ST. THOMAS COLLEGE Autonomous

ST. THOMAS COLLEGE (AUTONOMOUS), THRISSUR

BOARD OF STUDIES
MSc. MATHEMATICS

SYLLABUS AND SCHEME
2020 ADMISSION ONWARDS

MEMBERS OF BOARD OF STUDIES
Mathematics

1. Dr. Saju M. I.(Chairman)
2. Mr. Vincent Joseph Pulikkottil
3. Dr. Viji M.
4. Dr. (Sr.) Alphonsa Mathew
5. Mr. Antony John E. F.
6. Mr. Sabu A. S.
7. Dr. (Sr.) Julie Andrews
8. Mr. Renjith Varghese
9. Mr. Pratheesh George
10. Mr. Ashbin Mathew
11. Mr. Mathew Thomas
12. Dr. Didimos K. V., Assistant Professor, SH College, Kochi
13. Dr. Kiran Kumar V. B., Assistant Professor, CUSAT, Cochin
14. Mr. Vishnudas V., Assistant Manager, Kennametal India, Ltd, Bangalore
15. Dr. Joju K. T., Associate Professor, PrajyotiNikethan College, Pudukad
16. Dr. Sajith G., Sullamussalam Science College, Malapuram (University Nominee)

Contents

VISION, MISSION & CORE VALUES

MOTTO:

“Veritas Vos Liberabit” (The Truth will set you Free).

VISION:

Transforming the Youth through Holistic Education towards an Enlightened Society.

MISSION:

- To Ensure Inclusion and Access of Quality Education.
- To Provide an Environment of Learning that enhances Dissemination of Knowledge.
- To Nurture Research and Innovation for the betterment of Life and Progress of the Nation.
- To Undertake Collaborative Partnerships for Facilitating Exposure and Sharing.
- To Impart Social and Environmental Sensitivity in Students through Extension and Outreach.
- To Equip Students with Life Skills in Facing Challenges and Responsibilities
- To Help Students attain Moral, Spiritual and Emotional integrity.

CORE VALUES:

- Faith in God
- Pursuit of Excellence
- Integrity
- Diversity
- Compassion

PROGRAMME STRUCTURE

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
MTH3C11	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. MTH3E03Measure&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.

I. **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.

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

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

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

V. **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.

VI. **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.

MTH4V01 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 voice is 15. The same Board of two External Examiners shall conduct both the project evaluation and the comprehensive viva voice examination. The Board of Examiners shall evaluate at most 10 students per day.

EVALUATION AND GRADING

The valuation 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) Two tests

(ii) one assignment

(iii) one seminar and

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

Internal Examination:

Each of the two internaltestsistobea10weightageexaminationofdurationonehour indirect grading. The average of the final grade points of the two tests can be used to obtain the final consolidate d 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

Range of Attendance	Grading
>= 90 %	A +
85 % < = Attendance < 90 %	A
80 % < = Attendance < 85 %	B
75 % < = Attendance < 80 %	C
70 % < = Attendance < 75 %	D
< 70 %	E

Table 1: Internal Grade Calculation: Examples

Tests	Grade Point of Test 1	Grade Point of Test 2	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 End semester written examinations

For each course there will be an End semester 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 will consist of 9paragraph type questions each of weightage 2 of which at least 3 questions should be from each unit. 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.

Industrial Visit:

It is compulsory that every student has to undertake study tour of 1-2 days to visit Organizations / Institutes involved in higher education under the guidance of teachers. Submit a visit report countersigned by the Head of the department during the project evaluation. If a student fails to undergo the study tour, he/she may not be permitted to attend the project examination.

POST GRADUATE PROGRAM OUTCOMES:

At the end of Post Graduate Program at St. Thomas College (Autonomous), a student would have:

PO 1	Attained profound **Expertise in Discipline**.
PO 2	Acquired **Ability to function in multidisciplinary Domains**.
PO 3	Attained ability to exercise **Research Intelligence** in investigations and Innovations.
PO 4	Learnt Ethical Principles and be committed to **Professional Ethics**.
PO 5	Incorporated **Self-directed and Life-long Learning**.
PO 6	Obtained Ability to maneuver in diverse contexts with **Global Perspective**.
PO 7	Attained **Maturity to respond to one's calling**.

