File Ref.No.70516/GA - IV - J3/2019/Admn

UNIVERSITY OF CALICUT

Abstract

General & Academic - CBCSS PG Regulations 2019 - Scheme and Syllabus of M.Sc Mathematics Programme w.e.f 2020 Admission onwards -Incorporating Outcome Based Education - Implemented - Subject to ratification of Academic Council - Orders Issued.

G & A - IV - J

U.O.No. 5335/2021/Admn Dated, Calicut University.P.O, 17.05.2021

Read:-1) U.O.No. 8953/2019/Admn Dated 06.07.2019.
2) U.O.No. 1336/2020/Admn Dated 31.01.2020.
3) Item no.2 in the minutes of the meeting of Board of Studies in Mathematics PG, Dated 09.04.2021.
4) Remarks of the Dean, Faculty of Science, Dated 08.05.2021.
5) Orders of the Vice Chancellor in the file of even no, Dated 10.05.2021.

ORDER

1. The scheme and syllabus of M.Sc Mathematics Programme under CBCSS PG Regulations 2019 in the affiliated Colleges of the University, w.e.f 2019 admission onwards has been implemented, vide paper read (1) above and same has been modified, vide paper read (2) above.

2. The Board of Studies in Mathematics PG has resolved to incorpate Outcome Based Education (OBE) in the scheme and syllabus of M.Sc Mathematics Programme under affiliated colleges of the University, in tune with the new CBCSS PG Regulations 2019 with effect from 2020 Admission onwards, Vide paper read (3) above.

3. The Dean, Faculty of Science, vide paper read (4) above, has approved to implement the scheme and syllabus of M.Sc Mathematics Programme (CBCSS-PG-2019) incorporating Outcome Based Education (OBE) , in the syllabus forwarded by the Chairperson, Board of Studies in Mathematics PG, in tune with the new CBCSS PG Regulations 2019 with effect from 2020 Admission onwards.

4. Considering the urgency, the Vice Chancellor has accorded sanction to implement the scheme and syllabus of M.Sc Mathematics Programme incorporating Outcome Based Education (OBE) ,in the syllabus forwarded by the Chairperson,Board of Studies in Mathematics in tune with the new CBCSS PG Regulations under affiliated colleges of the University with effect from 2020 Admission onwards, subject to ratification by the Academic Council.

5. Scheme and syllabus of M.Sc Mathematics Programme (CBCSS) incorporating Outcome Based Education (OBE) is therefore implemented with effect from 2020 Admission onwards under affiliated colleges of the University, subject to ratification by the Academic Council.

6. Orders are issued accordingly.

7. U.O.No.1336/2020/Admn Dated 31.01.2020, is modified to this extend.(syllabus appended)

Arsad M

Assistant Registrar

To

The Principals of all Affiliated Colleges
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Forwarded / By Order

Section Officer

UNIVERSITY OF CALICUT

SYLLABUS FOR MSc MATHEMATICS (CBCSS) PG PROGRAMME

EFECTIVE FROM 2020 ADMISSION ONWARDS
Total Credits :80

PROGRAMME OUTCOME:

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

- **A solid understanding of graduate level algebra, analysis and topology.**
- **Using their mathematical knowledge to analyze certain problems in day to day life.**
- **Identifying unsolved yet relevant problems in a specific field.**
- **Undertaking original research on a particular topic.**
- **Communicate mathematics accurately and effectively in both written and oral form.**
- **Conducting scholarly or professional activities in an ethical manner.**

SEMESTER 1

Course Code	Title of the Course	No. of Credits	Work Load Hrs./week	Core/Audit Course
MTH1C01	Algebra- I	4	5	Core
MTH1C02	Linear Algebra	4	5	Core
MTH1C03	Real Analysis I	4	5	Core
MTH1C04	Discrete Mathematics	4	5	Core
MTH1C05	Number Theory	4	5	Core
MTH1A01	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
MTH2C06	Algebra- II	4	5	Core
MTH2C07	Real Analysis II	4	5	Core
MTH2C08	Topology	4	5	Core
MTH2C09	ODE & Calculus of Variations	4	5	Core
MTH2C10	Operations Research	4	5	Core
	Professional Competency Course[a]	4	0	Audit Course

