Est. in 1921

UNION CHRISTIAN COLLEGE (AUTONOMOUS) ALUVA

Affiliated to Mahatma Gandhi University, Kottayam, India
NAAC Accredited with A++ Grade in Vth cycle
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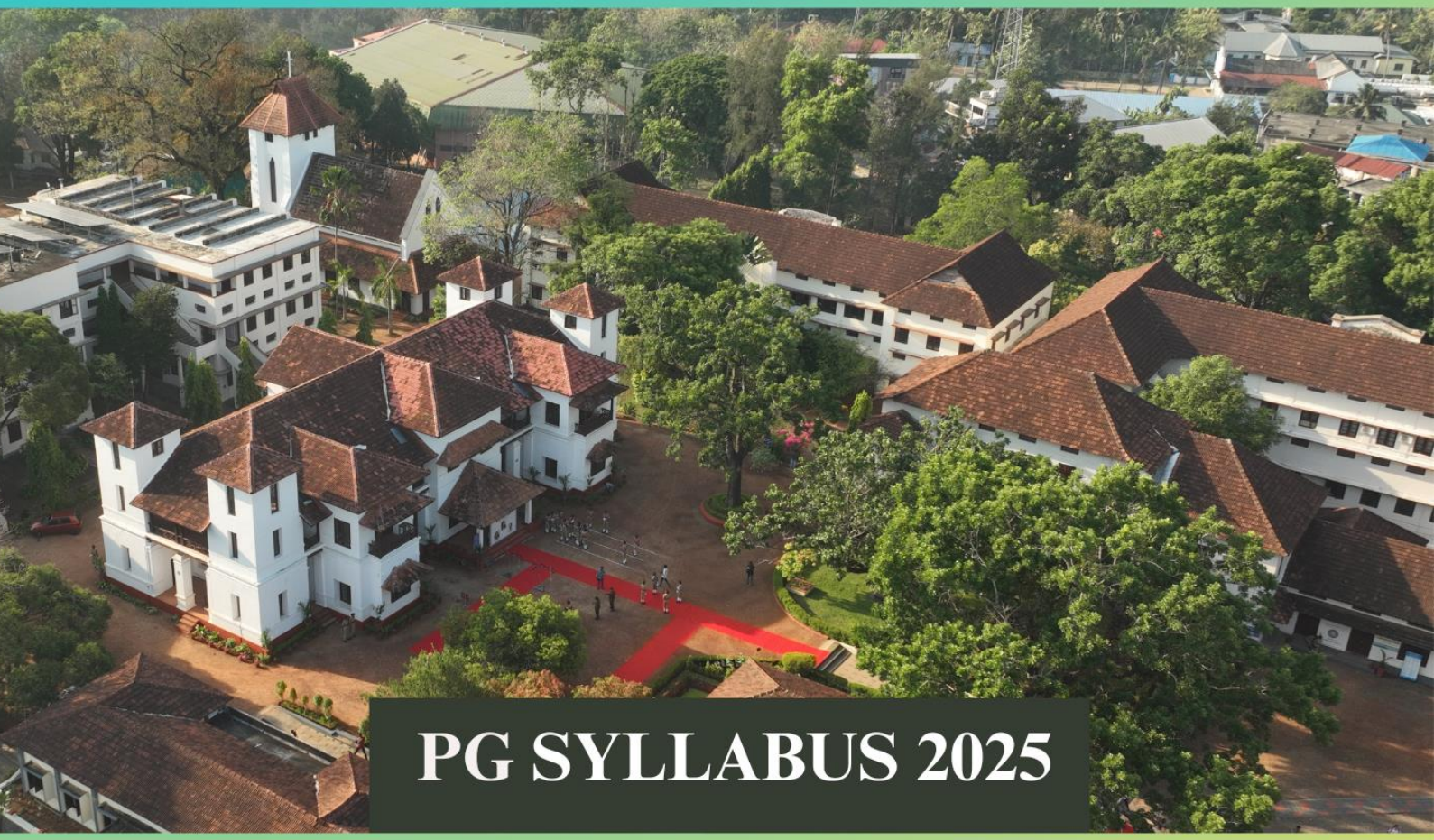
DEPARTMENT OF MATHEMATICS



PG SYLLABUS 2025

POSTGRADUATE PROGRAMME {UCC PGP}
IN MATHEMATICS

Master of Science in Mathematics

PROGRAMME STRUCTURE AND SYLLABUS
2025-26 ADMISSIONS ONWARDS

BOARD OF STUDIES IN MATHEMATICS (PG)
UNION CHRISTIAN COLLEGE, ALUVA
(Autonomous)
2025

PREFACE

The Board of Studies in Mathematics is pleased to present this syllabus, designed with a forward-looking vision to meet the evolving demands of modern education and to foster a deep, meaningful engagement with the subject of Mathematics.