PROGRAM SPECIFIC OUTCOMES:

PSO 1	Develop a strong base in theoretical and applied Mathematics.
PSO 2	Acquire their analytical thinking, logical deductions and rigor in reasoning.
PSO 3	Apply the tools to model the problems mathematically, analyze data quantitatively and create the ability to access and communicate mathematical information.
PSO 4	Acquire knowledge in recent developments in various branches of Mathematics and thus pursue research.

DETAILED SYLLABI

SEMESTER I

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/ week	CL	KC	Hrs.	PO	PSO
1	**MTH1C01**	**Core**	**ALGEBRA - I**	**4**	**5**					
CO	CO Statement									
CO 1	Create knowledge of plane isometries					Cr	C, P	15	2	
CO 2	Understand group action and its applications					U	C, P	10	2	
CO 3	Apply Sylow theorem to solve problems in group theory					Ap	C, P	25	3	1
CO 4	Understand group presentation					U	C	15	3	
CO 5	Explain polynomials over a ring.					U	C, P	15	3	

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, 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.

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lectures /week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs.</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>2</td><td>MTH1C02</td><td>Core</td><td>Linear Algebra</td><td>4</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Understand properties of vector spaces</td><td>U</td><td>C, P</td><td>25</td><td>1</td><td rowspan="5">3</td></tr>
<tr><td>CO 2</td><td colspan="5">Study linear transformations</td><td>U</td><td>C, P</td><td>15</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Illustrate elementary canonical forms</td><td>U</td><td>C, P</td><td>10</td><td>2</td></tr>
<tr><td>CO 4</td><td colspan="5">Develop an idea of inner product spaces</td><td>Ap</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Apply orthonormalization techniques to solve problems</td><td>Ap</td><td>C, P</td><td>15</td><td>6</td></tr>
</table>

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.

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/week	CL	KC	Hrs.	PO	PSO
3	**MTH1C03**	**Core**	**Real Analysis I**	**4**	**5**					
CO	CO Statement									
CO 1	Construct an idea of basic topology					Ap	C, P	25	1	
CO 2	Understand differentiation and related theorems					U	C, P	15	2	
CO 3	Understand differentiation of vector valued functions					U	C, P	10	6	2
CO 4	Develop knowledge of Riemann Stieltjes integral					Ap	C, P	15	3	
CO 5	Infer uniform continuity and uniform convergence					U	C, P	15	3	

TEXT: RUDIN W., PRINCIPLES OF MATHEMATICAL ANALYSIS (3rd 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; Alpha Science 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 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.

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/week	CL	KC	Hrs	PO	PSO
4	**MTH1C04**	**Core**	**Discrete Mathematics**	**4**	**5**					
CO	CO Statement									
CO 1	State concepts of order relations.					U	C	10	1	
CO 2	Interpret Boolean algebra and their properties					U	C, P	15	2	
CO 3	Develop concepts of graph and related terms					Ap	C, P	15	6	3
CO 4	Analyze characterization of special graphs					An	C, P	20	6	
CO 5	Construct concepts of automata and formal languages					Ap	C, P	20	3	

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

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, 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 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 Combina- torics; Hindustan Book Agency; 2009. **J. A. Clalrk**: A first look at Graph Theory; World Scientific; 1991.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
5	**MTH1C05**	**Core**	**Number Theory**	**4**	**5**					
CO	CO Statement									
CO 1	Identify arithmetic functions and Dirichlet multiplication					An	C, P	20	1	
CO 2	Explain importance of prime numbers					U	C, P	20	2	
CO 3	Discuss quadratic residue and quadratic reciprocity laws					Cr	C, P	15	2	1
CO 4	Demonstrate concepts in cryptography.					U	C, P	10	4	
CO 5	Classify symmetric and asymmetric cryptosystems					An	C, P	15	6	

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 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 (Incorpo- rated); 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; Mar- cel 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 II

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/week	C L	KC	Hrs	PO	PSO
6	**MTH2C06**	**Core**	**Algebra-II**	**4**	**5**					
CO	**CO Statement**									
CO 1	Understand concepts of prime and maximal ideals					U	C, P	20	1	
CO 2	Explain algebraic extension field					U	C	10	3	
CO 3	Summarize separable extension field					U	C, P	25	3	1
CO 4	Illustrate Galois theory					U	C, P	10	3	
CO 5	Create an idea of cyclotomic extensions					Cr	C, P	15	6	

