FAROOK COLLEGE (AUTONOMOUS)

Farook College PO, Kozhikode-673632

P.G Programme in Mathematics

Under

Choice Based Credit Semester System

SYLLABUS

(2022 Admission Onwards)

ORA ET LABORA

Prepared By:

Board of Studies in Mathematics

Farook College (Autonomous)

CERTIFICATE

I hereby certify that the documents attached are the bona fide copies of the syllabus of M.Sc. Mathematics programme to be effective from 2022 admission onwards.

Date: Principal

Place: Farook College

PROGRAMME OUTCOME:

Upon completing the M.Sc degree in the field of Mathematics, students have/capable of:

- Provide a strong foundation in different areas of Mathematics, so that the students can compete with their contemporaries and excel in the various careers in Mathematics.
- A solid understanding of graduate level algebra, analysis, topology, applied mathematics and graph theory.
- Using their mathematical knowledge to analyze certain problems in day-to-day life.
- Identifying unsolved yet relevant problems in a specific field.
- Communicate mathematics accurately and effectively in both written and oral form.
- Develop abstract mathematical thinking.
- Motivate and prepare the students to pursue higher studies and research, thus contributing to the ever-increasing academic demands of the country.
- Enrich the students with strong communication and interpersonal skills, broad knowledge and an understanding of multicultural and global perspectives, to work effectively in multidisciplinary teams, both as leaders and team members.
- Facilitate integral development of the personality of the student to deal with ethical and professional issues, and also to develop ability for independent and lifelong learning.

PROGRAMME SPECIFIC OUTCOME:

- Students will demonstrate in-depth knowledge of Mathematics, both in theory and application. They develop problem-solving skills and apply them independently to problems in pure and applied mathematics.

- Students will attain the ability to identify, formulate and solve challenging problems in Mathematics. They assimilate complex mathematical ideas and arguments.

- Students will be able to analyse complex problems in Mathematics and propose solutions using research-based knowledge.

- Students will be able to work individually or as a team member or leader in uniform and multidisciplinary settings.

- Students will develop confidence for self-education and ability for lifelong learning. Adjust themselves completely to the demands of the growing field of Mathematics by lifelong learning.

- Effectively communicate about their field of expertise on their activities, with their peer and society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations.

- Crack lectureship and fellowship exams approved by UGC like CSIR – NET/GATE/NBHM and SET.

- Students will be able to work with leading researchers in different areas across the globe.

SEMESTER 1

Course Code	Title of the Course	No. of Credits	Work Load Hrs./week	Core/Audit Course
MMT1C01	Algebra- I	4	5	core
MMT1C02	Linear Algebra	4	5	core
MMT1C03	Real Analysis I	4	5	core
MMT1C04	Discrete Mathematics	4	5	core
MMT1C05	Number Theory	4	5	core
MMT1A01	Ability Enhancement Course[a]	4	0	Audit Course

SEMESTER 2

Course Code	Title of the Course	No. of Credits	Work Load Hrs./week	Core/Elective
MMT2C06	Algebra- II	4	5	core
MMT2C07	Real Analysis II	4	5	core
MMT2C08	Topology	4	5	core
MMT2C09	ODE & calculus of variations	4	5	core
MMT2C10	Operations Research	4	5	core
MMT2A02 MMT2A03 MMT2A04	Professional Competency Course [a]	4		

SEMESTER 3

Course Code	Title of the Course	No. of Credits	Work Load Hrs./week	Core/Elective
MMT 3C11	Multivariable Calculus & Geometry	4	5	core
MMT3C12	Complex Analysis	4	5	core
MMT3C13	Functional Analysis	4	5	core
MMT3C14	PDE & Integral Equations	4	5	core
	Elective I*	3	5	Elective

SEMESTER 4

Course Code	Title of the Course	No. of Credits	Work Load Hrs./week	Core/Elective
MMT4C15	Advanced Functional Analysis	4	5	Core
	Elective II**	3	5	Elec.
	Elective III**	3	5	Elec.
	Elective IV**	3	5	Elec.
MMT4P01	Project	4	5	Core
MMT4 V01	Viva Voce	4		Core

[a] Evaluation of these courses will be as per the latest PG regulations.

* This Elective is to be selected from list of elective courses in third semester

** This Elective is to be selected from list of elective courses in fourth semester

List of Elective Courses in Third Semester

1. MMT3E01 Coding theory
2. MMT3E02 Cryptography
3. MMT3E03 Measure & Integration
4. MMT3E04 Probability Theory

List of Elective Courses in Fourth Semester

1. MMT4E05 Advanced Complex Analysis
2. MMT4E06 Algebraic Number Theory
3. MMT4E07 Algebraic Topology
4. MMT4E08 Commutative Algebra
5. MMT4E09 Differential Geometry
6. MMT4E10 Fluid Dynamics
7. MMT4E11 Graph Theory
8. MMT4E12 Representation Theory
9. MMT4E13 Wavelet Theory
10. MMT4E14 Computer Oriented Numerical Analysis

MMT1A01: ABILITY ENHANCEMENT COURSE(AEC)

Successful fulfillment of any one of the following shall be considered as the completion of AEC. (i) Internship, (ii) Class room seminar presentation, (iii) Publications, (iv) Case study analysis, (v) Paper presentation, (vi) Book reviews. A student can select any one of these as AEC.

Internship: Internship of duration 5 days under the guidance of a faculty in an institution/department other than the parent department. A certificate of the same should be obtained and submitted to the parent department.

Class room seminar: One seminar of duration one hour based on topics in mathematics beyond the prescribed syllabus.

Publications: One paper published in conference proceedings/ Journals. A copy of the same should be submitted to the parent department.

Case study analysis: Report of the case study should be submitted to the parent department.

Paper presentation: Presentation of a paper in a regional/ national/ international seminar/conference. A copy of the certificate of presentation should be submitted to the parent department.

Book Reviews: Review of a book. Report of the review should be submitted to the parent department.

PROFESSIONAL COMPETENCY COURSE (PCC)

A student can select any one of the following as Professional Competency course:

1. MMT2A02: Technical writing with $\LaTeX$.
2. MMT2A03: Scientific Programming with Scilab.
3. MMT2A04: Scientific Programming with C++.

MMT4P01: PROJECT

The Project Report (Dissertation) should be self-contained. It should contain table of con- tents, introduction, at least three chapters, bibliography and index. The main content may be of length not less than 30 pages in the A4 format with one and half line spacing. The project report should be prepared preferably in $\LaTeX$. There must be a project presentation by the student followed by a viva voce. The components and weightage of External and Internal valuation of the Project are as follows:

Components	**External(weightage)**	**Internal (weightage)**
Relevance of the topic & statement of problem	4	1
Methodology & analysis	4	1
Quality of Report & Presentation	4	1
Viva Voce	8	2
Total weightage	20	5

The external project evaluation shall be done by a Board consisting two External Examiners. The Grade Sheet is to be consolidated and must be signed by the External Examiners.

MMT4 V01: VIVA VOCE EXAMINATIONS

The Comprehensive Viva Voce is to be conducted by a Board consisting of two External Examiners. The viva voce must be based on the core papers of the entire programme. There should be questions from at least one course of each of the semesters I, II, and III. Total weightage of viva voce is 15. The same Board of two External Examiners shall conduct both the project evaluation and the comprehensive viva voce examination. The Board of Examiners shall evaluate at most 10 students per day.

EVALUATION AND GRADING

The evaluation scheme for each course except audit courses shall contain two parts.

(a)**Internal Evaluation:** 20% Weightage

(b) **External Evaluation:** 80% Weightage

Both the Internal and the External evaluation shall be carried out using direct grading system as per the general guidelines of the University.
Internal evaluation must consist of

(i) 2 tests
(ii) one assignment
(iii) one seminar and
(iv) attendance,

with weightage 2 for tests (together) and weightage 1 for each other component.

Each of the two internal tests is to be a 10 weightage examination of duration one hour in direct grading.

Question Paper Pattern for the written examinations

For each course there will be an external examination of duration 3 hours. The valuation will be done by Direct Grading System. Each question paper will consist of 8 short answer questions each of weightage 1, 9 paragraph type questions each of weightage 2, and 4 essay type questions each of weightage 5. All short answer questions are to be answered while 6 paragraph type questions and 2 essay type questions are to be answered with a total weightage of 30. The questions are to be evenly distributed over the entire syllabus (see the model question paper). More specifically, each question paper consists of three parts viz Part A, Part B and Part C. Part A will consist of 8 short answer type questions each of weightage 1 of which at least 2 questions should be from each module. Part B has 3 units based on the 3 modules of each course. From each module there will be three questions of which two should be answered. Part C will consist of four essay type questions each of weightage 5 of which 2 should be answered. These questions should cover the entire syllabus of the course.

Question Paper Pattern

M.Sc. Mathematics Examination
(FCCBCSS)

PAPER NAME AND CODE

Time: 3 hrs **Maximum: 30 Weightage**

Part A

*Answer **all** questions. Each question carries **1 weightage**.*

1)
2)
3)
4)
5)
6)
7)
8)

(8 × 1 = 8)

Part B

*Answer any **two** questions from each **unit**. Each question carries **2 weightage.***

Unit I

9)
10)
11)

Unit II

12)
13)
14)

Unit III

15)
16)
17)

(6 × 2 = 12)

Part C

*Answer any **two** questions. Each question carries **5 weightage.***

18) a)
 b)

19) a)
 b)

20) a)
 b)

21) a)
 b)

(2 × 5 = 10)

<u>Question Paper Pattern for the written examination of the Elective Course:</u>
<u>MMT4E 14: Computer Oriental Numerical Analysis</u>

In the case of the Elective Course MMT4E14: Computer Oriental Numerical Analysis, the external examination will consist of a written examination and a practical examination each of duration one and half hours. Each will carry a weightage of 15. Thus the total weightage is 30 as in the case of other courses. The details are appended to the syllabus of the course.

For the Elective Course MMT4E14: Computer Oriental Numerical Analysis there will be a Theory written examination and a practical examination each of duration one and half hours. The valuation will be done by Direct Grading System. The question paper for the written examination will consists of 4 short answer questions, each of weightage 1, 5 paragraph type questions each of weightage 2 and 2 essay type questions, each of weightage 5. **All short answer questions are to be answered while 3 paragraph type questions and 1 essay type questions are to be answered with a total weightage of 15. The questions are to be evenly distributed over the entire syllabus.**

The average of the final grade points of the two tests can be used to obtain the final consolidated letter grade for tests (together) according to the following table.