SEMESTER 3

Course Code	Title of the Course	No. of Credits	Work Load Hrs./week	Core/Elective
MTH 3C11	Multivariable Calculus & Geometry	4	5	Core
MTH3C12	Complex Analysis	4	5	Core
MTH3C13	Functional Analysis	4	5	Core
MTH3C14	PDE & Integral Equations	4	5	Core
	Elective I*	3	5	Elec.

SEMESTER 4

Course Code	Title of the Course	No. of Credits	Work Load Hrs./week	Core/Elective

MTH4C15	Advanced Functional Analysis	4	5	Core
	Elective II**	3	5	Elec.
	Elective III**	3	5	Elec.
	Elective IV**	3	5	Elec.
MTH4P01	Project	4	5	Core
MTH4 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. MTH3E01 Coding theory
2. MTH3E02 Cryptography
3. MTH3E03 Measure and Integration
4. MTH3E04 Probability Theory

List of Elective Courses in Fourth Semester

1. MTH4E05 Advanced Complex Analysis
2. MTH4E06 Algebraic Number Theory
3. MTH4E07 Algebraic Topology
4. MTH4E08 Commutative Algebra
5. MTH4E09 Differential Geometry
6. MTH4E10 Fluid Dynamics
7. MTH4E11 Graph Theory
8. MTH4E12 Representation Theory
9. MTH4E13 Wavelet Theory

ABILITY ENHANCEMENT COURSE(AEC)

Successful fulfilment 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. Technical writing with LaTeX.
2. Scientific Programming with Scilab.
3. Scientific Programming with Python.

PROJECT

The Project Report (Dissertation) should be self contained. It should contain table of contents, 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.

Viva Voce Examination

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 gradingsystem 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 fortests (together) and weightage 1 for each other component.

Each of the two internal tests is to be a 10 weightage examination of duration one hourin direct grading. 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	O
Student3	11	5	11/5 = 2.2	F

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 unit. 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.

Detailed Syllabi

Semester 1

MTH1C01: 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 group action on a set.
- Learn Sylow theorems and its applications.
- Understand the notion of free groups.
- Understand the concept rings of polynomials
- Learn group presentation.

TEXT : JOHN B. FRALEIGH, A FIRST COURSE IN ABSTRACT ALGEBRA(7^{th} 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, NonCommutative 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

MTH1C02: 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

MTH1C03: 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:

- Learn the topology of the real line
- Understand the notions of Continuity, Differentiation and Integration of real functions.
- Learn Uniform convergence of sequence of functions, equicontinuity of family of functions, and Weierstrass theorems.

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

Module 1

Basic Topololgy 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, Differentiation 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 Functions, 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; AlphaScience International; 2004.

[6] **V. Ganapathy Iyer**: Mathematical analysis; Tata McGrawHill; 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 Publications 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 VerlagUTM; 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; PrenticeHall of India; 1966

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

Semester 1

MTH1C04: 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 fundamentals of Graph Theory
- Learn the structure of graphs and familiarize the basic concepts to analyze different problems in different branches.
- Acquire a basic knowledge of formal languages, grammar and automata.
- Learn equivalence of deterministic and nondeterministic finite accepters.
- Learn the concepts of partial order relation and total order relation.

Acquire a knowledge of Boolean algebras and Boolean function and understand how these concepts arise in real life problems.

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 (3^{rd} Edn.), Narosa Publishing House, New Delhi, 2003.

Module 1

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 2

Basic concepts, Subgraphs, Degree of vertices, Paths and connectedness, Automor- phism 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 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 PubCo., 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 BartlettPublishers; 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 WesleyPub Co., Reading Mass; 1973.