This program aims to enrich students' understanding of mathematics by sharpening their logical reasoning, analytical thinking, and problem-solving abilities. A core focus is placed on connecting mathematical concepts with real-world applications, thereby enhancing the relevance and practicality of the subject in everyday life.

By cultivating curiosity and confidence in learners, this curriculum aspires to create an environment where mathematics is not just a subject to be studied, but a dynamic tool to explore, question, and understand the world around us. It seeks to encourage a research-oriented mindset, inspire students to pursue higher studies, and instill a sense of scientific integrity and objectivity in all academic and professional endeavors.

Ultimately, this program envisions mathematics education that is alive, vibrant, and transformative—empowering students to become thoughtful, innovative, and responsible contributors to society.

Chairperson
PG Board of Studies in Mathematics

BOARD OF STUDIES

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07	Dr. Aparna Lakshmanan S., Professor Department of Mathematics Cochin University of Science and Technology, Kochi - 682022	**Member**
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10	Dr. Manju K. Menon, Professor Department of Mathematics, St. Paul's College, Kalamassery	**Member**
11	Dr. K. P. Jose, Associate Professor Department of Mathematics, St. Peter's College, Kolenchery	**Member**

ACKNOWLEDGEMENT

The Postgraduate Board of studies expresses our sincere thanks to the Principal, the Manager of Union Christian College, Aluva and the Academic Council of the College for the guidance and help extended to us during the revision of M.Sc. Mathematics syllabus.
We also express our sincere appreciation to the members of the PG Board of Studies in Mathematics of Mahatma Gandhi University, who originally formulated and restructured M.Sc. Mathematics syllabus to suit the Credit and Semester System.
The present form of the syllabus includes certain modifications, thoughtfully incorporated based on the suggestions and recommendations of the members of the PG Board of Studies in Mathematics, Union Christian College, Aluva.

Table of Contents

M Sc MATHEMATICS Degree Program

1. **Aim of the Program**

Aims and objective:

- To improve the perspective of students on mathematics as per modern requirement.
- To enhance the logical, reasoning, analytical and problem solving skills of students.
- To orient students towards relating Mathematics to applications.
- To help the student build interest and confidence in learning the subject.
- To cultivate a research culture in young minds.
- To encourage students for pursuing higher studies in mathematics.
- To ultimately see that the learning of mathematics becomes more alive, vibrant, relevant and meaningful; a program that paves the way to seek and understand the world around them.
- To motivate students to uphold scientific integrity and objectivity in professional endeavours.

2. **Eligibility for Admissions**
   As per the rules and regulation of PG admission of M G University, 2019

3. **Medium of Instruction and Assessment**
   English

4. **Faculty under which the Degree is Awarded**
   Science

5. **Note on compliance with the UGC Minimum Standards for the conduct and award of Post Graduate Degrees**
   The programme is offered in accordance with the UGC minimum standards for the conduct an award of Post Graduate Degrees. The students have to secure 80 credits to complete the programme successfully.

THE PROGRAM STRUCTURE

Course Code	Title of the Course	Type of the Course	Hours per week	Credits
FIRST SEMESTER				
UCME010101	Abstract Algebra	Theory	5	4
UCME010102	Linear Algebra	Theory	5	4
UCME010103	Basic Topology	Theory	5	4
UCME010104	Real Analysis	Theory	5	4
UCME010105	Graph Theory	Theory	5	4
SECOND SEMESTER				
UCME010201	Advanced Abstract Algebra	Theory	5	4
UCME010202	Advanced Topology	Theory	5	4
UCME010203	Numerical Analysis with Python	Theory	5	4
UCME010204	Complex Analysis	Theory	5	4
UCME010205	Measure and Integration	Theory	5	4
THIRD SEMESTER				
UCME010301	Advanced Complex Analysis	Theory	5	4
UCME010302	Partial Differential Equations	Theory	5	4
UCME010303	Multivariate Calculus	Theory	5	4
UCME010304	Functional Analysis	Theory	5	4
UCME010305	Optimization Technique	Theory	5	4
FOURTH SEMESTER				
UCME010401	Spectral Theory	Theory	5	4
UCME010402	Analytic Number Theory	Theory	5	4
	Elective 1	Theory	5	3
	Elective 2	Theory	5	3
	Elective 3	Theory	5	3
Dissertation				1
Comprehensive Viva				2
Total Credits				80
Electives Offered				
UCME800401	Differential Geometry		5	3
UCME800402	Algorithmic Graph Theory		5	3
UCME800403	Combinatorics		5	3
UCME810401	Probability Theory		5	3
UCME810402	Operations Research		5	3
UCME810403	Coding Theory		5	3
UCME820401	Commutative Algebra		5	3
UCME820402	Ordinary Differential Equations		5	3
UCME820403	Classical Mechanics		5	3