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

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lecture s/week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>7</td><td>MTH2C07</td><td>Core</td><td>Real Analysis II</td><td>4</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Understand Lebesgue measure</td><td>U</td><td>C</td><td>15</td><td>1</td><td rowspan="5">2</td></tr>
<tr><td>CO 2</td><td colspan="5">Develop concept of integration of non-negative functions</td><td>U</td><td>C, P</td><td>15</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Explain functions of bounded variation</td><td>U</td><td>C</td><td>15</td><td>3</td></tr>
<tr><td>CO 4</td><td colspan="5">Interpret Lebesgue's differentiation theorem</td><td>U</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Illustrate signed measures and related theorems</td><td>U</td><td>C, P</td><td>20</td><td>6</td></tr>
</table>

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^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,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 Com- pany,New York.
[8] **Terence Tao:** ,An Introduction to Measure Theory,Graduate Studies in Mathemat- ics,Vol 126 AMS

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
8	**MTH2C08**	**Core**	**Topology**	**4**	**5**					
CO	**CO Statement**									
CO 1	Develop basic concepts of topological Spaces					Ap	C, P	15	1	2
CO 2	Identify quotient spaces					Ap	C, P	15	2	
CO 3	Explain spaces with special properties					U	C, P	15	2	
CO 4	Understand separation axioms					U	C, P	20	3	
CO 5	Analyze Urysohn and Tietze characterization of normality					An	C, P	15	3	

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 [Chapter 4 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

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lecture s/week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>9</td><td>MTH2C09</td><td>Core</td><td>ODE & calculus of variations</td><td>4</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Create concepts of power series solutions</td><td>Cr</td><td>C, P</td><td>25</td><td>1</td><td rowspan="5">3</td></tr>
<tr><td>CO 2</td><td colspan="5">Explain special functions of mathematical physics</td><td>U</td><td>C, P</td><td>10</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Develop idea of systems of first order equation</td><td>U</td><td>C, P</td><td>10</td><td>2</td></tr>
<tr><td>CO 4</td><td colspan="5">Analyze non-linear equations</td><td>An</td><td>C, P</td><td>10</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Demonstrate boundary value problems and related theorems</td><td>U</td><td>C, P</td><td>25</td><td>3</td></tr>
</table>

TEXT : SIMMONS, G.F., DIFFERENTIAL EQUATIONS WITH APPLICATIONS AND HISTORICAL NOTES(2nd Edn.), 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. (Omit Section 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 boundary value 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 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. Corpo- ration, Delhi; 1967

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

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. Of hours of Lectures /week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>10</td><td>MTH2C10</td><td>Core</td><td>Operations Research</td><td>4</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Identify convex functions</td><td>Ap</td><td>C, P</td><td>15</td><td>1</td><td rowspan="5">3</td></tr>
<tr><td>CO 2</td><td colspan="5">Understand modeling and solving of linear programming problems</td><td>U</td><td>C, P</td><td>15</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Interpret modeling and solving of integer programming problems</td><td>U</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 4</td><td colspan="5">Develop concepts of flow and potential in networks</td><td>Ap</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Explain theory of games</td><td>U</td><td>C, P</td><td>20</td><td>6</td></tr>
</table>

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 Delhi(Fifth printing); 2004
[7] **A. Ravindran, D.T. Philips and J.J. Solberg**: Operations Research- Principles and Practices(2nd Edn.); John Wiley & Sons; 2000
[8] **.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

Course	Code	Course Category	Name of the course	No.of Credits	No. of hours of Lectures/ week	CL	KL	PO	PSO
PCC 1	**MTH2A02**	**Professional Competency Course**	**TECHNICALWRITING WITH LATEX**	**4**	**0**				
CO	**CO Statement**								
CO 1	Understand the basic concept of LATEX					U	C, P	6	4
CO 2	Plan to prepare a research paper with LATEX					Ap	C, P	5	
CO 3	Develop a beamer presentation					Ap	C, P	6	

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**: 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**:TheLATEXWeb 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

<table>
<tr><td>Course</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No.of Credits</td><td>No. of hours of Lectures/ week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>PCC 2</td><td>MTH2A03</td><td>Professional Competency Course</td><td>PROGRA MMING WITH SCILAB</td><td>4</td><td>0</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Understand the basic Concepts of SCILAB</td><td>U</td><td>C</td><td>6</td><td rowspan="3">4</td></tr>
<tr><td>CO 2</td><td colspan="5">Develop 2-D & 3-D Graphics</td><td>Ap</td><td>C, P</td><td>6</td></tr>
<tr><td>CO 3</td><td colspan="5">Analyze Mathematical Problems with SCILAB</td><td>An</td><td>C P</td><td>5</td></tr>
</table>