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

[16]**L. Lovsz, J. Pelikn and K. Vesztergombi**: Discrete Mathematics: Elementaryand 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 TechnicalEssex(co-published with John Wiley and sons NY); 1985.

Semester 1

MTH1C05: 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. and
- Understand distribution of prime numbers and prime number theorem.
- Learn the concept of quadratic residues and Quadratic reciprocity laws.
- Get a basic knowledge in Cryptography

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, SpringerVerlag, NewYork, 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 ofText 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 ,Universitext; 1986

[5] **T. Koshy**: Elementary Number Theory with Applications; Harcourt / AcademicPress; 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.); AddisonWesley 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 Pythagoras to Riemann; Cambridge Univ Press; 2003

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

Semester 2

MTH2C06: 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 ofthe 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

MTH2C07: 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:

- Learn why and for what the theory of measure was introduced
- Learn the concept of measures and measurable functions
- Learn Lebesgue integration and its various properties
- Learn how to generalize the concept of measure theory.
- Learn that a measure may take negative values.

TEXT : H. L.Royden ,P. M. FitzpatrickH.L. REAL ANAYLSIS (4th Edn.), PrenticeHall 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^pspaces: Completeness and Approximation Chapter 7: Sections 7.1 ,7.2 ,7.3

References

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

MTH2C08: 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.
- 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 T_0, T_1, T_2, T_3 and T_4 of a topological space X which express how rich the open sets is. 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, Basic Concepts [Chapter4 and Chapter 5 Sections 1, Section 2 (excluding 2.11 and 2.12) and Section 3 only]

Module 2

Making Functions Continuous, Quotient Spaces, Spaces with Special Properties [Chapter 5 Section 4 and Chapter 6]

Module 3

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

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

MTH2C09: 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.

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

Module 1

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

Module 2

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

Module 3

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

References

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

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

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

[4] **E.A. Coddington**: An Introduction to Ordinary Differential Equations; Prentice Hallof India, New Delhi; 1974

[5] **R.Courant and D. Hilbert**: Methods of Mathematical Physics- vol I; Wiley EasternReprint; 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 InternationalEdn.; 1957

Semester 2

MTH2C10: OPERATIONS RESEARCH
No. of Credits: 4
No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will:

- Learn graphical method and the simplex algorithm for solving a linear programming problem.
- Learn more optimization techniques for solving the linear programming models-transportation problem and integer programming problem.
- Learn optimization techniques for solving some network related problems.
- Learn sensitivity analysis and parametric programming, which describes how various changes in the problem affect its solution.

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

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 [Chapter5: Sections 1 to 4, 6 7; Chapter 12: all Sections]

References

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

[2] **C.S. Beightler, D.T. Philiphs and D.J. Wilde**: Foundations of optimization (2ndEdn.); 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 Delhi (Fifth printing); 2004

[7] **A. Ravindran, D.T. Philips and J.J. Solberg**: Operations Research-Principlesand 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 PubCo. Delhi; 1989

Semester 2(PCC)

MTH2A02: 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 bibliographyand 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**: TEX for the Beginner. Addison-Wesley, Reading, 1992

[7] **D. E. Knuth**:The TEX Book. 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 LaTeX Web 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 LaTeX Graphics 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)

MTH2A03: 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 infunctions
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 Franois 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)