FIRST SEMESTER COURSES

UCME010101	**Abstract Algebra**
UCME010102	**Linear Algebra**
UCME010103	**Basic Topology**
UCME010104	**Real Analysis**
UCME010105	**Graph Theory**

UCME010101 - ABSTRACT ALGEBRA

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

Text Book: **John B. Fraleigh, Neal Brand, A First Course in Abstract Algebra, Eighth Edition, Pearson Education.**

Module 1: Finitely generated abelian groups, Factor groups, Isomorphism theorems **(Sections 9, 12 & 16**) **(25 hours)**

Module 2: Group action on a set, Applications of G-sets to counting, Sylow theorems **(Sections 14, 15 & 17)** **(25 hours)**

Module 3: The field of quotients of an integral domain, Rings of polynomials, Factorisation of polynomials over a field. **(Sections 26, 27 & 28)** **(20 hours)**

Module 4: Homomorphisms and factor rings, Prime and maximal ideals **(Sections 30 & 31)** **(20 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

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.

UCME010102 - LINEAR ALGEBRA

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

Text Book: Kenneth Hoffman / Ray Kunze (Second Edition), *Linear Algebra*, Prentice-Hall of India Pvt. Ltd., New Delhi, 1992.

Review : Chapter 1 of text

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)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**3**	**1**
Module III	**3**	**1**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:

1. Klaus Jonich. Linear Algebra, Springer Verlag.
2. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.
3. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.
4. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
5. S. Kumaresan, Linear Algebra A Geometrical Approach, Prentice Hall ofIndia, 2000.

UCME010103 - BASIC TOPOLOGY

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

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 excluded, Section 4; 4.1 to 4.12 (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 (20hours)

Module IV : Spaces with special properties :- Local connectedness and Paths Separation axioms:- Hierarchy of separation axioms
(Chapter 6 : Sections 3.1 to 3.8, Chapter 7 : Sections 1.1 to 1.17(20 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

Reference:

1) George F. Simmons, Introduction to Topology and Modern Analysis, McGraw- Hill Book Company,1963
2) James R. Munkres , Topology(second edition) , Pearson
3) I.M. Singer &J.A. Thorpe ,Lecture Notes on Elementary Topology &Geometry, Springer Verlag 2004

UCME010104 - REAL ANALYSIS

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

Text 1: **Tom Apostol, Mathematical Analysis (Second edition), Narosa Publishing House.**

Text 2: **Walter Rudin, Principles of Mathematical Analysis (Third 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.)

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

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

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

UCME010105 – GRAPH THEORY

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

Text : **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(Up to 1.7.2 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 Sections 4.1, 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 and 7.3(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)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

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. Sheldon Axler, Linear algebra done right, Second edition ,Springer.

SECOND SEMESTER COURSES

UCME010201	**Advanced Abstract Algebra**
UCME010202	**Advanced Topology**
UCME010203	**Numerical Analysis with Python**
UCME010204	**Complex Analysis**
UCME010205	**Measure and Integration**

UCME010201 - ADVANCED ABSTRACT ALGEBRA

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

Text Book : **John B. Fraleigh, Neal Brand, A First Course in Abstract Algebra, Eighth Edition, Pearson Education.**

Module 1: Unique factorization domains, Euclidean domains, Number Theory - Gaussian integers
(Section 34, 35 & 36 (36.1-36.5) of the text) **(25 hours)**

Module 2: Introduction to extension fields, Algebraic extensions, Geometric constructions, Finite fields
(Sections 39, 40 (40.1-40.18), 41 & 42 of the text) **(25 hours)**

Module 3: Introduction to Galois theory, Splitting fields
(Sections 43 & 44 of the text) **(20 hours)**

Module 4: Separable extensions, Galois Theory, Cyclotomic Extensions
(Sections 45, 46 & 48 (48.1-48.6) of the text) **(20 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

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.

UCME010202 - ADVANCED TOPOLOGY

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

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

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) (25hours)

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) (20 hours)

Module III : Embedding and Metrisation;- Evaluation functions into products – Embedding lemma and Tychonoff Embedding – The Urysohn Metrisation Theorem Variation of compactness

(Chapter 9: Section 1; 1.1 to 1.6, Section 2; 2.1 to 2.5 Section, 3; 3.1 to 3.4 (Chapter 11: Section1; 1.1 to 1.11 (Proof of 1.4 excluded)) (20 hours)

Module IV : Definition and convergence of nets, Topology and Convergence of Nets, Filters and their Convergence.

(Chapter 10: Section 1, Section 2, Section 3; 3.1 to 3.11 (Proofs of 3.8 and 3.9 excluded)) (25hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**2**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**3**	**2**	**1**
Total	**10**	**8**	**4**

References:

1) George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company,1963
2) Stephen Willard, General Topology, Addison-Wesley
3) James R. Munkres , Topology(second edition) , Pearson
4) I.M. Singer &J.A. Thorpe ,Lecture Notes on Elementary Topology &Geometry, Springer Verlag 2004

UCME010203 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

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

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

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, -

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.