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

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/week	CL	KC	PO	PSO
PCC 3	**MTH2A04**	**Professional Competency Course**	**SCIENTIFIC PROGRAMMING WITH PYTHON**	**4**	**0**				
CO	**CO Statement**								
CO 1	Explain basics of Python programming					U	C	6	4
CO 2	Apply Python programming in numerical analysis					Ap	C, P	6	
CO 3	Apply Python programming in Linear algebra					Ap	C, P	6	

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 Modules: using system modules, import statements, creating modules
5. Data Structures: Lists, tuples, sequences.
6. Writing a python script
7. Files: Input and output using file and pickle module
8. Exceptions: Errors, Try-except statement, raising exceptions, try-finally statement
9. Roots of Nonlinear Equations: Evaluation of Polynomials, Bisection method, Newton- Raphson Method, Complex roots by Bairstow method.
10. Direct Solution of Linear Equations: Solution by elimination, Gauss

Elimination method, Gauss Elimination with Pivoting, Triangular Factorisation method

11. 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 method (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 algorithmic approach) 3rd edition, McGraw-Hill, New Delhi
[4] **K. Sankara Rao :** Numerical Methods for Scientists and Engineers Prentice Hall of India, New Delhi.
[5] **Carl E Froberg :** Introduction to Numerical Analysis, Addison Wesley Pub Co, 2nd Edition
[6] **Knuth D.E. :** The Art of Computer Programming: Fundamental Algorithms(Volume I), 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 Publishing
[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 III

<table>
<tr><th>Course No</th><th>Code</th><th>Course Category</th><th>Name of the course</th><th>No. of Cred its</th><th>No. of hours of Lectur es/wee k</th><th rowspan="3">CL</th><th rowspan="3">KC</th><th rowspan="3">Hrs</th><th rowspan="3">PO</th><th rowspan="3">PSO</th></tr>
<tr><td>1</td><td>MTH3C11</td><td>Core</td><td>Multivariable Calculus & Geometry</td><td>4</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Develop an idea of functions of several variables</td><td>Ap</td><td>C, P</td><td>15</td><td>1</td><td rowspan="5">1</td></tr>
<tr><td>CO 2</td><td colspan="5">Understand contraction principle and inverse function theorem</td><td>U</td><td>C, P</td><td>15</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Analyze characterization of curves</td><td>An</td><td>C, P</td><td>20</td><td>2</td></tr>
<tr><td>CO 4</td><td colspan="5">Interpret characterization of surfaces</td><td>U</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Identify different curvatures</td><td>Ap</td><td>C, P</td><td>15</td><td>6</td></tr>
</table>

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

TEXT2: 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, 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

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; Publish or Perish, Boston; 1970

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

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

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lectures/ week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>2</td><td>MTH3C12</td><td>Core</td><td>Complex Analysis</td><td>4</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Develop concepts of conformality</td><td>Ap</td><td>C, P</td><td>25</td><td></td><td rowspan="5">2</td></tr>
<tr><td>CO 2</td><td colspan="5">Explain fundamental theorem and Cauchy's Integral formula</td><td>U</td><td>C, P</td><td>15</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Create an idea of analytical functions and related theorems</td><td>Cr</td><td>C, P</td><td>10</td><td>3</td></tr>
<tr><td>CO 4</td><td colspan="5">Understand power series expansion</td><td>U</td><td>C, P</td><td>20</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Understand periodic functions</td><td>U</td><td>C, P</td><td>10</td><td>3</td></tr>
</table>

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.

