR PROGRAMMING**	**29**	
4.01	Basic Concepts	1	
4.02	Taylor's series expansion and conditions for optimality	2	CO 05
4.03	Fibonacci Search	2	CO 05
4.04	Golden Section Search	1	CO 05
4.05	Hooke Jeevs Algorithm	2	CO 05
4.06	Gradient projection search	2	CO 05
4.07	Scaling and Oscillation	1	CO 05
4.08	Newton's Method of Gradient Projection	2	CO 05
4.09	Lagragian multiplier	2	CO 05
4.10	Constrained Derivative	3	CO 05
4.11	Project Gradient method with equality constraints	3	CO 05
4.12	Kuhn-Tucker Consitions	2	CO 05
4.13	Quadriatic Programming	1	CO 05
4.14	Complementary pivot problem	2	CO 05
4.15	LPP as Complementary Pivot Problem		CO 05
4.16	QPP as complementary pivot problem		CO 05
4.17	Complementary pivot Algorithm and Problems	3	CO 05

SYLLABUS

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: 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) (20 hours)

Module II: SENSITIVITY ANALYSIS; FLOW AND POTENTIALS IN NETWORKS

Introduction – changes in bi – changes in cj – Changes in aij – introduction of new variables – introduction of new constraints – deletion of variables - deletion of constraints –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 5.1 to 5.9 & 7.1 to 7.9, 7.15 of text - 1) (25 hours)

Module III: THEORY OF GAMES

Matrix (or rectangular) games – problem of games – minimax theorem, saddle point – strategies and pay off – theorems of matrix games – graphical solution – notion of dominance – rectangular game as an L.P. problem.
(Chapter 12; Sections: 12.1 – 12.9 of text – 1) (20 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 – project gradient methods with equality constraints – non-linear optimization: Kuhn-Tucker conditions – complimentary Pivot algorithms.
(Chapter 8; Sections: 8.1 – 8.14 of text – 2) (25 hours)

FOURTH SEMESTER

Course	Details
Code	**MT04C16**
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 various types of convergence and the relation between them.	Un	PSO 1
CO 2	To understand the important theorems in operator theory and to prove them.	Un	PSO 1
CO 3	To understand closed self adjoint and compact linear operators and their properties	Un	PSO 1,7
CO 4	To understand the spectrum of bounded and closed linear operators.	Un	PSO 1
CO 5	To understand the spectral properties in a Banach Algebra .	Un	PSO 1
CO 6	To understand unbounded linear operators and their properties.	Un	PSO 1

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

Module	Course Description	Hours	CO No.
	Module 1	**22**	
1.1	Strong and Weak Convergence, Convergence of Sequences of Operators and Functionals	10	CO 1
1.2	Open Mapping Theorem, Closed Linear Operators, Closed Graph Theorem	9	CO 2,4
1.3	Banach Fixed point theorem	3	CO 2
	Module 2	**22**	
2.1	Spectral theory in Finite Dimensional Normed Spaces, Basic Concepts	6	CO 2
2.2	Spectral Properties of Bounded Linear Operators, Further Properties of Resolvent and Spectrum	7	CO 2,4
2.3	Use of Complex Analysis in Spectral Theory	5	CO 4
2.4	Banach Algebras, Further Properties of Banach Algebras	4	CO 5
	Module 3	**20**	
3.1	Compact Linear Operators on Normed spaces, Further Properties of Compact Linear Operators	4	CO 2,3
3.2	Spectral Properties of compact Linear Operators on Normed spaces	6	CO 2,3
3.3	Further Spectral Properties of Compact Linear Operators	5	CO 2,3
3.4	Unbounded linear operators and their Hilbert adjoint operators, Hilbert adjoint operators, symmetric and self adjoint linear Operators	5	CO 3,6
	Module 4	**18**	
4.1	Spectral Properties of Bounded Self adjoint linear operators	6	CO 2,3,4
4.2	Further Spectral Properties of Bounded Self Adjoint Linear Operators	5	CO 2,3,4
4.3	Positive Operators, Projection Operators, Further Properties of Projections	7	CO 2,3

Text Book

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

Module I

Strong and weak convergence, convergence of sequence of operators and functionals, open mapping theorem, closed linear operators, closed graph theorem, Banach fixed point theorem.

(Chapter 4 - Sections 4.8, 4.9, 4.12 & 4.13 - Chapter 5 – Section 5.1 of the text) (25 hours)

Module 2

Spectral theory in finite dimensional normed space, basic concepts, spectral properties of bounded linear operators, further properties of resolvant and spectrum, use of complex analysis in spectral theory, Banach algebras, further properties of Banach algebras.

(Chapter 7 - Sections 71. to 7.7 of the text) (25 hours)

Module 3

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, unbounded linear operators and their Hilbert adjoint operators, Hilbert adjoint operators, symmetric and self adjoint linear operators.