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References

1. A primer on scientific programming with python, 3rd edition, Hans Petter Langtangen, Springer
2. Vernon L. Ceder, The Quick Python Book, Second Edition, Manning.
3. NumPy Reference Release 1.12.0, Written by the NumPy community. (available for free download at https://docs.scipy.org/doc/numpy-dev/numpy-ref.pdf)
4. S. D. Conte and Carl de Boor, Elementary Numerical Analysis – An algorithmic approach, Third Edition, McGraw-Hill Book Company.
5. S.S. Sastry, Introductory Methods of Numerical Analysis, Fifth Edition, PHI.

UCME010204 COMPLEX ANALYSIS

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

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 Section 2.4,Chapter – 2 Sections.2.1 to 2.5,Chapter – 3 Sections 2.1, 2.2, 2.3,2.4and ,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 – Sections 1 , 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)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

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

UCME010205 - MEASURE THEORY AND INTEGRATION

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

Text Book: **H. L. Royden, P.M. Fitzpatrick, Real Analysis Fourth Edition, Pearson Education**

Module 1: Lebesgue Measure: Introduction, Lebesgue outer measure, The σ 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 – Measureable functions

Chapter 17; Sections 17.1 to 17.2, 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)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:

1. G. de Barra : Measure Theory and integration , New Age International (P) Ltd., New DelhiNew 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
4. (P) Ltd., New Delhi, 1986(Reprint 2000).
5. R.G. Bartle, The Elements of Integration, John Wiley & Sons, Inc New York, 1966.

THIRD SEMESTER COURSES

UCME010301	**Advanced Complex Analysis**
UCME010302	**Partial Differential Equations**
UCME010303	**Multivariate Calculus**
UCME010304	**Functional Analysis**
UCME010305	**Optimization Technique**

UCME010301 - Advanced Complex Analysis

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

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

Module 1: Harmonic Functions – Definition 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
(Chapter 4 : Section 6: 6.1 - 6.5, Chapter 6 : Section 3 : 3.1 - 3.2 , Section 4 : 4.1)

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, Extension of $\zeta(s)$ to the Whole Plane, The Functional Equation, The Zeroes of the Zeta Function The Riemann Mapping Theorem – Statement and Proof
(Chapter 5 : Section 4 : 4.1 – 4.4, Chapter 6 : Section 1:1.1)

Module 4: Doubly Periodic Functions - The Period Module, Unimodular Transformations, The Canonical Basis, General Properties of Elliptic Functions The Weierstrass's Theory – The Weierstrass's ρ-function, The Functions $\zeta(s)$ and $\sigma(z)$, The Differential Equation
(Chapter 7 : Sections 2 : 2.1 - 2.4, Section 3 : 3.1 – 3.3)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

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 Application

UCME010302 – PARTIAL DIFFERENTIAL EQUATIONS

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

Text Book: 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. Origins of first order partial differential equation. **(20 hours)**

Module 2: Linear equations of first order. Integral surfaces passing through a given curve. Surfaces orthogonal to a given system of surfaces. Nonlinear 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. **(25 hours)**

Module 3: Jacobi' s method The origin of second order equations. Linear partial differential equations with constant coefficients. Equations with variable coefficients. **(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 the Logarithmic potential to the Theory of Functions. **(25 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:

1. Phoolan Prasad and Renuka Ravindran, Partial Differential Equations, New Age International
2. K Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India
3. E T Copson, Partial Differential Equations, S Chand and Co

UCME010303 - MULTIVARIATE CALCULUS

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

Text 1: **Tom Apostol, Mathematical Analysis, Second edition, Narosa Publishing House.**

Text 2: **Walter Rudin, Principles of Mathematical Analysis, Third edition – International Student Edition.**

Module 1: Functions of Several variables

Euclidean Space R^n, Open balls and sets in R^n, Closed sets, Adherent points, Accumulation points, closed sets and adherent points, The Bolzano Weierstrass Theorem, limits of complex valued functions, limits of vector valued functions, continuous complex valued and vector valued functions, Derivatives of vector valued functions, Partial Derivatives

Sections 3.1-3.3, 3.5-3.8 Sections 4.6, 4.7,4.10,4.11 Section 5.13, 5.14 of Text 1 **(20 hours**.)

Module 2: Multivariable Differential Calculus

The directional derivative, directional derivatives and continuity, the total derivative, 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 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 sufficient condition for equality of mixed partial derivatives, functions with non-zero Jacobian determinant, the inverse function theorem ,the implicit function theorem, extrema of real-valued functions of one 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 (28hours.)