Average grade point (2 tests)	**Grade for Tests**	**Grade Point for Tests**
4.5 to 5	A+	5
3.75 to 4.49	A	4
3 to 3.74	B	3
2 to 2.99	C	2
Below 2	D	1
Absent	E	0

Table 1: Internal Grade Calculation: Examples

Tests	Grade Point of Test1	Grade Point of Test2	Average Test Grade Point	Test Grade	Test Grade Point	Test Weightage	Test Weighted Grade Point
Student1	4.8	3.5	4.15	A	4	2	8
Student2	5	4.8	4.9	A+	5	2	10
Student3	2.3	4.7	3.5	B	3	2	6

Assignment	Assignment Grade	Assignment Grade Point	Assignment Weightage	Assignment Weighted Grade Point
Student1	A+	5	1	5
Student2	A	4	1	4
Student3	C	2	1	2

Seminar	Seminar Grade	Seminar Grade Point	Seminar Weightage	Seminar Weighted Grade Point
Student1	B	3	1	3
Student2	A+	5	1	5
Student3	D	1	1	1

Attendance	Attendance Grade	Attendance Grade Point	Attendance Weightage	Attendance Weighted Grade Point
Student1	A+	5	1	5
Student2	A+	5	1	5
Student3	C	2	1	2

Consolidation	Total Weighted Grade Point	Total Weightage	Total Internal Grade Point	Final Internal Grade
Student1	21	5	21/5 = 4.2	A
Student2	24	5	24/5 = 4.8	A+
Student3	11	5	11/5 = 2.2	C

Detailed Syllabi

SEMESTER 1

MMT1C01: ALGEBRA - I

No. of Credits: 4
No. Of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn factor group computation.
- Understand the notion of simple groups, group action on a set and their applications.
- Learn isomorphism theorems and its applications.
- Understand the notion of series of the groups.
- Learn Sylow theorems and their applications.
- Understand the notion of free groups.
- Learn group presentation.
- Understand the concept rings of polynomials
- Learn factorization of polynomial over a field.
- Able to work with different non commutative examples.
- Understand about ring homomorphism, ideal, factor rings and analogous properties of normal subgroups and ideals.

TEXT: JOHN B. FRALEIGH, A FIRST COURSE IN ABSTRACT ALGEBRA (7th Edn.), Pearson Education Inc., 2003.

Module 1

Plane Isometries, Direct products & finitely generated Abelian Groups, Factor Groups, Factor-Group Computations and Simple Groups, Group action on a set, Applications of G-set to counting [Sections 12, 11, 14, 15, 16, 17].

Module 2

Isomorphism theorems, Series of groups, (Omit Butterfly Lemma and proof of the Schreier Theorem), Sylow theorems, Applications of the Sylow theory, Free Groups (Omit Another look at free abelian groups) [Sections 34, 35, 36, 37, 39].

Module 3

Group Presentations, Rings of polynomials, Factorization of polynomials over a field, Non-Commutative examples, Homomorphism and factor rings [sections 40, 22, 23, 24, 26].

References

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

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

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

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

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

[6] **N. Jacobson**: Basic Algebra-Vol. I; Hindustan Publishing Corporation (India), Delhi; 1991.

[7] **T.Y. Lam**: Exercises in classical ring theory (2nd edn); Springer; 2003.

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

[9] **N.H. Mc Coy**: Introduction to modern algebra, Literary Licensing, LLC; 2012.

[10] **S. M. Ross**: Topics in Finite and Discrete Mathematics; Cambridge; 2000.

[11] **J. Rotman**: An Introduction to the Theory of Groups (4th edn.); Springer, 1999.

SEMESTER 1

MMT1C02: LINEAR ALGEBRA

No. of Credits: 4
No. Of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn basic properties of vector spaces.
- Understand the relation between linear transformations and matrices.
- Understand the concept of diagonalizable and triangulable operators and various fundamental results of these operators.
- Understand Primary decomposition Theorem.
- Learn basic properties inner product spaces.

TEXT: HOFFMAN K and KUNZE R., LINEAR ALGEBRA (2*nd* Edn.), Prentice-Hall of India, 1991.

Module 1

Vector Spaces & Linear Transformations [Chapter 2 Sections 2.1 - 2.4; Chapter 3, Sections 3.1 to 3.3 from the text]

Module 2

Linear Transformations (continued) and Elementary Canonical Forms [Chapter 3 Sections 3.4 - 3.7; Chapter 6, Sections 6.1 to 6.4 from the text]

Module 3

Elementary Canonical Forms (continued), Inner Product Spaces [Chapter 6, Sections 6.6 & 6.7; Chapter 8, Sections 8.1 & 8.2 from the text]

References

[1] **P. R. Halmos**: Finite Dimensional Vector spaces; Narosa Pub House, New Delhi; 1980.

[2] **A. K. Hazra**: Matrix: Algebra, Calculus and generalised inverse- Part I; Cambridge International Science Publishing; 2007.

[3] **I. N. Herstein**: Topics in Algebra; Wiley Eastern Ltd Reprint; 1991.

[4] **S. Kumaresan**: Linear Algebra-A Geometric Approach; Prentice Hall of India; 2000.

[5] **S. Lang**: Linear Algebra; Addison Wesley Pub.Co.Reading, Mass; 1972.

[6] **S. Maclane and G. Bikhrkhoff**: Algebra; Macmillan Pub Co NY; 1967.

[7] **N. H. McCoy and R. Thomas**: Algebra; Allyn Bacon Inc NY; 1977.

[8] **R. R. Stoll and E.T.Wong**: Linear Algebra; Academic Press International Edn; 1968.

[9] **G. Strang**: linear algebra and its applications (4th edn.); Cengage Learning; 2006.

SEMESTER 1

MMT1C03: REAL ANALYSIS I

No. of Credits: 4

No. Of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Determine the basic topological properties of subsets of the real numbers.
- Use the definitions of convergence of sequences, series, and functions.
- Determine the continuity, differentiability, and integrability of functions defined on subsets of the real line.
- Produce rigorous proofs of results that arise in the context of real analysis.

TEXT: RUDIN W., PRINCIPLES OF MATHEMATICAL ANALYSIS (3rd Edn.), Mc. Graw-Hill, 1986.

Module 1

Basic Topology Finite, Countable and Uncountable sets Metric Spaces, Compact Sets, Perfect Sets, Connected Sets. Continuity - Limits of function, Continuous functions, Continuity and compactness, continuity and connectedness, Discontinuities, Monotonic functions, Infinite limits and Limits at Infinity [Chapter 2 & Chapter 4].

Module 2

Differentiation The derivative of a real function, Mean Value theorems, The continuity of Derivatives, L Hospitals Rule, Derivatives of Higher Order, Taylors Theorem, Differ- entiation of Vector valued functions. The Riemann Stieltjes Integral, - Definition and Existence of the integral, properties of the integral, Integration and Differentiation [Chapter 5 & Chapter 6 up to and including 6.22].

Module 3

The Riemann Stieltjes Integral (Continued) - Integration of Vector vector-valued Func- tions, Rectifiable curves. Sequences and Series of Functions - Discussion of Main problem, Uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and Differentiation. Equicontinuous Families of Functions, The Stone Weierstrass Theorem [Chapters 6 (from 6.23 to 6.27) & Chapter 7 (upto and including 7.27 only)].

References

[1] **H. Amann and J. Escher**: Analysis-I; Birkhuser; 2006.

[2] **T. M. Apostol**: Mathematical Analysis (2nd Edn.); Narosa; 2002.

[3] **R. G. Bartle**: Elements of Real Analysis (2nd Edn.); Wiley International Edn.; 1976.

[4] **R. G. Bartle and D.R. Sherbert**: Introduction to Real Analysis; John Wiley Bros; 1982.

[5] **J. V. Deshpande**: Mathematical Analysis and Applications- an Introduction; Alpha Science International; 2004.

[6] **V. Ganapathy Iyer**: Mathematical analysis; TataMcGrawHill; 2003.

[7] **R. A. Gordon**: Real Analysis- a first course (2nd Edn.); Pearson; 2009.

[8] **F. James**: Fundamentals of Real analysis; CRC Press; 1991.

[9] **A. N. Kolmogorov and S. V. Fomin**: Introductory Real Analysis; Dover Publica- tions Inc; 1998.

[10] **S. Lang**: Under Graduate Analysis (2nd Edn.); Springer-Verlag; 1997.

[11] **M. H. Protter and C. B. Moray**: A first course in Real Analysis; Springer Verlag UTM; 1977.

[12] **C. C. Pugh**: Real Mathematical Analysis, Springer; 2010.

[13] **K. A. Ross**: Elementary Analysis- The Theory of Calculus (2nd edn.); Springer; 2013.

[14] **A. H. Smith and Jr. W.A. Albrecht**: Fundamental concepts of analysis; Prentice Hall of India; 1966

[15] **V. A. Zorich**: Mathematical Analysis-I; Springer; 2008.

SEMESTER 1

MMT1C04: DISCRETE MATHEMATICS
No. of Credits: 4
No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Understand the fundamental concepts in Graph Theory, with a sense of some of its modern applications.
- Learn the structure of graphs and familiarize the basic concepts to analyze different problems in different branches.
- Learn different types of graphs.
- Learn the concepts of partial order relations and lattices.
- Introduce Boolean algebra as a significant component of abstract algebra and to familiarize Boolean functions.
- Acquire a basic knowledge of formal languages, grammar and automata.
- Learn equivalence of deterministic and nondeterministic finite accepters.

TEXT 1: R. BALAKRISHNAN and K. RANGANATHAN, A TEXT BOOK OF GRAPH THEORY, Springer-Verlag New York, Inc., 2000.

TEXT 2: K. D JOSHI, FOUNDATIONS OF DISCRETE MATHEMATICS, New Age International(P) Limited, New Delhi, 1989.

TEXT 3: PETER LINZ, AN INTRODUCTION TO FORMAL LANGUAGES AND AUTOMATA (2^{nd} Edn.), Narosa Publishing House, New Delhi, 1997.

Module 1

Basic concepts, Subgraphs, Degree of vertices, Paths and connectedness, Automorphism of a simple graph, Operations on graphs, Vertex cuts and Edge cuts, Connectivity and Edge connectivity, Trees-Definition, Characterization and Simple properties, Eulerian graphs, Planar and Non planar graphs, Euler formula and its consequences, K_5 and $K_{3,3}$ are non planar graphs, Dual of a plane graph. [TEXT 1 Chapter 1 Sections 1.1, 1.2, 1.3, 1.4, 1.5, 1.7, Chapter 3 Sections 3.1, 3.2, Chapter 4 Section 4.1(upto and including 4.1.10), Chapter 6; Section 6.1 (upto and including 6.1.2), Chapter 8: Sections 8.1(upto and including 8.1.7), 8.2 (upto and including 8.2.7), 8.3, 8.4]

Module 2

Order Relations, Lattices; Boolean Algebra Definition and Properties, Boolean Functions. [TEXT 2 - Chapter 3 (section.3 (3.1-3.11), chapter 4 (sections 1& 2)].