MTH2A04: SCIENTIFIC PROGRAMMING WITH PYTHON(PCC)
No. of Credits: 4

1. Literal Constants, Numbers, Strings, Variables, Identifier, Data types
2. Operators, Operator Precedence, Expressions
3. Control flow: If, while, for, break, continue statements
4. Functions: Defining a function, function parameters, local variables, default arguments, keywords, return statement, Doc-strings
5. Modules: using system modules, import statements, creating modules
6. Data Structures: Lists, tuples, sequences.
7. Writing a python script
8. Files: Input and output using file and pickle module
9. Exceptions: Errors, Try-except statement, raising exceptions, try-finally statement
10. Roots of Nonlinear Equations: Evaluation of Polynomials, Bisection method, Newton-Raphson Method, Complex roots by Bairstow method.
11. Direct Solution of Linear Equations: Solution by elimination, Gauss Elimination method, Gauss Elimination with Pivoting, Triangular Factorisation method
12. Iterative Solution of Linear Equations: Jacobi Iteration method, Gauss-Seidel method.
13. Curve Fitting-Interpolation: Lagrange Interpolation Polynomial, Newton Interpolation Polynomial, Divided Difference Table, Interpolation with Equidistant points.
14. Numerical Differentiation: Differentiating Continuous functions, Differentiating Tabulated functions.
15. Numerical Integration: Trapezoidal Rule, Simpsons 1/3 rule.
16. Numerical Solution of Ordinary Differential Equations: Eulers Method, Rung-Kutta (Order 4)
17. Eigenvalue problems: Polynomial Method, Power method.

References

[1] **Swaroop C H:**, A Byte of Python.

[2] **Amit Saha:** ,Doing Math with Python, No Starch Press, 2015.

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

[4] **K. Sankara Rao:** Numerical Methods for Scientists and Engineers Prentice Hall ofIndia, New Delhi.

[5] **Carl E Froberg:** Introduction to Numerical Analysis, Addison Wesley Pub Co, 2ndEdition

[6] **Knuth D.E.:** The Art of Computer Programming: Fundamental Algorithms(VolumeI), Addison Wesley, Narosa Publication, New Delhi.

[7] Python Programming, wikibooks contributors Programming Python, Mark Lutz,

[8] Python 3 Object Oriented Programming, Dusty Philips, PACKT Open source Pub-lishing

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

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

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

Semester 3

MTH3C11: 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 (2^{nd} 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, Reparametrisation, 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

Level surfaces, Ruled surfaces and surfaces of revolution, Applications of the inverse function theorem, Lengths of curves on surfaces, Equiareal maps and a theorem of Archimedes, The second fundamental form, The Gauss and Weingarten maps, Normal and geodesic curvatures. Gaussian and mean curvatures, Principal curvatures of a surface. [Chapter 5 Sections 1 , 3 & 6, Chapter 6 Sections 1 and 4(up to and including 6.4.3) 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; Publishor Perish, Boston; 1970

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

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

Semester 3

MTH3C12: 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 (complex) differentiation and integration of functions defined on the complex plane and their properties.
- Be thorough in power series representation of analytic functions, different versions of Cauchy's Theorem.
- Get an idea of singularities of analytic functions and their classifications.
- Learn different versions of maximum modulus 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 Cauchys Theorem and simple connectivity, Counting zeros; the Open Mapping Theorem and Goursats Theorem.

Module 3

The classification of singularities, Residues, The Argument Principle and The Maximum Principle, Schwarz's Lemma, Convex functions and Hadamards 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

MTH3C13: FUNCTIONAL 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 normed linear spaces and Hilbert spaces.
- Learn various properties operators defined on both normed and Hilbert spaces.
- Understand the concept dual space.
- Learn the completeness of the space bounded linear operators.

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

Module 1

Linear Spaces; normed spaces; first examples: Linear spaces, Normed spaces; first examples, Holder's inequality, Minkowski's inequality, Topological and geometric notions, Quotient normed space, Completeness; completion. [Chapter 1 Sections 1.1- 1.5]

Module 2

Hilbert spaces: Basic notions; first examples, Cauchy- Schwartz inequality and Hilbertian norm, Bessels inequality, Complete systems, Gram-Schmidt orthogonalization procedure, orthogonal bases, Parseval' identity; Projection; orthogonal decompositions; Separable case, The distance from a point to a convex set, Orthogonal decomposition; linear functionals; Linear functionals in a general linear space, Bounded linear functionals, Bounded linear functionals in a Hilbert space, An example of a non-separable Hilbert space. [Chapter 2; Sections 2.1-2.3(omit Proposition 2.1. 15)]

Module 3

The dual space; The Hahn Banach Theorem and its first consequences, corollaries of the Hahn Banach theorem, Examples of dual spaces. Bounded linear Operators; Completeness of the space of bounded linear operators, Examples of linear operators, Compact operators, Compact sets, The space of compact operators, Dual operators, Operators of finite rank, Compactness of the integral operators in L2, Convergence in the space of bounded operators, Invertible operators [Chapter3; Sections 3.1 , 3.2; Chapter4; Sections 4.1- 4.7]

References

[1] **B. V. Limaye**: Functional Analysis, New Age International Ltd, New Delhi, 1996.