(Chapter 8 - Sections 8.1 to 8.4 - Chapter 10 Sections 10.1 & 10.2 of the text) (20 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, 9.2, 9.3, 9.5, 9.6 of the text) (20 hours)

Books for References :

1. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York , 1963.
2. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi 1989.
3. Somasundaram. D, Functional Analysis, S.Viswanathan Pvt Ltd, Madras, 1994.
4. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd, Meerut: 1996.
5. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, 2008.

Course	Details
Code	**MT04E01**
Title	**ANALYTIC NUMBER THEORY**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 4th Semester
Type	Core

COURSE OUTCOMES

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, App	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 resedue systems.	Un	PSO 1
CO 8	To understand the geometric representation of partitions and derive the Euler's pentagonal - number theorems	Un	PSO 1

Ap-Apply Un-Understand

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 Λ(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 Λ(n),The partial sums of a Dirichlet product, Applications to μ(n) and of Λ(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	**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, The Sieve of Eratosathenes and Euler j -function.

(Chapter -4 Sections 4.1 to 4.7 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, Two applications

(Chapter 5, 6 Sections 6.1 to 6.5) (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.**

Course	Details
Code	**MT04E05**
Title	**MATHEMATICAL ECONOMICS**
Degree	M.Sc.
Branch	Mathematics
Year/Semester	2nd Year / 4th Semester
Type	Core

COURSE OUTCOMES

COURSE OUTCOME NO.	**COURSE OUTCOMES**	**Cognitive Level**	**PSO NO.**
CO 1	To understand the concept of marginal rate of substitution.	Un	PSO 1,2
CO 2	To understand the theory of demand.	Un	PSO 1
CO 3	To solve the problems related to the theory of consumer behaviour.	Un,Ap	PSO 1, 4
CO 4	To understand the meaning and nature of production function.	Un	PSO 1
CO 5	To solve the problems related to Euler's theorem, Cobb Douglas production function and CES production function.	Un,Ap	PSO 1,4
CO 6	To understand the meaning and main features of input output analysis.	Un	PSO 1
CO 7	To apply the input output analysis	Ap	PSO 1,4
CO 8	To understand and solve difference equations.	Un	PSO 1,4

Ap- Apply Un-Understand

COURSE DESCRIPTION

MT04E05- MATHEMATICAL ECONOMICS

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

Module		**Course Description**	**Hrs.**	**Co No.**
I	**1.0**	**Module I**	**20**	
	1.1	The theory of consumer behaviour- Introductory	2	1
	1.2	Maximization of utility	3	1
	1.3	Indifference cure approach	2	1
	1.4	Marginal rate of substitution	2	1
	1.5	Consumer's equilibrium	3	1
	1.6	Demand curve	2	2
	1.7	Relative preference theory of demand	2	2
	1.8	Numerical problems related to these theory part	4	3
II	**2.0**	**Module II**	**30**	
	2.1	Meaning and nature of production function	2	4
	2.2	The law of variable proportion	3	4
	2.3	Isoquants	2	4
	2.4	Marginal technical rate of substitution	2	4
	2.5	Producer's equilibrium	3	4
	2.6	Expansion path	2	4
	2.7	The elasticity of substitution	2	4
	2.8	Ridge lines and economic region of production	3	4
	2.9	Euler's theorem	2	5
	2.10	Cobb Douglas production function	3	5
	2.11	The CES Production function	3	5
	2.12	Numerical problems related to these theory parts	3	5
III	**3.0**	**Module III**	**20**	
	3.1	Meaning of input – output	3	6
	3.2	Main features of analysis	3	6
	3.3	Assumptions	3	6
	3.4	Leontief's static and dynamic model, limitations	4	6,7
	3.5	Importance and Applications of analysis	3	6,7
	3.6	Numerical problems related to these theory parts.	4	7
IV	**4.0**	**Module IV**	**20**	
	4.1	Difference equations –Introduction, Definition and Classification of Difference equations	2	8
	4.2	Linear Difference equations	1	8
	4.3	Solution of Difference equations	2	8
	4.4	Linear First-Order Difference equations with constant coefficients	2	8
	4.5	Behaviour of the solution sequence	2	8
	4.6	Equilibrium and Stability	2	8
	4.7	Applications of Difference equations in Economic Models	1	8
	4.8	The Harrod Model	2	8

	4.9	The General Cobweb Model	2	8
	4.10	Consumption Model	2	8
	4.11	Income – Consumption – Investment Model.	2	8

Syllabus

Textbooks:

1. Singh S.P, Anil K.Parashar, Singh H.P, Econometrics and Mathematical Economics, S. Chand & Company, 2002.
2. JEAN E. WEBER, MATHEMATICAL ANALYSIS Business and Economic Applications, Fourth edition, HARPER & ROW PUBLISHERS, New York.