Module 3

Automata and Formal Languages: Introduction to the theory of Computation: Three basic concepts, some applications, Finite Automata: Deterministic finite accepters, Non deterministic accepters, Equivalence of deterministic and nondeterministic finite accepters. [TEXT 3 - Chapter 1 (sections 1.2 & 1.3); Chapter 2 (sections 2.1, 2.2 & 2.3)]

References

[1] **J. C. Abbot**: Sets, lattices and Boolean Algebras; Allyn and Bacon, Boston; 1969.

[2] **J. A. Bondy, U.S.R. Murty**: Graph Theory; Springer; 2000.

[3] **S. M. Cioaba and M.R. Murty**: A First Course in Graph Theory and Combinatorics; Hindustan Book Agency; 2009.

[4] **J. A. Clalrk**: A first look at Graph Theory; World Scientific; 1991.

[5] **Colman and Busby**: Discrete Mathematical Structures; Prentice Hall of India; 1985.

[6] **C. J. Dale**: An Introduction to Data base systems (3rd Edn.); Addison Wesley Pub Co., Reading Mass; 1981.

[7] **R. Diestel**: Graph Theory (4th Edn.); Springer-Verlag; 2010

[8] **S. R. Givant and P. Halmos**: Introduction to boolean algebras; Springer; 2009.

[9] **R. P. Grimaldi**: Discrete and Combinatorial Mathematics- an applied introduction (5th edn.); Pearson; 2007.

[10] **J. L. Gross**: Graph theory and its applications (2nd edn.); Chapman & Hall/CRC; 2005.

[11] **F. Harary**: Graph Theory; Narosa Pub. House, New Delhi; 1992.

[12] **D. J. Hunter**: Essentials of Discrete Mathematics (3rd edn.); Jones and Bartlett Publishers; 2015.

[13] **A. V. Kelarev**: Graph Algebras and Automata; CRC Press; 2003

[14] **D. E. Knuth**: The art of Computer programming -Vols. I to III; Addison Wesley Pub Co., Reading Mass; 1973.

[15] **C. L. Liu**: Elements of Discrete Mathematics (2nd Edn.); Mc Graw Hill International Edns. Singapore; 1985.

[16] **L. Lovsz, J. Pelikn and K. Vesztergombi**: Discrete Mathematics: Elementary and beyond; Springer; 2003.

[17]**J. G. Michaels and K.H. Rosen**: Applications of Discrete Mathematics; McGraw- Hill International Edn. (Mathematics & Statistics Series); 1992.

[18] **Narasing Deo**: Graph Theory with applications to Engineering and Computer Science; Prentice Hall of India; 1987.

[19]**W. T. Tutte**: Graph Theory; Cambridge University Press; 2001

[20] **D. B. West**: Introduction to graph theory; Prentice Hall; 2000.

[21]**R. J. Wilson**: Introduction to Graph Theory; Longman Scientific and Technical Essex(co-published with John Wiley and sons NY); 1985.

SEMESTER 1

MMT1CO5: NUMBER THEORY
No. of Credits: 4
No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Be able to effectively express the concepts and results of number theory.
- Learn basic theory of arithmetical functions and Dirichlet multiplication, averages of some arithmetical functions.
- Understand distribution of prime numbers and prime number theorem.
- Learn the concept of quadratic residues and quadratic reciprocity laws.
- Get a basic knowledge of cryptography, and students can use cryptography as a tool for solving problems in related applied subjects.

TEXT 1 : APOSTOL T.M., INTRODUCTION TO ANALYTIC NUMBER THEORY, Narosa Publishing House, New Delhi, 1990.

TEXT 2: KOBLITZ NEAL A., COURSE IN NUMBER THEROY AND CRYPTOGRAPHY, Springer Verlag, New York, 1987.

Module 1

Arithmetical functions and Dirichlet multiplication; Averages of arithmetical functions [Chapter 2: sections 2.1 to 2.14, 2.18, 2.19; Chapter 3: sections 3.1 to 3.4, 3.9 to 3.12 of Text 1]

Module 2

Some elementary theorems on the distribution of prime numbers [Chapter 4: Sections 4.1 to 4.10 of Text 1]

Module 3

Quadratic residues and quadratic reciprocity law [Chapter 9: sections 9.1 to 9.8 of Text 1] Cryptography, Public key [Chapters 3; Chapter 4 sections 1 and 2 of Text 2.]

References

[1] **A. Beautelspacher**: Cryptology; Mathematical Association of America (Incorporated); 1994

[2] **H. Davenport**: The higher arithmetic (6th Edn.); Cambridge Univ. Press; 1992

[3] **G. H. Hardy and E.M. Wright**: Introduction to the theory of numbers; Oxford International Edn; 1985

[4] **A. Hurwitz & N. Kritiko**: Lectures on Number Theory; Springer Verlag, Universi- text; 1986

[5] **T. Koshy**: Elementary Number Theory with Applications; Harcourt / Academic Press; 2002

[6] **D. Redmond**: Number Theory; Monographs & Texts in Mathematics No: 220; Marcel Dekker Inc.; 1994

[7] **P. Ribenboim**: The little book of Big Primes; Springer-Verlag, New York; 1991

[8] **K.H. Rosen**: Elementary Number Theory and its applications (3rd Edn.); Addison Wesley Pub Co.; 1993

[9] **W. Stallings**: Cryptography and Network Security-Principles and Practices; PHI; 2004

[10] **D.R. Stinson**: Cryptography- Theory and Practice (2nd Edn.); Chapman & Hall / CRC (214. Simon Sing: The Code Book The Fourth Estate London); 1999

[11] **J. Stopple**: A Primer of Analytic Number Theory-From Pythagorus to Riemann; Cambridge Univ Press; 2003.

[12] **S.Y. Yan**: Number Theroy for Computing (2nd Edn.); Springer-Verlag; 2002.

SEMESTER 2

MMT2C06: ALGEBRA II

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn different types of extensions of fields.
- Learn automorphisms of fields.
- Get a basic knowledge in Galois Theory.
- Learn how to apply Galois Theory in various contexts.

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

Module 1

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

Module 2

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

Module 3

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

References

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

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

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

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

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

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

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

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

[9] **N.H. Mc Coy**: Introduction to modern algebra, Literary Licensing, LLC; 2012

[10] **J. Rotman**: An Introduction to the Theory of Groups (4th edn.); Springer; 1999

[11] **I. Stewart**: Galois theory (3rd edn.); Chapman & Hall/CRC; 2003.

SEMESTER 2

MMT2C07: REAL ANALYSIS II

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Understand why and in what context the theory of measure was introduced.
- Learn the concept of measures and measurable functions.
- Learn Lebesgue integration and its various properties.
- Discover how to generalize the concept of measure theory.
- Understand that the Lebesgue integration is more general theory than Riemann integration theory and will be aware with some examples of functions which are not integrable in sense of Riemann theory of integration but they are integrable in sense of Lebesgue integration.

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

Module 1

The Real Numbers:Sets, Sequences and Functions Chapter 1 : Sigma Algebra , Borel sets Section 1.4 : Proposition13

Lebesgue Measure Chapter 2: Sections 2.1, 2.2 ,2.3 ,2.4 ,2.5 ,2.6,2.7 upto preposition19.

Lebesgue Measurable Functions Chapter 3: Sections 3.1, 3.2, 3.3

Module 2

Lebesgue Integration Chapter 4: Sections 4.1, 4.2, 4.3, 4.4, 4.5, 4.6

Lebesgue Integration: Further Topics Chapter 5: Sections: 5.1, 5.2 ,5.3

Module 3

Differentiation and Integration Chapter 6: Sections 6.1, 6.2, 6.3 6.4, 6.5,6.6 The

L^p spaces: Completeness and Approximation Chapter 7: Sections 7.1 ,7.2 ,7.3

References

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

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

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

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

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

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

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

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

SEMESTER 2

MMT2C08: TOPOLOGY

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Be proficient in the abstract notion of a topological space, where continuous function are defined in terms of open set not in the traditional $\varepsilon - \delta$ definition used in analysis.
- Demonstrate an understanding of the concepts of metric spaces and topological spaces, and their role in Mathematics.
- Prove basic results about completeness, compactness, connectedness and convergence within these structures.
- Demonstrate familiarity with a range of examples of these structures.
- Realize Intermediate value theorem is a statement about connectedness, Bolzano Weierstrass theorem is a theorem about compactness and so on.
- Learn the concept of quotient topology.
- Learn five properties such as T0, T1, T2, T3 and T4 of a topological space X which express how rich the open sets are. More precisely, each of them tells us how tightly a closed subset can be wrapped in an open set.

TEXT: JOSHI, K.D., INTRODUCTION TO GENERAL TOPOLOGY (Revised Edn.), New Age International(P) Ltd., New Delhi, 1983.

Module 1

A Quick Revision of Chapter 1,2 and 3. Topological Spaces: Definition of a Topological Space, Examples of a Topological Spaces, Bases and sub-bases, Subspaces. Basic Concepts: Closed sets and Closure, Neighbourhoods, Interior and Accumulation Points. [Chapter 4 and Chapter 5: Sections 1 & Section 2 (excluding 2.11 and 2.12) and Section 3 only]

Module 2

Basic Concepts: Making Functions Continuous, Quotient Spaces. Spaces with Special Properties: Smallness Conditions on a space, Connectedness. [Chapter 5 : Section 4 and Chapter 6: Sections 1 & 2]

Module 3

Separation Axioms: Hierarchy of Separation Axioms. Products and Coproducts: Cartesian Products of Families of Sets, The Product Topology. [Chapter 7: Section 1; Chapter 8: Sections 1 & 2]

References

[1] **M.A. Armstrong**: Basic Topology; Springer- Verlag New York; 1983

[2] **J. Dugundji**: Topology; Prentice Hall of India; 1975

[3] **M. Gemignani**: Elementary Topology; Addison Wesley Pub Co Reading Mass; 1971

[4] **M.G. Murdeshwar**: General Topology (2nd Edn.); Wiley Eastern Ltd; 1990

[5] **G.F. Simmons**: Introduction to Topology and Modern Analysis; McGraw-Hill Inter- national Student Edn.; 1963

[6] **S. Willard**: General Topology; Addison Wesley Pub Co., Reading Mass; 1976.

SEMESTER 2

MMT2C09: ODE AND CALCULUS OF VARIATIONS

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn the existence of uniqueness of solutions for a system of first order ODEs.
- Learn many solution techniques such as separation of variables, variation of parameter power series method, Frobeniious method etc.
- Learn method of solving system of first order differential calculus equations.
- Get an idea of how to analyze the behavior of solutions such as stability, asymptotic stability etc.
- Get a basic knowledge of Calculus of variation.
- Solve problems of ordinary differential equations arising in various fields.

TEXT: SIMMONS, G.F., DIFFERENTIAL EQUATIONS WITH APPLICATIONS AND HISTORICAL NOTES (3rd Edn.), New Delhi, 2016.