[Chapt .IV section 2,3,4,5,6]

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

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
3	**MTH3C13**	**Core**	**Functional Analysis**	**4**	**5**					
CO	CO Statement									
CO 1	Develop concepts of Normed Linear spaces					U	C, P	25	1	
CO 2	Analyze innerproduct spaces					U	C, P	20	1	
CO 3	Explain bounded linear funtionals and their properties					U	C, P	15	2	4
CO 4	Discuss Hahn-Banach theorem and its consequences					U	C, P	10	3	
CO 5	Understand compact operators and invertible operators					An	C, P	10	3	

TEXT : YULI EIDELMAN, VITALI MILMAN & ANTONIS TSOLOMITIS; FUNC- TIONAL 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 ineaquality, 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 ineaquality and Hilber- tian norm,Bessels ineaquality,Completesystems, Gram-Schmidt orthogonalization procedure, orthogonal bases, Parseval' identity; Projection; orthgonal decompositions; Separable case, The distance from a point to a convex set, Orthogonal decomposition; lin- ear 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; John Wiley & Sons; 1958

[6] **Kolmogorov and S.V. Fomin**: Elements of the Theory of Functions and Functional Analysis (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

Course No	Code	Course Category	Name of the course	No. of Credits	No. of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
4	**MTH3 C14**	**Core**	**PDE & Integral Equations**	**4**	**5**					
CO	CO Statement									
CO 1	Summarize first order partial differential equations					U	C, P	15		
CO 2	Develop methods of solving first order partial differential equations					Ap	C, P	15	2	
CO 3	Apply second order partial differential equations					Ap	C, P	15	3	3
CO 4	Identify methods of solving second order partial differential equations					Ap	C, P	10	3	
CO 5	Demonstrate integral equations					U	C, P	25	3	

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, 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 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. Cor- poration, Delhi; 1967

[9] **I. Sneddon**: Elements of Partial Differential Equations; McGraw-Hill International Edn.; 195

ELECTIVE 1 IN SEMESTER III

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lecture s/week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>E 01</td><td>MTH3E01</td><td>Elective</td><td>Coding theory</td><td>3</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Discuss strong concept of error detection, correction and their effects</td><td>Cr</td><td>C, P</td><td>25</td><td>2</td><td rowspan="5">3</td></tr>
<tr><td>CO 2</td><td colspan="5">Demonstrate different types of codes</td><td>U</td><td>C, P</td><td>20</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Interpret cyclic linear codes and dual cyclic codes</td><td>U</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 4</td><td colspan="5">Create cyclic hamming codes</td><td>Cr</td><td>C, P</td><td>10</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Develop decoding 2 error correcting BCH linear codes</td><td>Ap</td><td>C, P</td><td>10</td><td>3</td></tr>
</table>

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, 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

ELECTIVE 2 IN SEMESTER III

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lectures/ week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>E 02</td><td>MTH3E02</td><td>Elective</td><td>Cryptography</td><td>3</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Develop knowledge in classical cryptography</td><td>Ap</td><td>C, P</td><td>15</td><td>2</td><td rowspan="5">4</td></tr>
<tr><td>CO 2</td><td colspan="5">Discuss simple cryptosystems</td><td>Cr</td><td>C, P</td><td>20</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Analyze different ciphers</td><td>An</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 4</td><td colspan="5">Create block ciphers</td><td>Cr</td><td>C, P</td><td>20</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Understand cryptographic hash functions</td><td>U</td><td>C, P</td><td>10</td><td>6</td></tr>
</table>

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, Huff- man 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 Mathemat- ical 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.

ELECTIVE 3 IN SEMESTER III

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lectures/week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>E 03</td><td>MTH3E03</td><td>Elective</td><td>Measure & Integration</td><td>3</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Explain measurability and their properties</td><td>U</td><td>C, P</td><td>15</td><td>2</td><td rowspan="5">2</td></tr>
<tr><td>CO 2</td><td colspan="5">Understand integration of complex functions using concepts of measure</td><td>U</td><td>C, P</td><td>10</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Analyze Riesz representation theorem</td><td>An</td><td>C, P</td><td>15</td><td>1</td></tr>
<tr><td>CO 4</td><td colspan="5">Create knowledge in Lebesgue measures and their completion</td><td>Cr</td><td>C, P</td><td>20</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Develop non measurable infinite set</td><td>Ap</td><td>C, P</td><td>20</td><td>3</td></tr>
</table>

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 Func- tions, 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

ELECTIVE 4 IN SEMESTER III

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lecture s/week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>E04</td><td>MTH3E04</td><td>Elective</td><td>Probability Theory</td><td>3</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Understand random variables and their probability distributions</td><td>U</td><td>C, P</td><td>15</td><td></td><td rowspan="5">2</td></tr>
<tr><td>CO 2</td><td colspan="5">Explain moments and generating functions</td><td>U</td><td>C, P</td><td>10</td><td>1</td></tr>
<tr><td>CO 3</td><td colspan="5">Analyze multiple random variables</td><td>An</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 4</td><td colspan="5">Identify covariance, correlation and moments.</td><td>Ap</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Illustrate law of large numbers</td><td>U</td><td>C, P</td><td>25</td><td>3</td></tr>
</table>

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 Lim- ited, 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 Mathe- matical Statistics (Sixth Edn.), Pearson 2005.