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

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

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

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

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

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

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

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

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

Semester 3

MTH3C14: 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.

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 character- istics, Examples of the characteristics method, The existence and uniqueness theorem, The Lagrange method, Conservation laws and shock waves, The eikonal equation, General nonlinear equations

Second-order linear equations in two indenpendent 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 solution, 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, Further applications of the heat equation

Elliptic equations: Introduction, Basic properties of elliptic problems, The maximum principle, Applications of the maximum principle, Greens identities, The maximum principle 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 Equations Printice Hallof India ,New Delhi; 1974

[4] **R. Courant and D.Hilbert**: Methods of Mathematical Physics-Vol I; Wiley EasternReprint; 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 EasternLtd, 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 InternationalEdn.; 1957

Semester 3(Elective)

MTH3E01: 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 to

- 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 $C =< S >$ 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, RedHulles 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 Algorithmsand 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)

MTH3E02: 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, 2ndEdition.

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:** Handbookof Applied Cryptography, CRC Press, 1996.

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

Semester 3(Elective)

MTH3E03: 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 be constructed on a topological space which ensures the measurability of all continuous function and how a measure called Borel measure is defined on this sigma algebra which ensures the integrability of a huge class of continuous functions.
- Understand the regularity properties Borel measures.
- Realize a measure may take real values even complex values.
- Learn to characterize bounded linear functionals on L^p.
- 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) SecondReprint

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

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

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

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

Semester 3(Elective)

MTH3E04: PROBABILITY THEORY

No. of Credits: 3

No. of hours of Lectures/week : 5

Course Outcome: Upon the successful completion of the course students will learn to

- 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: 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 Variables. 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 PubHouse, 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

MTH4C15 ADVANCED FUNCTIONAL ANALYSIS

No. of Credits: 4

No. of hours of Lectures/week: 5

Course Outcome: Upon the successful completion of the course students will learn to

- Understand the notions of Fredholm theory of compact Operators and their properties
- Apply the theory to understand and solve some problems of integral equations at an appropriate level of difficulty.
- Describe the construction of the spectral integral.
- Recognize the fundamentals of Banach spaces and Banach Algebras.

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

Module 1

Spectrum, Fredholm Theory of Compact operators; Classification of spectrum, Fred- holm Theory of Compact operators. Self adjoint operators; General properties, Self adjoint compact operators, spectral theory, Minimax principle, Applications to integral operators. [Chapter5; Sections 5.1, 5.2; Chapter6; Sections 6.1, 6.2]

Module 2

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

Module 3

The fundamental theorems and the basic methods; Auxiliary results, The Banach open mapping Theorem, The closed graph Theorem, The Banach- Steinhaus theorem, Bases in Banach spaces, Linear functionals; the Hahn Banach theorem, Separation of Convex sets. Banach Algebras; Preliminaries, Gelfand's theorem on maximal ideals [Chapter9 Sections9.1- 9.7; Chapter10, Sections10.1, 10.2]

References

[1] **B. V. Limaye**: Functional Analysis, New Age International Ltd, New Delhi, 1996.