Module 1

Power Series Solutions and Special functions; Some Special Functions of Mathematical Physics. [Chapter 5: Sections 27, 28, 29, 30, 31, 32; Chapter 8: Sections 44, 45]

Module 2

Some special functions of Mathematical Physics (continued), Systems of First Order Equations; Non linear Equations [Chapter 8: Sections 46, 47; Chapter 10: Sections 55, 56; Chapter 11 : Sections 58, 59, 60, 61, 62]

Module 3

Qualitative Properties of Solutions, The Existence and Uniqueness of Solutions, The Calculus of Variations. [Chapter 4: Sections 24, 25; Chapter 13 : Sections 68, 69, 70: Chapter 12 : Sections 65, 66, 67]

References

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

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

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

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

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

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

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

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

SEMESTER 2

MMT2C10: OPERATIONS RESEARCH

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Identify and develop linear programming models of real-life systems.
- Use mathematical techniques to solve linear programming and integer programming problems.
- Develop mathematical skills to analyze and solve network flow problems.
- Conduct and interpret sensitivity analysis.
- Recognize and model strategic situations as games and solve them using various techniques.

TEXT: K.V. MITAL; C. MOHAN., OPTIMIZATION METHODS IN OPERATIONS RESEARCH AND SYSTEMS ANALYSIS (3rd. Edn.), New Age International(P) Ltd., 1996.

(Pre requisites: A basic course in calculus and Linear Algebra)

Module 1

Convex Functions; Linear Programming [Chapter 2: Sections 11 to 12; Chapter 3 : Sections 1 to 15, 17 from the text]

Module 2

Linear Programming (contd.); Transportation Problem [Chapter 3: Sections 18 to 20, 22; Chapter 4 Sections 1 to 11, 13 from the text]

Module 3

Integer Programming; Sensitivity Analysis [Chapter 6: Sections 1 to 9; Chapter 7 Sections 1 to 10 from the text] Flow and Potential in Networks; Theory of Games [Chapter 5: Sections 1 to 4, 6 7; Chapter 12: all Sections]

References

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

[2] **C.S. Beightler, D.T. Philiphs and D.J. Wilde**: Foundations of optimization (2nd Edn.); Prentice Hall of India, Delhi; 1979

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

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

[5] **H.S. Kasana and K.D. Kumar**: Introductory Operations Research-Theory and Applications; Springer-Verlag; 2003

[6] **R. Panneerselvam**: Operations Research; PHI, New Delh i(Fifth printing); 2004

[7] **Ravindran, D.T. Philips and J.J. Solberg**: Operations Research-Principles and Practices (2nd Edn.); John Wiley & Sons; 2000

[8] **G. Strang**: Linear Algebra and Its Applications (4th Edn.); Cengage Learning; 2006

[9] **Hamdy A. Taha**: Operations Research- An Introduction (4th Edn.); Macmillan Pub Co. Delhi; 1989.

SEMESTER 2 (PCC)

MMT2A02: TECHNICAL WRITING WITH LaTeX (PCC)

No. of Credits: 4

1. Installation of the software LaTeX
2. Understanding LaTeX compilation
3. Basic Syntex, Writing equations, Matrix, Tables
4. Page Layout: Titles, Abstract, Chapters, Sections, Equation references, citation.
5. List making environments
6. Table of contents, Generating new commands
7. Figure handling, numbering, List of figures, List of tables, Generating bibliography and index
8. Beamer presentation
9. Pstricks: drawing simple pictures, Function plotting, drawing pictures with nodes
10. Tikz:drawing simple pictures, Function plotting, drawing pictures with nodes

References

[1] L. Lamport: A Document Preparation System, User's Guide and Reference Manual, Addison-Wesley, New York, second edition, 1994.

[2] M.R.C. van Dongen:LaTeX and Friends, Springer-Verlag Berlin Heidelberg 2012.

[3] Stefan Kottwitz: LaTeX Cookbook, Packt Publishing 2015.

[4] David F. Griffths and Desmond J. Higham: Learning LaTeX (second edition), Siam 2016.

[5] George Gratzer: Practical LaTeX, Springer 2015.

[6] W. Snow: TeXfor the Beginner. Addison-Wesley, Reading, 1992

[7] D. E. Knuth:The TeXBook. Addison-Wesley, Reading, second edition, 1986

[8] M. Goossens, F. Mittelbach, and A. Samarin:The LaTeXCompanion. Addison- Wesley, Reading, MA, second edition, 2000.

[9] M. Goossens and S. Rahtz:The LaTeXWeb Companion: Integrating TEX, HTML, and XML. Addison-Wesley Series on Tools and Techniques for Computer Typesetting. Addison-Wesley, Reading, MA, 1999.

[10] M. Goossens, S. Rahtz and F. Mittelbach: The LaTeXGraphics Companion: Illustrating Documents with TeX and PostScript. Addison-Wesley Series on Tools and Techniques for Computer Typesetting. Addison-Wesley, New York, 1997.

SEMESTER 2 (PCC)

MMT2A03: SCIENTIFIC PROGRAMMING WITH SCILAB (PCC)

No. of Credits: 4

1. Installation of the software Scilab.
2. Basic syntax, Mathematical Operators, Predefined constants, Built in functions.
3. Complex numbers, Polynomials, Vectors, Matrix. Handling these data structures using built in functions
4. Programming
   (a) Functions
   (b) Loops
   (c) Conditional statements
   (d) Handling .sci files
5. Installation of additional packages e.g. "optimization"
6. Graphics handling
   (a) 2D, 3D
   (b) Generating .jpg files
   (c) Function plotting
   (d) Data plotting
7. Applications
   (a) Numerical Linear Algebra (Solving linear equations, eigenvalues etc.)
   (b) Numerical Analysis: iterative methods
   (c) ODE: plotting solution curves

References

[1] **Claude Gomez, Carey Bunks Jean-Philippe Chancelier Fran ois Delebecque Mauriee Goursat Ramine Nikoukhah Serge Steer**: Engineering and Scientific Computing with Scilab, Springer-Science, LLC, 1998.

[2] **Sandeep Nagar**: Introduction to Scilab For Engineers and Scientists, Apress, 2017.

SEMESTER 2 (PCC)

MMT2A04: SCIENTIFIC PROGRAMMING WITH C++ (PCC)

No. of Credits: 4

[1] C++ Programming Basics

[2] Loops and Decisions

[3] Structures

[4] Functions

[5] Objects and Classes (Sections: A Simple class, C++ Objects as Physical Objects, C++ Objects as data Types and Constructors Only)

[6] Arrays: (Sections: Array Fundamentals, Function Declared with array Arguments Only)

[7] Algorithms

[8] Solutions of Algebraic Equations

[9] Interpolation

[10] Differentiation, Integration

[11] Solutions of Differential equations

References

1) ROBERT LAFORE, OBJECT ORIENTED PROGRAMMING IN C++ (3rd Edn.), Galgotia Publications(Pvt. Ltd.), Ansari Road, New Delhi, 2007.
2) V. RAJARAMAN, COMPUTER ORIENTED NUMERICAL METHODS, Prentice Hall of India, New Delhi.
3) S.D. Conte and Carl De Boor: Elementary Numerical Analysis-an Algorithmic Approach (3rd Edn.); Mc Graw Hill book company, New Delhi, 2007.
4) K. Sankara Rao: Numerical Methods for Scientists and Engineers; Prentice hall of India, New Delhi, 2007.
5) Carl E. Froberg: Introduction to Numerical Analysis (2nd Edn.); Addison Wesley Pub. Co., 1974.
6) A Ralston: A First Course in Numerical Analysis; Mc Graw Hill Book Company, 1978
7) John H Mathews: Numerical Methods for Mathematics, Science and Engg; Prentice Hall of India, New Delhi, 1992.
8) Kunthe D.E: The Art of Computer Programming-VOL I: Fundamental Algorithms; Addison Wesley Narosa, New Delhi, 1997.
9) Herbert Schildt: C++: The Complete Reference (3rd Edn.); Mc Graw-Hill Pub. Co. Ltd., New Delhi, 1982.
10) Yashavant P. Kanetkar: Let Us C++; BPB Publications, New Delhi, 2003.
11) E. Balagurusami: Object Oriented Programming with C++; Tata Mc. Graw - Hill Publishing Co. Ltd., New Delhi, 2013.
12) Schaum Series: Programming in C++; Tata Mc Graw-Hill Publishing Co. Ltd., New Delhi, 2000.

SEMESTER 3

MMT3C11: MULTIVARIABLE CALCULUS AND GEOMETRY

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

• Be proficient in differentiation of functions of several variables.

• Understand curves in plane and in space.

• Get a deep knowledge of Curvature, torsion, Serret-Frenet formulae

• Learn Fundamental theorem of curves in plane and space.

• Learn the concept of Surfaces in three-dimension, smooth surfaces, surfaces of revolution

• Learn explicitly tangent and normal to the surfaces.

• Get a thorough understanding of oriented surfaces, first and second fundamental forms surfaces, gaussian curvature and geodesic curvature and so on.

TEXT 1: RUDIN W., PRINCIPLES OF MATHEMATICAL ANALYSIS, (3rd Edn.), Mc. Graw Hill, 1986.

TEXT 2: ANDREW PRESSLEY, ELEMENTARY DIFFERENTIAL GEOMETRY (2nd Edn.), Springer-Verlag, 2010.

Module 1

Functions of Several Variables Linear Transformations, Differentiation, The Contraction Principle, The Inverse Function Theorem, the Implicit Function Theorem. [Chapter 9 – Sections 1–29, 33–37 from Text -1]

Module 2

What is a curve? Arc-length, Reparametrization, Closed curves, Level curves versus parametrized curves. Curvature, Plane curves, Space curves What is a surface, Smooth surfaces, Smooth maps, Tangents and derivatives, Normals and orientability. [Chapter 1 Sections 1– 5, Chapter 2 Sections 1 – 3, Chapter 4 Sections 1 – 5 from Text - 2]

Module 3

Applications of the inverse function theorem, Lengths of curves on surfaces, The second fundamental form, The Gauss and Weingarten maps, Normal and geodesic curvatures. Gaussian and mean curvatures, Principal curvatures of a surface. [Chapter 5 & 6, Chapter 6 Sections 1 Chapter 7 Sections 1 – 3, Chapter 8 Sections 1 – 2 from Text - 2]

References

[1] **M. P. do Carmo**: Differential Geometry of Curves and Surfaces;

[2] **W. Klingenberg**: A course in Differential Geometry;

[3] **J. R. Munkres**: Analysis on Manifolds; Westview Press; 1997

[4] **C. C. Pugh**: Real Mathematical Analysis, Springer; 2010

[5] **M. Spivak:** A Comprehensive Introduction to Differential Geometry-Vol. I; Publish or Perish, Boston; 1970

[6] **M. Spivak**: Calculus on Manifolds; Westview Press; 1971

[7] **V.A. Zorich**: Mathematical Analysis-I; Springer; 2008

SEMESTER 3

MMT3C12: COMPLEX ANALYSIS

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn the concept of differentiability and analyticity of a function using limits.
- Use the Cauchy-Riemann equation to determine whether/where a function is differentiable/analytic.
- Demonstrate the understanding of conformal mappings
- Demonstrate knowledge of integration in complex plane
- Understand and use the different versions of Cauchy's theorem and Cauchy's integral formulas.
- Manipulate and use the power series representation of analytic functions.
- Get an idea of singularities of an analytic function and their classification.
- Understand residues and their use in integration.
- Understand and develop manipulation skills in the use of Rouche's Theorem.
- Understand certain theorems like open mapping theorem, maximum modulus principle, Hadamard's three circles theorem.