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 of Text 2, except example 10.4, proof of

theorem 10.7) (20 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:-

1. Limaye Balmohan Vishnu, Multivariate Analysis, Springer.
2. Satish Shirali and Harikrishnan, Multivariable Analysis, Springer

UCME010304 - FUNCTIONAL ANALYSIS

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

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

Module 1: Further Examples of Metric Spaces, 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 1.2, 1.5, 1.6; Chapter 2 - Sections 2.1 to 2.5)

Module 2: 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)

Module 3: 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, Representation of Functionals on Hilbert Spaces

(Chapter 3 - Sections 3.1 to 3.5, 3.8)

Module 4: 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.

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

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

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.

UCME010305 OPTIMIZATION TECHNIQUES

5 hours/week (Total Hours : 90) **4 credits**

Text -1 **K.V. Mital and C. Mohan, Optimization Methods in Operation Research and Systems Analysis, 3rd edition.**

Text -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)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**2**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**3**	**2**	**1**
Total	**10**	**8**	**4**

Reference:-

1. S.S. Rao, Optimization Theory and Applications, 2nd edition, New Age International Pvt.
2. J.K. Sharma, Operations Research: Theory and Applications, 3rd edition, Macmillan India Ltd.
3. Hamdy A. Thaha, Operations Research – An Introduction, 6th edition, Prentice Hall of India Pvt. Ltd.

FOURTH SEMESTER COURSES

UCME010401	**Spectral Theory**
UCME010402	**Analytic Number Theory**
Electives	
UCME800401	**Differential Geometry**
UCME800402	**Algorithmic Graph Theory**
UCME800403	**Combinatorics**
UCME810401	**Probability Theory**
UCME810402	**Operations Research**
UCME810403	**Coding Theory**
UCME820401	**Commutate Algebra**
UCME820402	**Ordinary Differential Equations**
UCME820403	**Classical Mechanics**

UCME010401 - SPECTRAL THEORY

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

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.
(Chapter5 – Section 5.1; Chapter 7 - Sections 7.1 to 7.4) (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.
(Chapter 7 - Sections 7.6, 7.7; Chapter 8 - Sections 8.1 to 8.3) (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)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

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.

UCME010402 - ANALYTIC NUMBER THEORY

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

Text: **Tom M. Apostol, Introduction to Analytic Number Theory, Springer International Student Edition, Narosa Publishing House**

Module I: **Arithmetical functions and Dirichlet multiplication** - Introduction, The Möbius function μ(n), The Euler totient function ϕ(n), A relation connecting ϕ and μ, A product formula for ϕ(n), The Dirichlet product of arithmetical functions, Dirichlet inverses and the Möbius inversion formula, The Mangoldt function Λ(n), Multiplicative functions, Multiplicative functions and Dirichlet Multiplication, The inverse of a completely multiplicative function, Liouville's function λ(n), The divisor function σ_α(n), Generalized convolutions

Averages of arithmetical functions - Introduction, The big oh notation, Asymptotic equality of functions, Euler's summation formula, Some elementary asymptotic formulas, The average order of d(n), The average order of the divisor functions σ_α(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 Λ(n)

(Chapter 2: Sections 2.1 to 2.14, Chapter 3: Sections 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 P_n, Shapiro's tauberian theorem, Applications of Shapiro's theorem, An asymptotic formula for the partial sums $\sum_{P \le X} \frac{1}{P}$

(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, Polynomial congruences 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: Sections 5.1 to 5.8)** **(25 hours)**

Module IV: **Quadratic residues and the quadratic reciprocity law** - Quadratic residues, 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: Sections 9.1 to 9.6)** **(20 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**2**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:

1. David M. Burton, Elementary number Theory, Seventh edition,Tata McGraw-Hill Edition 2012
2. Kenneth H. Rosen, Elementary Number Theory and its Applications, Sixth Edition, 2011
3. Hardy G. H. and Wright E. M., Introduction to the Theory of Numbers, Oxford,1981
4. Leveque W. J., Topics in Number Theory, Addison Wesley, 1961
5. J.P.Serre, A Course in Arithmetic, GTM Vol.7, Springer-Verlag, 1973

Elective Group

UCME800401 - DIFFERENTIAL GEOMETRY

5 Hours/Week (Total Hours : 90) **3 Credits**

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) (20 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 and Parametrized surfaces
(Chapters 12 & 14 of the text). (25 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:-

1. Serge Lang, Differential Manifolds
2. I.M. Siger, J.A Thorpe, Lecture notes on Elementary topology and Geometry, Springer – Verlag, 1967.
3. S. Sternberg, Lectures on Differential Geometry, Prentice-Hall, 1964.
4. M. DoCarmo, Differential Geometry of curves and surfaces.
5. Goursat, Mathematical Analysis, Vol – 1(last two chapters)

UCME800402: 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)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

Reference:-

1. Alan Gibbons, Algorithmic Graph Theory, Cambridge University Press, 1985
2. Mchugh. J.A, Algorithmic Graph Theory, Prentice-Hall, 1990 Golumbic. M, Algorithmic Graph Theory and Perfect Graphs, Academic press.