SEMESTER IV

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. Of hours of Lectures /week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>1</td><td>MTH 4C15</td><td>Core</td><td>Advanced Functional Analysis</td><td>4</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Explain spectrum of compact operators</td><td>U</td><td>C, P</td><td>15</td><td>1</td><td rowspan="5">4</td></tr>
<tr><td>CO 2</td><td colspan="5">Understand ordering in the space of self adjoint operators</td><td>U</td><td>C, P</td><td>15</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Discuss projection maps</td><td>U</td><td>C, P</td><td>10</td><td>3</td></tr>
<tr><td>CO 4</td><td colspan="5">Analyze Banach open mapping theorem</td><td>U</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Understand Banach Algebra</td><td>Ap</td><td>C, P</td><td>25</td><td>3</td></tr>
</table>

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, Fredholm 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 upto 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 &LawrenceNarici:** 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.DunfordandJ.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 Analysi 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)

[15] **YuliEidelman,Vitali Milman and Antonis Tsolomitis:** Functional analysis An Introduction, Graduate Studies in Mathematics Vol. 66 American Mathematical Soci- ety 2004.

ELECTIVE 1 IN SEMESTER IV

Course No	Code	Course Category	Name of the course	No. of Credits	No. Of hours of Lectures /week	CL	KC	Hrs	PO	PSO
E01	**MTH 4E05**	**Elective**	**Advanced Complex Analysis**	**3**	**5**					
CO	**CO Statement**									
CO 1	Analyze Mittag-Leffler theorem and Weierstrass theorem					An	C, P	20	1	
CO 2	Understand infinite products					U	C	20	2	
CO 3	Explain entire functions of finite order					U	C, P	15	2	4
CO 4	Apply multiple valued functions in complex analysis					Ap	C, P	15	3	
CO 5	Demonstrate space of analytic and meromorphic functions					U	C, P	10	3	

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

Module 1

The Space of continuous functions $C(tt, \Omega)$, 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 reflexion principle, Analytic continuation along a path, Monotromy theorem, Jensen's formula, The Genus and order of an entire func- tion, 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)

ELECTIVE 2 IN SEMESTER IV

<table>
<tr><td>Course No</td><td>Code</td><td>Course Category</td><td>Name of the course</td><td>No. of Credits</td><td>No. of hours of Lectures /week</td><td rowspan="3">CL</td><td rowspan="3">KC</td><td rowspan="3">Hrs</td><td rowspan="3">PO</td><td rowspan="3">PSO</td></tr>
<tr><td>E02</td><td>MTH 4E06</td><td>Elective</td><td>Algebraic Number Theory</td><td>3</td><td>5</td></tr>
<tr><td>CO</td><td colspan="5">CO Statement</td></tr>
<tr><td>CO 1</td><td colspan="5">Understand symmetric polynomials, modules and algebraic numbers</td><td>U</td><td>C, P</td><td>15</td><td>1</td><td rowspan="5">1</td></tr>
<tr><td>CO 2</td><td colspan="5">Explain ring of integers, quadratic fields and cyclotomic fields</td><td>U</td><td>C, P</td><td>10</td><td>2</td></tr>
<tr><td>CO 3</td><td colspan="5">Illustrate different factorizations</td><td>U</td><td>C, P</td><td>25</td><td>2</td></tr>
<tr><td>CO 4</td><td colspan="5">Explain Minkowski theorem</td><td>U</td><td>C, P</td><td>15</td><td>3</td></tr>
<tr><td>CO 5</td><td colspan="5">Develop Fermats last thorem</td><td>Ap</td><td>C, P</td><td>15</td><td>3</td></tr>
</table>

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. Lang :** Algebraic Number Theory, Addison Wesley Pub Co., Reading, Mass, (1970)

[3] 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 Verlag 2000.