TEXT: JOHN B. CONWAY, FUNCTIONS OF ONE COMPLEX VARIABLE (2nd Edn.); Springer International Student Edition; 1992

Module 1

The extended plane and its spherical representation, Power series, Analytic functions, Analytic functions as mappings, Mobius transformations, Riemann-Stieltijes integrals [Chapt. I Section 6; Chapt. III Sections 1, 2 and 3; Chapter IV Section 1]

Module 2

Power series representation of analytic functions, Zeros of an analytic function, The index of a closed curve, Cauchy's Theorem and Integral Formula, The homotopic version of Cauchy's Theorem and simple connectivity, Counting zeros; the Open Mapping Theorem and Goursat's Theorem.

Module 3

The classification of singularities, Residues, The Argument Principle and The Maximum Principle, Schwarz's Lemma, Convex functions and Hadamard's three circles theorem [Chapt. V: Sections 1, 2, 3; Chapter VI Sections 1, 2, 3]

References

[1] **H. Cartan**: Elementary Theory of analytic functions of one or several variables; Addison - Wesley Pub. Co.; 1973

[2] **T.W. Gamelin**: Complex Analysis; Springer-Verlag, NY Inc.; 2001

[3] **T.O. Moore and E.H. Hadlock**: Complex Analysis, Series in Pure Mathematics- Vol. 9; World Scientific; 1991

[4] **L. Pennisi**: Elements of Complex Variables (2nd Edn.); Holf, Rinehart & Winston; 1976

[5] **R. Remmert**: Theory of Complex Functions; UTM, Springer-Verlag, NY; 1991

[6] **W. Rudin**: Real and Complex Analysis (3rd Edn.); Mc Graw - Hill International Editions; 1987

[7] **H. Sliverman**: Complex Variables; Houghton Mifflin Co. Boston; 1975.

SEMESTER 3

MMT3C13: FUNCTIONAL ANALYSIS

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Appreciate how functional analysis uses and unifies ideas from vector spaces, the theory of metrics, and complex analysis.
- Learn the concept of normed linear spaces and various properties operators defined on them.
- Understand and apply fundamental theorems from the theory of normed and Banach spaces, including the Hahn-Banach theorem, the open mapping theorem, the closed graph theorem and the Stone – Weierstrass theorem.
- Appreciate the role of Zorn's Lemma.

TEXT: LIMAYE B.V, FUNCTIONAL ANALYSIS, (2nd Edn.) New Age International Ltd, Publishers, New Delhi, Bangalore (1996)

Module 1

Metric spaces and Continuous Functions: Completeness (section 3, 3.1 to 3.4, 3.11 to 3.13(without proof)), Lebesgue Measure and Integration on ℝ: Lp spaces, Fourier series and Integrals (section 4.5 to 4.7, 4.8 to 4.11(without proof)), Normed spaces (section 5).

Module 2

Continuity of linear maps: Bounded Linear Maps (section 6), Hahn-Banach Theorems: Unique Hahn-Banach extensions (section 7, omit Banach limits), Banach spaces (section 8)

Module 3

Uniform Boundedness Principle (section 9 (upto and including 9.3), omit Quadrature Formulae and Matrix Transformations and Summability Methods), Closed Graph and Open Mapping Theorems (section 10), Bounded Inverse Theorem (section 11.1).

References

[1] **G. Bachman and L. Narici**: Functional Analysis; Academic Press, NY; 1970

[2] **J. B. Conway**: Functional Analysis; Narosa Pub House, New Delhi; 1978

[3] **J. Dieudonne**: Foundations of Modern analysis; Academic Press; 1969

[4] **W. Dunford and J. Schwartz**: Linear Operators - Part 1: General Theory; John Wiley & Sons; 1958

[5] **Kolmogorov and S.V. Fomin**: Elements of the Theory of Functions and Functional Analysis (English translation); Graylock Press, Rochaster NY; 1972

[6] **E. Kreyszig**: Introductory Functional Analysis with applications; John Wiley & Sons; 1978

[7] **F. Riesz and B. Nagy**: Functional analysis; Frederick Unger NY; 1955

[8] **W. Rudin**: Functional Analysis; TMH edition; 1978

[9] **W. Rudin**: Real and Complex Analysis (3rd Edn.); McGraw-Hill; 1987

[10] **Yuli Eidelman,Vitali Milman and Antonis Tsolomitis**, Functional analysis An Introduction, Graduate Studies in Mathematics, Vol. 66 American Mathematical Society, 2004.

SEMESTER 3

MMT3C14: PDE and Integral Equations

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn a technique to solve first order PDE and analyse the solution to get information about the parameters involved in the model.
- Learn explicit representations of solutions of three important classes of PDE Heat equations Laplace equation and wave equation for initial value problems.
- Get an idea about Integral equations.
- Learn the relation between Integral and differential Equations
- Understand the formation and solution of some significant PDEs like wave equation, heat equation and diffusion equation.
- Apply the knowledge of PDEs and their solutions in order to understand physical phenomena.

TEXT 1: AN INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS, YEHUDA PINCHOVER AND JACOB RUBINSTEIN, Cambridge University Press

TEXT 2: HILDEBRAND, F.B., METHODS OF APPLIED MATHEMATICS (2nd Edn.), Prentice-Hall of India, New Delhi, 1972.

Module 1

First-order equations: Introduction, Quasilinear equations, The method of characteristics, Examples of the characteristics method, The existence and uniqueness theorem, The Lagrange method, The eikonal equation, General nonlinear equations

Second-order linear equations in two independent variables: Introduction, Classification, Canonical form of hyperbolic equations, Canonical form of parabolic equations, Canonical form of elliptic equations

The one-dimensional wave equation: Introduction, Canonical form and general solu- tion, The Cauchy problem and d'Alemberts formula, Domain of dependence and region of influence, The Cauchy problem for the nonhomogeneous wave equation [Chapter 2, 3 and 4 from Text 1]

Module 2

The method of separation of variables: Introduction, Heat equation: homogeneous boundary condition, Separation of variables for the wave equation, Separation of variables for nonhomogeneous equations, The energy method and uniqueness,

Elliptic equations: Introduction, Basic properties of elliptic problems, The maximum principle, Applications of the maximum principle, Greens identities, The maximum prin- ciple for the heat equation, Separation of variables for elliptic problems, Poissons formula [Chapter 5 and 7 from Text 1]

Module 3

Integral Equations: Introduction, Relations between differential and integral equations, The Green's functions, Fredholom equations with separable kernels, Illustrative examples, Hilbert-Schmidt Theory, Iterative methods for solving Equations of the second kind. The Newmann Series, Fredholm Theory [Sections 3.1 3.3, 3.6 3.11 from the Text 2]

References

[1] **Amaranath T.**:Partial Differential Equations, Narosa, New Delhi, 1997.

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

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

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

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

[6] **F. John**: Partial Differential Equations; Narosa Pub House New Delhi; 1986

[7] **Phoolan Prasad Renuka Ravindran**: Partial Differential Equations; Wiley Eastern Ltd, New Delhi; 1985

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

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

SEMESTER 3 (Elective)

MMT3E01: CODING THEORY

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn the basics of coding theory.
- Learn to detect and correct the error patterns.
- Learn to implement the fundamental concepts in linear algebra to coding theory.
- Understand about different types of coding and decoding methods and develop the problem-solving ability.
- Attain the skills to represent cyclic codes in terms of polynomials.

TEXT: D.J. Hoffman, Coding Theory: The Essentials, Mareel Dekker Inc, 1991.

Module 1

Detecting and correcting error patterns, Information rate, the effects of error detection and correction, finding the most likely code word transmitted, weight and distance, MLD, Error detecting and correcting codes. linear codes, bases for $C = \langle S \rangle$ and $C\perp$, generating and parity cheek matrices, equivalent codes, distance of linear code, MLD for a linear code, reliability of IMLD for linear codes [Chapter 1 & Chapter 2]

Module 2

Perfect codes, hamming code, Extended code, Golay code and extended Golay code, Red Hulles codes [Chapter 3: Sections 1 to 8].

Module 3

Cyclic linear codes, polynomial encoding and decoding, dual cyclic codes, BCH linear codes, Cyclic Hamming code, Decoding 2 error correcting BCH codes [Chapter 4 and Appendix A of the chapter, Chapter 5]

References

[1] **E.R. Berlekamp:** Algebraic coding theory, Mc Graw Hill, 1968

[2] **P.J. Cameron and J.H. Van Lint:** Fundamentals of Wavelets Theory Algorithms and Applications, John Wiley and Sons, Newyork. , 1999.

[3] **Yves Nievergelt:** Graphs, codes and designs, CUP.

[4] **H. Hill :** A first Course in Coding Theory, OUP, 1986.

SEMESTER 3 (Elective)

MMT3E02: CRYPTOGRAPHY

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Understand the fundamentals of cryptography and cryptanalysis.
- Acquire a knowledge of Claude Shanon's ideas to cryptography, including the concepts of perfect secrecy and the use of information theory to cryptography.
- Learn to use substitution -permutation networks as a mathematical model to introduce many of the concepts of modern block cipher design and analysis including differential and linear cryptoanalysis.
- Familiarize different cryptographic hash functions and their application to the construction of message authentication codes.

TEXT: Douglas R. Stinson, Cryptography Theory and Practice, Chapman & Hall, 2nd Edition.

Module 1

Classical Cryptography: Some Simple Cryptosystems, Shift Cipher, Substitution Cipher, Affine Cipher, Vigenere Cipher, Hill Cipher, Permutation Cipher, Stream Ciphers. Cryptanalysis of the Affine, Substitution, Vigenere, Hill and LFSR Stream Cipher.

Module 2

Shannons Theory:- Elementary Probability Theory, Perfect Secrecy, Entropy, Huffman Encodings, Properties of Entropy, Spurious Keys and Unicity Distance, Product Cryptosystem.