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

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

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

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

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

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

[8] **W.Dunford and J. Schwartz:** Linear Operators Part1,GeneralTheory John Wiley & Sons (1958)

[9] **E.Kreyszig:** Introductory Functional Analysis with Applications John Wiley & Sons(1978)

[10] **F. Riesz and B. Nagy:** Functional Analysis Frederick Unger NY (1955)

[11] **J.B.Conway:** Functional Analysis Narosa Pub House New Delhi (1978)

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

[13] **Walter Rudin:** Introduction to Real and Complex Analysis TMH edition (1975)

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

Semester 4(Elective)

MTH4E05: 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 1: JOHN B. CONWAY, FUNCTIONS OF ONE COMPLEX VARIABLE (2nd Edn.), Springer International Student Edition, 1973

Module 1

The Space of continuous functions $C(G, \Omega)$, 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 reflection principle, Analytic continuation along a path, Monotromy theorem, Jensen's formula, The Genus and order of an entire function, Statement of Hadamars factorization theorem [Chapt. VIII: Section 3, Chapter 9 sections 1,2 and 3, Chapter 11 sections 1, 2 , Section 3 Statement of Hadamars 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)

MTH4E06: 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 Do- mains, Euclidean 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. Lang :** Algebraic Number Theory, Addison Wesley Pub Co., Reading, Mass, (1970).

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

[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 Murthy :** Problems in Algebraic Number Theory, Springer Verlag2000.

Semester4(Elective)

MTH4E07: 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.

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 thetext]

Module 2

Simplicial Homology Groups (Contd.): The Euler Poincare's Theorem; Pseudo manifolds and the homology groups of S_n. 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

Semester4(Elective)

MTH4E08: 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 thetext]

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 Ideals; 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

Semester4(Elective)

MTH4E09: 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 parametrized n- surfaces are the same.
- Develop a knowledge of the Gauss and Weingarten maps and apply them to apply them to describe various properties of surfaces.

TEXT: J.A.THORPE, ELEMENTARY TOPICS IN DIFFERENTIAL GEOMETRY, **Springer- Verlag, New York, Inc. 1979.**

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, ArcLength and Line Integrals. [Chapters: 7,8,9,10,11 from the text].

Module 3

Curvature of Surfaces, Parametrized Surfaces, Local Equivalence of Surfaces and ParametrizedSurfaces. [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. Guillemin and A. Pollack:** Differential Topology, Prentice Hall Inc EnglewoodCliffs NJ (1974)

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

[5] **M. Spivak:** A Comprehensive Introduction to Differential, Geometry, (Volumes 1 to5), Publish or Perish, Boston (1970, 75)

[6] **R. Millman 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)

Semester4(Elective)

MTH4E10: 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 aero- foil, 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: Axi symmetrical motions, Stock Stream function, Simple force, 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 ofIndia ,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 Press1987

Semester4(Elective)

MTH4E11: GRAPH THEORY
No. of Credits: 3

No. of hours of Lectures/week : 5

Course Outcome: Upon the successful completion of the course students will:

- Learn different types of graphs.
- Learn the concept matching in graphs and related results.
- Understand what is meant by coloring.
- Learn 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, Applicationsand Algorithms, Pearson Printice Hall, 2007.

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

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

Semester4(Elective)

MTH4E12 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 Representa tions, Com- plete reducibility, Schurs lemma, The commutant(endomorphism) algebra. (Sections: 1.1to 1.8)

Module 2

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

[1]

Module 3

Induced representations, reciprocity law, the alternating group A5, Normal sub- groups, Transitive groups, the symmetric group, induced characters of S_n. (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 Associative Algebras, John Wiley & Sons, New York (1962)

[2] **Faulton:** The Reprsentation Theory of Finite Groups, Lecture Notes in Mathematics,No. 682, Springer Representation 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 of Finite Groups, Graduate Text in Mathematics,Vol 42, Springer (1977).

Semester 4(Elective)

MTH4E13: 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 Z_N.

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

Module 2

Wavelets on Z: $l^2(Z)$, Complete orthonormal sets in Hilbert spaces, $L^2([\ \pi, \pi))$ and Fourier series, The Fourier Transform and convolution on $l^2(Z)$, First stage Wavelets onZ, Implementation and Examples. [Chapter 4: sections 4.1 to 4.6 and 4.7]

Module 3

Wavelets on R: $L^2(R)$ 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 Al-gorithms 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.