UCME800403 COMBINATORICS

5 Hours/Week (Total Hours : 90) **3 Credits**

Text : **Chen Chuan Chong , Koh Khee Meng , Principles and Techniques in Combinatorics., World Scientific Publishing, 2007**

Module I Permutations and combinations: Two basic counting principles, Permutations, Circular permutations, Combinations, The injection and bijection principles, Arrangements and selections with repetitions, Distribution Problems **(Chapter 1 of the text Sections 1.1 – 1.7)**
(22 hours)

Module II The Pigeonhole Principle and Ramsey numbers: Introduction, The Pigeonhole principle, More examples, Ramsey Type problems and Ramsey numbers,Bounds for Ramsey numbers
(Chapter 3 of the text Sections 3.1 - 3.5) **(18 hours)**

Module III The Principle of Inclusion and Exclusion: Introduction, The principle, A generalization , Integer solutions and shortest routes, Surjective mappings and Stirling Numbers of second kind, Derangements and A Generalization.
(Chapter 4 of the text Sections 4.1 – 4.6) **(25 hours)**

Module IV Generating Functions & Recurrence relations: Generating Functions: Ordinary generating functions, Some modeling Problems, Partition of Integers, Exponential generating functions
Recurrence Relations: Introduction, Two examples, Linear homogeneous recurrence relations, General Linear recurrence relations.
(Chapter 5 & Chapter 6 of the text Sections 6.1- 6.4) **(25 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**2**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:-

1. V Krishnamoorthy, Combinatorics theory and applications, E. Hoewood, 1986
2. Hall,Jr, Combinatorial Theory, Wiley- Interscinice, 1998.
3 .Brualdi, R A, Introductory Combinatorics, Prentice Hall,1992

UCME810401 PROBABILITY THEORY

5 Hours/Week (Total Hours : 90) 3 Credits

Text 1: **V.K (2001) *An Introduction to Probability and Statistics*, 2nd Edn, Wiley India (P) Ltd, New Delhi.**

Text 2: **Bhat B.R (1999) *Modern Probability Theory*, 3rd Edn, New Age International (P) Ltd, New Delhi.**

Text 3: **S.C Gupta and V.K Kapoor (2002) *Fundamentals of Mathematical Statistics*, 11th Edn, Sultan Chand & Sons, New Delhi.**

Module 1: Introduction and different approaches to probability, Probability Axioms - Addition rule, Principle of inclusion and exclusion, Bonferroni's inequality, Boole's inequality, Implication rule, Sequence of events and their limits, Conditional Probability, Multiplication rule on Probability, Baye's Theorem, Independence of Events, Borel 0-1 Criterion.

Text Book 1 : - Sections 1.2 , 1.3 (till Remarks 5), 1.5, 1.6

Text Book 2 : -Sections 9.3(b)

Module 2: Random variable, Probability distribution, Discrete and Continuous random variables, Function of a random variable, Expectation and Moments of a random variable, Generating Functions, Moment inequalities – Markov's inequality, Chebychev- Bienayme's inequality, Lyapunov's inequality.

Text Book 1 :- Chapters 2- Section 2.1 to 2.5(till example 7) and Chapter 3–Section 3.2 except proofs of Theorem 4,5,6 , Section 3.3, Section 3.4)

Module 3: Multiple random variable, Independence of random variables, Covariance and Correlation and moments, Addition and Multiplication theorems on expectation, Cr inequality, Holder's inequality, Cauchy- Schwartz's inequality, Jensen's inequality, Minkowski's inequality, Conditional expectation.

Text Book 1 :Sections 4.2 to 4.3 (till example 6), 4.5 (till theorem 6 including its Corollary's 1 and 2, 4.6.

Text Book 2 :Section 5.3 (c) and (d).

Module 4: Convergence of sequence of random variables – Convergence in law, Convergence in probability, Convergence in r^{th} mean, Convergence almost surely. Weak Law of Large Numbers-Kintchine's Weak Law of Large Numbers, Strong Law of Large Numbers-Kolmogrov strong law of large numbers, Central Limit Theorem- Lindberg- Levy form and Liapunov'sform of Central Limit Theorem (simple application problems)

Text Book 1 : Section 6.2 (till Theorem 12),For the remaining part of the module reference may be done from any of the Text Books 1, 2 or3.