Module 3

Block Ciphers: Substitution Permutation Networks, Linear Cryptanalysis, Differential Cryptanalysis, Data Encryption Standard (DES), Advanced Encryption Standard (AES). Cryptographic Hash Functions: Hash Functions and Data integrity, Security of Hash Functions, iterated hash functions- MD5, SHA 1, Message Authentication Codes, Unconditionally Secure MAC s. [Chapter 1 : Section 1.1(1.1.1 to 1.1.7), Section 1.2 (1.2.1 to 1.2.5) ; Chapter 2 : Sections

2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7 ; Chapter 3 : Sections 3.1, 3.2, 3.3 (3.3.1 to 3.3.3), Sect.3.4, Sect. 3.5(3.5.1,3.5.2), Sect.3.6(3.6.1, 3.6.2); Chapter 4 : Sections 4.1, 4.2 (4.2.1 to 4.2.3), Section 4.3 (4.3.1, 4.3.2), Section 4.4(4.4.1, 4.4.2), Section 4.5 (4.5.1, 4.5.2)]

References

[1] **Jeffrey Hoffstein:** Jill Pipher, Joseph H. Silverman, An Introduction to Mathematical Cryptography, Springer International Edition.

[2] **H. Deffs & H. Knebl:** Introduction to Cryptography, Springer Verlag, 2002.

[3] **Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone:** Handbook of Applied Cryptography, CRC Press, 1996.

[4] **William Stallings:** Cryptography and Network Security Principles and Practice, Third Edition, Prentice-hall India, 2003.

SEMESTER 3 (Elective)

MMT3E03: MEASURE AND INTEGRATION

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn how a measure will be helpful to generalize the concept of an integral.
- Learn how a smallest sigma algebra containing all open sets to be constructed on a topological space which ensures the measurability of all continuous functions.
- Learn how a measure called Borel measure is defined on the sigma algebra which ensures the integrability of a huge class of continuous functions.
- Understand the regularity properties of Borel measures.
- Realize a measure may take real values even complex values.
- Learn to characterize bounded linear functionals on L^p- Space.
- Learn product measure and their completion.

TEXT: WALTER RUDIN, REAL AND COMPLEX ANALYSIS (3rd Edn.), Mc.Graw- Hill International Edn., New Delhi, 1987.

Module 1

The concept of measurability, Simple functions, Elementary properties of measures, Arithmetic in [0,infinity], Integration of Positive Functions, Integration of Complex Functions, The Role Played by Sets of Measure zero, Topological Preliminaries, The Riesz Representation Theorem. (Chap. 1, Sections: 1.2 to 1.41 Chap. 2, Sections: 2.3 to 2.14)

Module 2

Regularity Properties of Borel Measures, Lebesgue Measure, Continuity Properties of Measurable Functions. Total Variation, Absolute Continuity, Consequences of Radon - Nikodym Theorem. (Chap. 2, Sections: 2.15 to 2.25 Chap. 6, Sections: 6.1 to 6.14)

Module 3

Bounded Linear Functionals on L^p, The Riesz Representation Theorem, Measurability on Cartesian Products, Product Measures, The Fubini Theorem, Completion of Product Measures. (Chap. 6, Sections: 6.15 to 6.19, Chap. 8, Sections: 8.1 to 8.11)

References

[1] **P.R. Halmos:** Measure Theory, Narosa Pub. House New Delhi (1981) Second Reprint.

[2] **H.L. Roydon:** Real Analysis, Macmillan International Edition (1988) Third Edition.

[3] **E.Hewitt & K. Stromberg :** Real and Abstract Analysis, Narosa Pub. House New Delhi (1978).

[4] **A.E.Taylor:** General Theory of Functions and Integration, Blaidsell Publishing Co NY (1965).

[5] **G.De Barra :** Measure Theory and Integration, Wiley Eastern Ltd. Bangalore(1981).

SEMESTER 3 (Elective)

MMT3E04: PROBABILITY THEORY

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Understand the concept of random variables, probability and distribution function of a random variable.
- Apply the knowledge of convergence a sequence of random variables almost surely, in probability and distribution.
- Apply the knowledge of central limit theorem in relevant situations.
- Develop problem solving techniques to solve real world problems.
- Able to translate real world problems into probability models.
- Evaluate and apply moments and characteristic functions and understand the concept of inequalities.

TEXT: D An Introduction to Probability Theory and Statistics (Second Edition), By Vijay K. Rohatgi and A.K. MD. Ehsanes Saleh, John Wiley Sons Inc. New York

Module 1

Random Variables and Their Probability Distributions Random Variables. Probability Distribution of a random Variable. Discrete and Continuous Random Variables. Functions of a random Variable. Chapter 2 of Text. (Sections 2.1- 2.5) Moments and Generating Functions. Moments of a distribution Function. Generating Functions. Some Moment Inequalities. Chapter 3 of Text. (Sections 3.1- 3.4)

Module 2

Multiple Random Variables. Multiple random Variables. Independent Random Vari- ables. Functions of several Random variables. Covariance, Correlation and Moments. Conditional Expectations Order statistics and their Distributions. Chapter 4 of Text. (Sections 4.1- 4.7)

Module 3

Limit Theorems. Modes of Convergence. Weak law of Large Numbers. Strong Law of large Numbers. Limiting Moment Generating Functions. Central Limit Theorem. Chapter 6 of Text. (Sections 6.1- 6.6)

References

[1] **B.R. Bhat:** MODERN PROBABILITY THEORY (Second Edn.) Wiley Eastern Limited, Delhi (1988).

[2] **K.L. Chung:** Elementary Probability Theory with Stochastic Processes Narosa Pub House, New Delhi (1980).

[3] **W.E.Feller:** An Introduction to Probability Theory and its Applications Vols I & II- John Wiley & Sons, (1968) and (1971).

[4] **Rukmangadachari E.:** Probability and Statistics, Pearson (2012).

[5] **Robert V Hogg, Allen Craig & Joseph W McKean:** Introduction to Mathematical Statistics (Sixth Edn.), Pearson 2005.

SEMESTER 4

MMT4C15: ADVANCED FUNCTIONAL ANALYSIS

No. of Credits: 4

No. of hours of Lectures/week: 5

COURSE OUTCOMES:

Upon the successful completion of the course student will:

- Identify spectrum, particularly eigen spectrum and approximate eigen spectrum.
- Understand the concept of dual space of a normed linear space.
- Understand the concept of weak convergence of a sequence in a normed space.
- Understand and check the reflexivity of a space.
- Understand the concept of orthogonal projection and Riesz representation theorem.
- Understand the concept of compact, positive, adjoint, self-adjoint, normal and unitary operators
- Understand the concept of compact self-adjoint operators and the spectral theorem

TEXT: LIMAYE B.V, FUNCTIONAL ANALYSIS, (2nd Edn.) New Age International Ltd, Publishers, New Delhi, Bangalore (1996)

Module 1

Spectrum of a Bounded Operator (Section 12), Duals and Transposes (section 13, upto and including 13.6), Weak Convergence (Section 15(15.1 (without proof) and 15.2 upto 15.2(c) (without proof))); Reflexivity (section 16(16.1 to 16.2, 16.4(a) and (b), 16.5(without proof), 16.6(without proof), Omit 16.3).

Module 2

Compact Linear Map (Section 17 (upto and including 17.3)); Spectrum of a compact operator (Section 18 (18.1 to 18.5, 18.7(a)); Quick Review of Chapter 21 (Inner Product Space) and Chapter 22 (Orthonormal Sets); Projection and Riesz Representation Theorems.
(Section 24 (up to and including 24.6)).

Module 3

Bounded Operators and Adjoints (Section 25(omit 25.4(b))); Normal, Unitary and Self Adjoint Operators (section 26, omit Fourier-Plancherel Transform), Spectrum and Numerical Range (section 27(omit 27.6)); Compact self-Adjoint Operators (section 28 (omit 28.3(b), 28.7 and 28.8(b))).

References

[1] **Yuli Eidelman,Vitali Milman and Antonis Tsolomitis**, Functional analysis An Introduction, Graduate Studies in Mathematics Vol. 66 American Mathematical Society 2004.

[2] **R. Bhatia:** Notes on Functional Analysis TRIM series, Hindustan Book Agency

[3] **Kesavan S:** Functional Analysis TRIM series, Hindustan Book Agency

[4] **S David Promislow:** A First Course in Functional Analysis, John wiley & Sons, INC., (2008)

[5] **Sunder V.S:** Functional Analysis TRIM Series, Hindustan Book Agency

[6] **George Bachman &LawrenceNarici:** Functional Analysis Academic Press, NY (1970)

[7] **E.Kreyszig:** Introductory Functional Analysis with Applications; John Wiley and Sons; 1978

[8] **J.B.Conway**: Functional Analysis; Narosa Pub House New Delhi; 1978

[9] **Walter Rudin:** Functional Analysis TMH edition (1978)

[10] **J.Dieudonne:** Foundations of Modern Analysis Academic Press (1969).

SEMESTER 4 (Elective)

MMT4E05: ADVANCED COMPLEX ANALYSIS

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Get a deep knowledge about the space of continuous functions from an open set in the complex plane to a region of the complex plane.
- Learn a technique to extend the domain over which a complex analytic function is defined.
- Understand that there is a unique conformal map f of the unit disk onto a simply connected domain of the extended complex plane such that f (0) and arg f′ (0) take given values
- Express some functions as infinite series or products

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

Module 1

The Space of continuous functions C (tt, Ω), Spaces of Analytic functions, Spaces of meromorphic functions, The Riemann Mapping theorem, Weierstrass Factorization Theorem [Chapter. VII: Sections 1, 2, 3,4 and 5]

Module 2

Factorization of the sine function, Gamma function, The Riemann Zeta function, Runge's theorem, Simple connectedness
[Chapt. VII: Sections 6, 7 and 8, Chapter VIII Sections 1 and 2]

Module 3

Mittage–Leffler's Theorem, Schwarz reflexion principle, Analytic continuation along a path, Monotromy theorem, Jensen's formula, The Genus and order of an entire function, Statement of Hadamards factorization theorem [Chapt. VIII: Section 3, Chapter 9 sections 1,2 and 3, Chapter 11 sections 1, 2 , Section 3 Statement of Hadamards factorization theorem only]

References

[1] **Cartan H:** Elementary Theory of Analytic Functions of one or Several Variables, Addison-Wesley Pub. Co. (1973).

[2] **Conway J.B:** Functions of One Complex Variable, Narosa Pub. Co, New Delhi (1973).

[3] **Moore T.O. & Hadlock E.H:** Complex Analysis, Series in Pure Mathematics - Vol. 9. World Scientific, (1991).

[4] **Pennisi L:** Elements of Complex Variables, Holf, Rinehart & Winston, 2nd Edn. (1976).

[5] **Rudin W:** Real and Complex Analysis, 3rd Edn. Mc Graw-Hill International Edn. (1987).

[6] **Silverman H:** Compex Variables, Houghton Mifflin Co. Boston (1975).

[7] **Remmert R:** Theory of Complex Functions, UTM, Springer- verlag, NY, (1991).

SEMESTER 4 (Elective)

MMT4E06: ALGEBRAIC NUMBER THEORY

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Understand that abstract algebra may be used to solve certain problems in Number Theory.
- Learn about arithmetic of algebraic number fields.
- Understand that the familiar unique factorization property may fail in the case of ring of integers of some quadratic fields while a unique factorization theory holds for ideals of ring of integers of a number field.
- Learn finiteness of class numbers.
- Understand that the notions of algebraic numbers may be applied to prove Kummer's special case of Fermat's Last Theorem.