Module:-1

The theory of consumer behaviour- Introductory, Maximization of utility, Indifference cure approach, Marginal rate of substitution, Consumer's equilibrium, Demand curve, Relative preference theory of demand, Numerical problems related to these theory part.

(Chapter – 13 .Sections 13.1, 13.2, 13.3, 13.4, 13.5, 13.6 & 13.13 of text - 1)(20 hours)

Module:-2

The production function:- Meaning and nature of production function, The law of variable proportion, Isoquants, Marginal technical rate of substitution, Producer's equilibrium, expansion path, The elasticity of substitution, Ridge lines and economic region of production, Euler's theorem, Cobb Douglas production function, The CES Production function, Numerical problems related to these theory parts.

(Chapter – 14. Sections 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.7, 14.8, 14.9, 14.10 & 14.11 of text - 1) (30 hours)

Module:-3

Input – Output Analysis:- Meaning of input – output, main features of analysis, Assumptions, Leontief's static and dynamic model, limitations, Importance and Applications of analysis, Numerical problems related to these theory parts.

(Chapter – 15. Sections 15.1, 15.2, 15.3, 15.4, 15.5,15.6, 15.7, 15.8 & 15.9 of text - 1) (20 hours)

Module:- 4

Difference equations –Introduction, Definition and Classification of Difference equations, Linear Difference equations, Solution of Difference equations, Linear First-Order Difference equations with constant coefficients, Behaviour of the solution sequence, Equilibrium and Stability, Applications of Difference equations in Economic Models, The Harrod Model, The General Cobweb Model, Consumption Model, Income – Consumption – Investment Model.

(Chapter 6 Sections 6.1 to 6.5 of text 2) (20 hours)

Course	Details
Course Code	MT04E04
Name of the Course	Probability Theory
Semester	IV
Hours Per Week	5
Credit	4

CO No	Course Outcome	Cognitive Level	PSO No
CO 01	Compare the various definitions of probability.	U	
CO 02	Solve the probability problems using the properties of probability	Ap	
CO 03	Compare the commonly used statistical distributions and their properties	U	
CO 04	Develop best Statistics that can be used for estimation purpose	Ap	
CO 05	Develop statistical test statistics which can be used to test parameters in commonly used tests.	Ap	
CO 06	Explain the application of linear models in Statistics	Ap	

	Description of Course Outcomes	**1**	
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

PROBABILITY THEORY

All questions shall be based on the relevant portions of the reference books given in the end of each module

Module - 1

Discrete Probability (Empirical, Classical and Axiomatic approaches), Independent events, Bayes theorem, Random variables, and distribution functions (univariate and multivariate), Expectation and moments, marginal and conditional distributions. Probability Inequalities (Chebychev, Markov). Modes of convergence, Weak and Strong laws of large numbers (Khintchine's Weak Law , Kolmogrov Strong Law, Bernaulli's Strong Law) Central Limit theorem (Lindeberg-Levy theorem).

References.

1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand & Sons, 2011.

2. V.K. Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, 2nd Ed. Wiley Eastern Ltd., 1986.

Module – 2

Standard discrete and continuous univariate distributions (Binomial, Poisson, Negative binomial, Geometric, Exponential, Hypergeometric, Normal, Rectangular, Cauchy's, Gamma, Beta,), Multivariate normal distribution, Wishart distribution and their properties.

References.

For univariate distributions, refer the book

1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand & Sons, 2011.

For Multivariate distributions, refer the book

2. T.W. Anderson, An Introduction to Multivariate Statistical Analysis, 3rd Ed., Wiley Interscience, 2003.

Module – 3

Methods of estimation, properties of estimators, Cramer-Rao inequality, Fisher-Neyman criterion for sufficiency, Rao-Blackwell theorem, completeness ,method of maximum likelihood, properties of maximum likelihood estimators , method of moments. Tests of hypothesis: most powerful and uniformly most powerful tests (Neyman – Pearson Lemma).

References.

For Estimation, refer the book

1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand & Sons, 2011.

For Tests of Hypothesis, refer the book

2. V.K. Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, 2nd Ed. Wiley Eastern Ltd., 1986.

Module- 4

Gauss-Markov models, estimability of parameters, best linear unbiased estimators, Analysis of variance and covariance. One way and two way classification with one observation per cell.

References.

1. D.D. Joshi, Linear Estimation and Design of Experiments, Wiley Eastern Ltd., 1990.
2. C.R. Rao, Linear Statistical Inference and its Applications, John Wiely, New York. ,1965.
3. W.G.Cochran and G.M. Cox , Experimental Designs, 2nd Ed., John Wiely, New York. , 1957.