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References

1. S.C Gupta and V.K Kapoor (2002) *Fundamentals of Mathematical Statistics*, 11th Edn, Sultan Chand & Sons, New Delhi
2. Mukhopadhyay, P. (2011) *An Introduction to the Theory of Probability*, World Scientific Publishing Company.
3. Billingsley P. (1985) *Probability and Measure*, Wiley India (P) Ltd.
4. Laha R.G and Rohatgi V.K (1979) *Probability Theory*, Wiley India (P) Ltd.
5. Loeve M (1963) *Probability Theory*, Allied East – West Press.
6. Feller W. (1976) *AnIntroduction to Probability Theory and Its Applications*, Vol. 2, Wiley India (P) Ltd.

UCME810402 OPERATIONS RESEARCH

5 Hours/Week (Total Hours : 90) **3 Credits**

Text 1: **K.V. Mital and C. Mohan, Optimization Methods in Operations Research and System Analysis, 3rd edition, New Age International Pvt. Ltd..**

Text 2 : **A. Ravindran , Don T. Philips and James J. Solberg., Operations Research Principles and Practice, 2nd edition, John Wiley and Sons.**

Module 1: Dynamic Programming Introduction , Problem 1- Minimum path problem, Problem 2 -Single additive constraint, additively separable return, Problem 3– Single multiplicative constraint, additively separable return, Problem 4- Single additive constraint, multiplicatively separable return, Computational economy in DP , Serial multistage model, Examples of failure ,Decomposition , Backward and forward recursion , Systems with more than one constraints, Applications of D.P to continuous systems.

(Chapter 10; Sections 10.1 – 10.12 of text 1)

Module 2: Continuous time random processes An example, Formal definitions and theory, the assumptions reconsidered, Steady state probabilities, Birth death processes, The Poisson process.

(Chapter 6 ; Sections 6.11 – 6.16 of text 2)

Module 3: Queueing Systems Introduction, An example, General Characteristics, Performance Measures, Relations Among the performance Measures, Markovian Queueing Models, The M/M/1 Model, Limited Queue Capacity, Multiple Servers, An example, Finite Sources.

(Chapter 7; Sections 7.1 –7.11 of text 2)

Module 4: Inventory Models Introduction The classical Economic Order Quantity, A Numerical example, Sensitivity Analysis, Non Zero lead Time, The EOQ. with shortages allowed The Production Lot size (PLS) models ,The Newsboy Problem (a single period model) ,A Lot size reorder point model, Variable lead times, The importance of selecting the right model.

(Chapter 8; Sections: 8.1 – 8.14 of text 2)

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:

1. Fundamentals of Queueing Theory, Donald Gross, Carl M. Harris, 3rd edition, John Wiley and Sons.
2. Hamdy A. Taha, Operations Research – An Introduction, 6th edition, Prentice Hall of India Pvt. Ltd.
3. Man Mohan, P.K. Gupta and Kanti Swarup, Operations Research, Sultan Chand and Sons.

UCME810403 : CODING THEORY

5 hours/week (Total Hours : 90) **3 Credits**

Text : **Vera Pless 3rd Edition , Introduction to the theory of error coding codes, Wiley Inter Science**

Module I: Introduction Basic Definitions Weight, Maximum Likelihood decoding Synarome decoding, Perfect Codes, Hamming codes, Sphere packing bound, more general facts.
(Chapter 1 & Chapter 2 Sections 2.1, 2.2, 2.3 of the text) **(25 hours)**

Module II: Self dual codes, The Golay codes, A double error correction BCH code and a field of 16 elements.
(Chapter 2 Section 2.4 & Chapter 3 of the text) **(20 hours)**

Module III: Finite fields
(Chapter 4 of the text) **(20 hours)**

Module IV: Cyclic Codes, BCH codes
(Chapter 5 & Chapter 7 of the text) **(25 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**2**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:-

1. R-Lidi, G. Pliz, Applied Abstract Algebra, Springer Verlag.
2. J.H.Van Lint, Introduction to Coding Theory, Springer Verlag
3. R.E.Blahut, Error- Control Codes, Addison Wesley.

UCME820401: COMMUTATIVE ALGEBRA

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

Text Book : Gregor Kemper, A Course in Commutative Algebra, Springer, ISSN0072- 5285, ISBN978-3-642-03544-6

Module I: **The Algebra-Geometry Lexicon – Hilbert's Nullstellensatz** Maximal ideals, Jacobson Rings, Coordinate Rings, Simple problems. **(Chapter1 Sections 1.1, 1.2 & 1.3 of the text)** **(25hours)**

Module II: **Noetherian and Artinian Rings.**
The Noether and Artin Properties for Rings and Modules, Notherian Rings and Modules, Simple problems
(Chapter2 Sections 2.1 & 2.2, of the text) **(20 hours)**

Module III: **The Zariski Topology**
Affine Varieties, Spectra, Noetherian and Irreducible Spaces, Simple problems.
(Chapter 3 Sections 3.1, 3.2 & 3.3 of the text) **(25 hours)**

Module IV: **A Summary of the Lexicon**
True Geometry: Affine Varieties, Abstract Geometry : Spectra , Simple problems
(Chapter 4 Sections 4.1 & 4.2, of the text). **(20 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**2**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References: -

1. William W. Adams, Phillippe Loustaunau, An Introduction to Grobner bases, Graduate Studies in Mathematics 3, American Mathematical Society, 1994, [117]
2. Michael F Attiyah, Ian Grant Macdonald, Introduction to Commutative Algebra, Addison- Wesley, Reading, 1969[174]
3. Nicolas Bourbaki, General Topology, Chapters 1 – 4, Springer, Berlin, 1993, [117,118,161].