TEXT: I. N. STEWART & D.O. TALL, ALGEBRAIC NUMBER THEORY, (2nd Edn.), Chapman & Hall, (1987)

Module 1

Symmetric polynomials, Modules, Free abelian groups, Algebraic Numbers, Conjugates and Discriminants, Algebraic Integers, Integral Bases, Norms and Traces, Rings of Integers, Quadratic Fields, Cyclotomic Fields. [Chapter1, Sections 1.4 to 1.6; Chapter 2, Sections 2.1 to 2.6; Chapter 3, Sections 3.1 and 3.2 from the text]

Module 2

Historical background, Trivial Factorizations, Factorization into Irreducibles, Examples of Nonunique Factorization into Irreducibles, Prime Factorization, Euclidean Domains, Eucidean Quadratic fields Ideals Historical background, Prime Factorization of Ideals, The norm of an ideal [Chapter 4, Sections 4.1 to 4.7, Chapter 5, Sections 5.1 to 5.3.]

Module 3

Lattices, The Quotient Torus, Minkowski theorem, The Space Lst, The Class-Group An Existence Theorem, Finiteness of the Class-Group, Factorization of a Rational Prime, Fermats Last Theorem Some history, Elementary Considerations, Kummers Lemma, Kummers Theorem. [Chapter 6, Chapter 7, Section 7.1 Chapter 8, Chapter 9, Sections
9.1 to 9.3, Chapter 10. Section 10.1, Chapter 11: 11.1 to 11.4.]

References

[1] **P. Samuel:** Theory of Algebraic Numbers, Herman Paris Houghton Mifflin, NY, (1975)

[2] **S. Lan:** Algebraic Number Theory, Addison Wesley Pub Co., Reading, Mass, (1970)

[3] **bf D. Marcus**: Number Fields, Universitext, Springer Verlag, NY, (1976)

[4] 4**T.I.FR. Pamphlet No: 4:** Algebraic Number Theory (Bombay, 1966)

[5] **Harvey Cohn:** Advanced Number Theory, Dover Publications Inc., NY, (1980).

[6] **Andre Weil:** Basic Number Theory, (3rd Edn.), Springer Verlag, NY, (1974)

[7] **G.H. Hardy and E.M. Wright:** An Introduction to the Theory of Numbers, Oxford University Press.

[8] **Z.I. Borevich & I.R.Shafarevich:** Number Theory, Academic Press, NY 1966.

[9] **Esmonde & Ram Murth :** Problems in Algebraic Number Theory, Springer Verlag 2000.

SEMESTER 4 (Elective)

MMT4E07: ALGEBRAIC TOPOLOGY

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn how basic geometric structures may be studied by transforming them into algebraic questions.
- Learn basics of homology theory and apply it to get a generalization of Eulers formula to a general polyhedral.
- Learn to associate a group called fundamental group to every topological space.
- Learn that two objects that can be deformed into one another will have the same homology group and that homemorphic spaces have isomorphic fundamental groups.
- Learn Brouwer fixed point theorem and related results.

TEXT: FRED H. CROOM., BASIC CONCEPTS OF ALGEBRAIC TOPOLOGY, UTM, Springer - Verlag, NY, 1978.

(Pre requisites: Fundamentals of group theory and Topology)

Module 1

Geometric Complexes and Polyhedra: Introduction. Examples, Geometric Complexes and Polyhedra, Orientation of geometric complexes. Simplicial Homology Groups: Chains, cycles, Boundaries and homology groups, Examples of homology groups; The structure of homology groups; [Chapter 1: Sections 1.1 to 1.4; Chapter 2: Sections 2.1 to 2.3 from the text].

Module 2

Simplicial Homology Groups (Contd.): The Euler Poincare's Theorem; Pseudomani- folds and the homology groups of Sn. Simplicial Approximation: Introduction, Simplicial approximation, Induced homomorphisms on the Homology groups, The Brouwer fixed point theorem and related results [Chapter 2: Sections 2.4, 2.5; Chapter 3: Sections 3.1 to 3.4 from the text]

Module 3

The Fundamental Group: Introduction, Homotopic Paths and the Fundamental Group, The Covering Homotopy Property for S1, Examples of Fundamental Groups. [Chapter 4: Sections 4.1 to 4.4 from the text]

References

[1] **Eilenberg S, Steenrod N.**: Foundations of Algebraic Topology; Princeton Univ. Press; 1952.

[2] **S.T. Hu**: Homology Theory; Holden-Day; 1965.

[3] **Massey W.S.**: Algebraic Topology : An Introduction; Springer Verlag NY; 1977.

[4] **C.T.C. Wall**: A Geometric Introduction to Topology; Addison-Wesley Pub. Co. Reading Mass; 1972

SEMESTER 4 (Elective)

MMT4E08: COMMUTATIVE ALGEBRA

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Basic properties of commutative rings, ideals and modules over commutative rings,
- Learn uniqueness theorem for a decomposable ideal.
- Learn integrally closed domain and valuation ring.
- Understand the basic theory of Noetherian and Artin Rings

TEXT: ATIYAH M.F., MACKONALD I. G., INTRODUCTION TO COMMUTATIVE ALGEBRA, Addison Wesley, NY, 1969.

Module 1

Rings and Ideals, Modules [Chapters I and II from the text]

Module 2

Rings and Modules of Fractions, Primary Decomposition [Chapters III & IV from the text]

Module 3

Integral Dependence and Valuation, Chain conditions, Noetherian rings, Artinian rings [Chapters V, VI, VII & VIII from the text]

References

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

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

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

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

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

[6] **O. Zariski, P. Samuel**: Commutative Algebra- Vols. I & II; Van Nostrand, Princeton; 1960

SEMESTER 4 (Elective)

MMT4E09: DIFFERENTIAL GEOMETRY

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Understand how calculus of several variables can be used to develop the geometry of n-dimensional oriented n-surface in $\mathbb{R}^{n+1}$.
- Understand locally n-surfaces and parameterized n-surfaces are the same.
- Develop a knowledge of the Gauss and Weingarten maps and apply them to describe various properties of surfaces.

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

Module 1

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

Module 2

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

Module 3

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

References

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

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

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

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

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

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

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

SEMESTER 4 (Elective)

MMT4E10: FLUID DYNAMICS
No. of Credits: 3
No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn the concept of Equation of Motion and how they relate the dynamics of flow to the pressure and density fields.
- Learn the concepts of streaming motions and Aerofoils.
- Learn the concepts of Sources and Sinks.
- Get an idea of Stream function and its uses to plot stream lines which represent trajectories of particles in a steady flow.

TEXT: L.M. MILNE-THOMSON, THEORETICAL HYDRODYNAMICS, (Fifth Edition) Mac Millan Press, London, 1979.

Module 1

EQUATIONS OF MOTION: Differentiation w.r.t. the time, The equation of continuity Boundary condition (Kinematical and Physical), Rate of change of linear momentum, The equation of motion of an invicid fluid, Conservative forces, Steady motion, The energy equation, Rate of change of circulation, Vortex motion, Permanence of vorticity, Pressure equation, Connectivity, Acyclic and cyclic irrotational motion, Kinetic energy of liquid, Kelvins minimum energy theorem. TWO-DIMENSIONAL MOTION: Motion in two- dimensions, Intrinsic expression for the vorticity; The rate of change of vorticity; Intrinsic equations of steady motion; Stream function; Velocity derived from the stream-function; Rankine's method; The stream function of a uniform stream; Vector expression for velocity and vorticity; Equation satisfied by stream function; The pressure equation; Stagnation points; The velocity potential of a liquid; The equation satisfied by the velocity potential. [Chapter III: Sections 3.10, 3.20, 3.30, 3.31, 3.40, 3.41, 3.43, 3.45, 3.50, 3.51, 3.52, 3.53, 3.60, 3.70, 3.71, 3.72, 3.73. Chapter IV: All Sections.]

Module 2

STREAMING MOTIONS: Complex potential; The complex velocity stagnation points, The speed, The equations of the streamlines, The circle theorem, Streaming motion past a circular cylinder; The dividing streamline, The pressure distribution on the cylinder, Cavitation, Rigid boundaries and the circle theorem, The Joukowski transformation, Theorem of Blasius. AEROFOILS: Circulation about a circular cylinder, The circulation between concentric cylinders, Streaming and circulation for a circular cylinder, The aerofoil, Further investigations of the Joukowski transformation Geometrical construction for the transformation, The theorem of Kutta and Joukowski. [Chaper VI: Sections 6.0, 6.01, 6.02, 6.03, 6.05, 6.21, 6.22, 6.23, 6.24, 6.25, 6.30, 6.41. Chapter VII: Sections 7.10, 7.11, 7.12, 7.20, 7.30, 7.31, 7.45.]

Module 3

SOURCES AND SINKS: Two dimensional sources, The complex potential for a simple source, Combination of sources and streams, Source and sink of equal strengths Doublet, Source and equal sink in a stream, The method of images, Effect on a wall of a source parallel to the wall, General method for images in a plane, Image of a doublet in a plane, Sources in conformal transformation Source in an angle between two walls, Source outside a circular cylinder, The force exerted on a circular cylinder by a source. STKOKES' STREAM FUNCTION: Axisymmetrical motions Stokes stream function, Simple source, Uniform stream, Source in a uniform stream, Finite line source, Airship forms, Source and equal sink - Doublet; Rankin's solids. [Chapter VIII. Sections 8.10, 8.12, 8.20, 8.22, 8.23, 8.30, 8.40, 8.41, 8.42, 8.43, 8.50, 8.51, 8.60, 8.61, 8.62. Chapter XVI. Sections 16.0, 16.1, 16.20, 16.22, 16.23, 16.24, 16.25, 16.26, 16.27]

References

[1] **Von Mises and K.O. Friedrichs:** Fluid Dynamics, Springer International Edition. Reprint, (1988)

[2] **James EA John:** Introduction to Fluid Mechanics (2nd Edn.), Prentice Hall of India , Delhi,(1983).

[3] **Chorlten:** Text Book of Fluid Dynamics, CBS Publishers, Delhi 1985

[4] **A. R. Patterson:** A First Course in Fluid Dynamics, Cambridge University Press 1987

SEMESTER 4 (Elective)

MMT4E11: GRAPH THEORY
No. of Credits: 3
No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Understand the fundamental concepts in Graph Theory, with a sense of some of its modern applications.
- Learn different types of graphs.
- Understand the properties of trees and be able to find a minimal spanning tree for a given weighted graph.
- Understand Eulerian and Hamiltonian graphs.
- Apply the knowledge of graphs to solve a real-life problem.
- Learn the concept of matching in graphs and related results.
- Understand what is meant by coloring.
- Analyze characterization of planar graphs.

TEXT: J.A. Bondy and U.S.R.Murty : Graph Theory with applications. Macmillan.

Module 1

Basic concepts of Graph. Trees, Cut edges and Bonds, Cut vertices, Cayleys Formula, The Connector Problem, Connectivity, Blocks, Construction of Reliable Communication Networks, Euler Tours, Hamilton Cycles, The Chineese Postman Problem, The Travelling Salesman Problem.

Module 2

Matchings, Matchings and Coverings in Bipartite Graphs, Perfect Matchings, The Personnel Assignment Problem, Edge Chromatic Number, Vizings Theorem, The Timetabling Problem, Independent Sets, Ramseys Theorem

Module 3

Vertex Colouring-Chromatic Number, Brooks Theorem, Chromatic Polynomial, Girth and Chromatic Number, A Storage Problem, Plane and Planar Graphs, Dual Graphs, Eulers

Formula, Bridges, Kuratowskis Theorem, The Five-Colour Theorem, Directed Graphs, Directed Paths, Directed Cycles.

[Chapter 2 Sections 2.1 (Definitions & Statements only), 2.2, 2.3, 2.4, 2.5; Chapter 3 Sections 3.1, 3.2, 3.3; Chapter 4 Sections 4.1 (Definitions & Statements only), 4.2, 4.3, 4.4; Chapter 5 Sections 5.1, 5.2, 5.3, 5.4; Chapter 6 Sections 6.1,6.2,6.3; Chapter 7 Sections 7.1, 7.2; Chapter 8 Sections 8.1, 8.2, 8.4, 8.5, 8.6; Chapter 9 Sections (9.1,9.2,9.3 Definitions & Statements only), 9.4, 9.5, 9.6; Chapter 10 Sections 10.1, 10.2, 10.3.

References

[1] **F. Harary :** Graph Theory, Narosa publishers, Reprint 2013.

[2] **Geir Agnarsson, Raymond Greenlaw:** Graph Theory Modelling, Applications and Algorithms, Pearson Printice Hall, 2007.

[3] **John Clark and Derek Allan Holton:** A First look at Graph Theory, World Scientific (Singapore) in 1991 and Allied Publishers (India) in 1995

[4] **R. Balakrishnan & K. Ranganathan:** A Text Book of Graph Theory, Springer Verlag, 2nd edition 2012.

SEMESTER 4 (Elective)

MMT4E12: REPRESENTATION THEORY

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn the concept of G-Modules and commutant algebra.
- Learn the concepts of orthogonality relations and the finite abelian groups.
- Learn the concepts of induced representations and normal subgroups.

TEXT: Walter Ledermann, Introduction to Group Characters (Second Edition).

Module 1

Introduction, G- modules, Characters, Reducibility, Permutation Representations, Complete reducibility, Schurs lemma, The commutant(endomorphism) algebra. (Sections: 1.1 to 1.8)

Module 2

Orthogonality relations, the group algebra, the character table, finite abelian groups, the lifting process, linear characters. (section: 2.1 to 2.6)

Module 3

Induced representations, reciprocity law, the alternating group A5, Normal sub- groups, Transitive groups, the symmetric group, induced characters of Sn. (Sections: 3.1 to 3.4 & 4.1 to 4.3)

References

[1] **C. W. Kurtis and I. Reiner:** Representation Theory of Finite Groups and Asso- ciative Algebras, John Wiley & Sons, New York (1962)

[2] **Faulton:** The Reprsentation Theory of Finite Groups, Lecture Notes in Mathematics, No. 682, Springer 1978.

[3] **C. Musli:** Reprsentations of Finite Groups, Hindustan Book Agency, New Delhi (1993).

[4] **I. Schur:** Theory of Group Characters, Academic Press, London (1977).

[5] **J.P. Serre:** Linear Representation of Finite Groups, Graduate Text in Mathematics, Vol 42, Springer (1977).

SEMESTER 4 (Elective)

MMT4E13: WAVELET THEORY

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Learn the concept of discrete Fourier Transforms and its basic properties.
- Learn how to construct Wavelets on $\mathbb{Z}N$ and $\mathbb{Z}$.
- Learn Wavelets on $\mathbb{R}$ and construction of MRA.

TEXT: Michael. W. Frazier, An Introduction to Wavelets through Linear Algebra, Springer, Newyork, 1999.

Module 1

The discrete Fourier transforms: Basic Properties of Discrete Fourier Transforms, Translation invariant Linear Transforms, The Fast Fourier Transforms. Wavelets on ZN.

Construction of wavelets on ZN - The First Stage, Construction of Wavelets on ZN: The Iteration Step. [Chapter 2: sections 2.1 to 2.3; Chapter 3: sections 3.1 and 3.2]

Module 2

Wavelets on Z: A2(Z), Complete orthonormal sets in Hilbert spaces, L2([π, π)) and Fourier series, The Fourier Transform and convolution on A2(Z) , First stage Wavelets on Z, Implementation and Examples.[Chapter 4: sections 4.1 to 4.6 and 4.7]

Module 3

Wavelets on R: L2(R) and approximate identities, The Fourier transform on R, Multiresolution analysis and wavelets, Construction of MRA. [Chapter 5: sections 5.1 to 5.4]

References

[1] **C.K. Chui:** An introduction to wavelets, Academic Press,1992

[2] **Jaideva. C. Goswami, Andrew K Chan:** Fundamentals of Wavelets Theory Algorithms and Applications, John Wiley and Sons, Newyork. , 1999.

[3] **Yves Nievergelt:** Wavelets made easy, Birkhauser, Boston,1999.

[4] **G. Bachman, L.Narici and E. Beckenstein :** Fourier and wavelet analysis, Springer, 2006.

SEMESTER 4 (Elective)

MMT4E14: COMPUTER ORIENTED NUMERICAL ANALYSIS

No. of Credits: 3

No. of hours of Lectures/week: 5

COURSE OUTCOME:

Upon the successful completion of the course students will:

- Understand one of the most popular and robust general purpose programming language Python.
- Understand how scientific programming can be performed using Python using various open-source mathematics libraries and tools available.
- Solve any concrete mathematics or general science problem programmatically using numerical methods.
- Apply numerical methods to obtain approximate solutions to mathematical problems.
- Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, system of linear equations and the solution of differential equations.
- Analyze and evaluate the accuracy of common numerical methods.
- Implement numerical methods in python.
- Write efficient, well-documented python code and present numerical results in an informative way.

Programming Language: Python

TEXT 1: A Byte of Python, Swaroop C H

TEXT 2: Numerical Methods, E Balagurusamy, Tata McGraw-Hill Publishing Company Limited, New Delhi.

Module 1

(Text Book 1, Text Book 2)

A quick review of preliminaries of computers, numerical computing, programming languages, Algorithms, flow charts, computer codes based on chapter 1, 2 and 3 of text book 2

Approximations and errors in computing: Significant Digits, Numerical Errors, Absolute and relative errors, convergence of iterative processes and error estimation. (Sections 4.2, 4.4, 4, 7, 4.11 and 4.12 of text book 2)

A quick review of chapters 1, 2 and 3 of Text Book 1

Chapter 4: The Basics: Literal Constants, Numbers, Strings, Variables, Identifier, Data types

Chapter 5: Operators, Operator Precedence, Expressions

Chapter 6: Control flow: If, while, for, break, continue statements

Chapter 7: Functions: Defining a function, function parameters, local variables, default arguments, keywords, return statement, Doc-strings

Chapter 8: Modules: using system modules, import statements, creating modules

Chapter 9: Data Structures: Lists, tuples, sequences.

Chapter 10: Writing a python script

Chapter 12: Files: Input and output using file and pickle module

Chapter 13: Exceptions: Errors, Try-except statement, raising exceptions, try-finally statement

Module 2

(Text Book 2)

Chapter 6: Roots of Nonlinear Equations: Evaluation of Polynomials, Bisection method, Newton-Raphson Method. (Sections 6.5, 6.6 and 6.8)

Chapter 7: Direct Solution of Linear Equations: Solution by elimination, Gauss Elimination method, Gauss Elimination with Pivoting, Triangular Factorisation method (Dolitle Algorithm). (Sections 7.3, 7.4, 7.5 and 7.7)

Chapter 8: Iterative Solution of Linear Equations: Jacobi Iteration method, Gauss-Seidel method. (Sections 8.2 and 8.3)

Module 3

(Text Book 2)

Chapter 9: Curve Fitting-Interpolation: Lagrange Interpolation Polynomial, Newton Interpolation Polynomial, Divided Difference Table, Interpolation with Equidistant points. (Sections 9.4, 9.5, 9.6 and 9.7)

Chapter 11: Numerical Differentiation: Differentiating Continuous functions, Differentiating Tabulated functions. (Sections 11.2 and 11.3)

Chapter 12: Numerical Integration: Trapezoidal Rule, Simpson's 1/3 rule. (Sections 12.3 and 12.4)

Chapter 13: Numerical Solution of Ordinary Differential Equations: Euler's Method, Rung-Kutta method (Order 4) (Sections 13.3 and 13.6).

Chapter 14: Eigenvalue problems: Polynomial Method, Power method. (Sections 14.5 and 14.6)

PRACTICAL PART

The following programs in Python have to be done on a computer and a record of algorithm, Printout of the program and printout of solution as shown by the computer for each program should be maintained. These should be bound together and submitted to the examiners at the time of practical examination.

Sample Programs (Recommended)

GCD of two numbers

To Check an integer prime

Evaluation of Totient Function

Writing of Fibonacci sequence

Listing of prime numbers

Average and maximum of a set of numbers

Programs (Compulsory)

Part A

Lagrange Interpolation

Newton's Interpolation

Bisection Method

Newton-Raphson Method

Numerical Differentiation of continuous function

Numerical Differentiation of tabulated function

Trapezoidal rule of Integration

Simpson's rule of Integration

Part B

Euler's method

Runge – Kutta method of order 4

Gauss elimination with pivoting

Runge – Kutta method of order 4

Gauss – Seidal iteration

Eigen value evaluation

Triangular Factorisation

References:

[1] SD Conte and Carl De Boor: Elementary Numerical Analysis (An algorithmic approach) – 3rd edition, McGraw-Hill, New Delhi

[2] K. Sankara Rao: Numerical Methods for Scientists and Engineers – Prentice Hall of India, New Delhi.

[3] Carl E Froberg: Introduction to Numerical Analysis, Addison Wesley Pub Co, 2nd Edition

[4] Knuth D.E.: The Art of Computer Programming: Fundamental Algorithms (Volume I), Addison Wesley, Narosa Publication, New Delhi.

[5] Python Programming, wikibooks contributors

[6] Programming Python, Mark Lutz,

[7] Python 3 Object Oriented Programming, Dusty Philips, PACKT Open-source Publishing

[8] Python Programming Fundamentals, Kent D Lee, Springer

[9] Learning to Program Using Python, Cody Jackson, Kindle Edition

[10] Online reading: http://pythonbooks.revolunet.com/