UCME820402: Ordinary Differential Equations

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

Text : **George F. Simmons, Differential Equations with Applications and Historical Notes, Second Edition, Tata McGraw Hill Publishing Company Limited**

Module I : **Qualitative properties of solutions and Boundary value problems**
Oscillations and the sturm separation theorem,the sturm comparison theorem, Eigen values, eigen functions and the vibrating string , Sturm – Liouville problems
(Sections 24, 25, 40 and 43 of the text) **(20 hours)**

Module II : Some Special Functions of Mathematical Physics
Legendre polynomials, Properties of Legendre polynomials, Bessel`s functions, the gamma function, properties of Bessel functions, Additional properties of Bessel functions
(Sections 44, 45, 46, 47 and Appendix C of the text) **(25 hours)**

Module III : System of First order Equations and Non linear Equations
General remarks on systems, Linear systems, Homogeneous linear systems with constant coefficients, Nonlinear systems. Volterra`s prey- predator equations, Autonomous systems. The phase plane and its phenonina, Types of Critical points. Stability, Critical Points and stability for linear systems, Stability by Liapunov`s direct method.
(Sections 54 to 61 of the text) **(25 hours)**

Module IV: **The Existence and Uniqueness of Solutions**
The method of successive approximations, Picard`s theorem, Systems. The second order linear equation
(Sections 68, 69 and 70 of the text) **(20 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**2**	**2**	**1**
Module II	**3**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:-

1. Shepley L. Ross - Differential Equations, 3rd ed., (Wiley India).
2. E.A. Coddington - An Introduction to Ordinary Differential Equation, PHI.
3. W.E. Boyce & R.C. Diprima - Elementary Differential Equations and boundary value Problems, (Wiley India)
4. S. Balachandra Rao & H. Ranuradha – Differential Equation with Applications and Programs (Universities Press)

UCME820403 : CLASSICAL MECHANICS

5 Hours/Week (Total Hours : 90) **3 Credits**

Text: **L. D. Landau and E. M. Lifshitz- MECHANICS, (Third Edition) (Butter worth – Heinenann)**

Module 1: Generalized coordinates, the Principle of least action, Galileo's relativity principle, the Legrangian for a free particle, Legrangian for a system of particle,energy, momentum, center of mass, angular momentum, motion in one dimension,determination of the potential energy from the period of oscillation, the reduced mass,motion in a central field.
(Section 1 to 9, 11 to 14 of the text) **(25 hours)**

Module 2: Free oscillation in one dimension, angular velocity, the inertia tensor, angular momentum of a rigid body, the equation of motion of a rigid body, Eulerian angle,Euler's equation.
(Section 21, 31 to 36 of the text) **(20 hours)**

Module 3: The Hamilton's equation, the Routhian, Poisson brackets, the action as a functionof the coordinates, Maupertui's principle.
(Section 40 to 44 of the text) **(25 hours)**

Module 4: The Canonical transformation, Liouville's theorem, the Hamiltonian – Jacobi equation, separation of the variables, adiabatic invariants, canonical Variables **(Section 45 – 50 of the text)** **(20 hours)**

Question Paper Pattern

	Section A	Section B	Section C
Module I	**3**	**2**	**1**
Module II	**2**	**2**	**1**
Module III	**3**	**2**	**1**
Module IV	**2**	**2**	**1**
Total	**10**	**8**	**4**

References:-

1. M. G. Calkin, Lagrangian and Hamiltonian Mechanics, Allied
2. Herbert Goldstein, Classical Mechanics, Narosa
3. K C Gupta, Classical Mechanics of particles and Rigid Bodies, Wiley Eastern

MODEL QUESTION PAPER PATTERN

***QP Code*……..** **Reg. No…….…..**

Name ……..……

M Sc (Mathematics) Degree (C.S.S) Examination, ……

……. Semester

Faculty of Science

Name of Course

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1.

2.

3.

4.

5.

6.

7.

8.

9.

10. **(8 x 1 = 8)**

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11

12.

13.

14.

15.

16.

17.

18. (**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19.
20.
21.
22. (**2 x 5 = 10)**