ELECTIVE 3 IN SEMESTER IV:

Course No	Code	Course Category	Name of the course	No. of Credits	No. Of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
E03	**MTH 4E07**	**Elective**	**Algebraic Topology**	**3**	**5**					
CO	**CO Statement**									
CO 1	Understand geometric complexes and polyhedra					U	C, P	15	1	
CO 2	Explain simplicial homology groups					U	C, P	10	2	
CO 3	Explain simplicial approximations					U	C, P	15	3	2
CO 4	Understyand Brouwer fixed point theorem and related results					U	C, P	15	3	
CO 5	Develop homotopic paths and covering homotopy property					Ap	C, P	25	3	

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; Pseudomanifolds 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

ELECTIVE 4 IN SEMESTER IV

Course No	Code	Course Category	Name of the course	No. of Credits	No. Of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
E04	**MTH 4E08**	**Elective**	**Commutative Algebra**	**3**	**5**					
CO	**CO Statement**									
CO 1	Understand properties of rings and ideals					U	C, P	15	1	
CO 2	Explain modules					U	C, P	10	1	
CO 3	Identify modules of fractions					Ap	C, P	25	2	1
CO 4	Interpret integral dependence and valuation					U	C, P	15	3	
CO 5	Compare Noetherian rings and Artinian rings					U	C, P	15	3	

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

ELECTIVE 5 IN SEMESTER IV

Course No	Code	Course Category	Name of the course	No. of Credits	No. Of hours of Lectures /week	CL	KC	Hrs	PO	PSO
E05	**MTH 4E09**	**Elective**	**Differential Geometry**	**3**	**5**					
CO	**CO Statement**									
CO 1	Understand concepts of graphs and level sets					U	C, P	15	1	
CO 2	Explain vector fields on surfaces					U	C, P	10	1	
CO 3	Analyze geodesics, parallel transport and Weingarten map.					An	C, P	25	2	3
CO 4	Explain properties of surfaces-curvature, local equivalence.					U	C, P	15	3	
CO 5	Identify different types of surfaces					Ap	C, P	15	3	

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)

ELECTIVE 6 IN SEMESTER IV

Course No	Code	Course Category	Name of the course	No. of Credits	No. Of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
E06	**MTH4 E10**	**Elective**	**Fluid Dynamics**	**3**	**5**					
CO	**CO Statement**									
CO 1	Analyze equations of motion					An	C, P	15	1	4
CO 2	Discuss two-dimensional motion					Cr	C, P	10	1	
CO 3	Explain streaming motions and aerofoils					U	C, P	25	2	
CO 4	Interpret sources and sinks					U	C, P	15	3	
CO 5	Understand Stokes' stream functions					U	C, P	15	3	

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: 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

ELECTIVE 7 IN SEMESTER IV

Course No	Code	Course Category	Name of the course	No. of Credits	No. Of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
E07	**MTH 4E11**	**Elective**	**Graph Theory**	**3**	**5**					
CO	**CO Statement**									
CO 1	Understand graph, vertex, path and cycles					U	C, P	15	2	4
CO 2	Explain connectivity in communication networks					U	C, P	10	2	
CO 3	Develop matchings and coverings in bipartite graphs					Ap	C, P	25	2	
CO 4	Explain chromatic number and related topics					U	C, P	15	3	
CO 5	Illustrate coloring problem and study some special graphs					U	C, P	15	3	

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 Per- sonnel 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

ELECTIVE 8 IN SEMESTER IV

Course No	Code	Course Category	Name of the course	No. of Credits	No. Of hours of Lectures /week	CL	KC	Hrs	PO	PSO
E08	**MTH 4E12**	**Elective**	**Representation Theory**	**3**	**5**					
CO	**CO Statement**									
CO 1	Understand G-modules					U	C, P	15	2	4
CO 2	Develop idea of reducibility					Ap	C, P	10	2	
CO 3	Analyze orthogonality relations					An	C, P	25	2	
CO 4	Develop induced representations					Ap	C, P	15	3	
CO 5	Explain reciprocity law					U	C, P	15	3	

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 subgroups, 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 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).

ELECTIVE 9 IN SEMESTER IV

Course No	Code	Course Category	Name of the course	No. of Credits	No. Of hours of Lectures/ week	CL	KC	Hrs	PO	PSO
E09	**MTH 4E13**	**Elective**	**Wavelet Theory**	**3**	**5**					
CO	**CO Statement**									
CO 1	Understand basic properties of discrete fourier transforms					U	C, P	15	1	4
CO 2	Develop wavelets on ZN					Ap	C, P	10	2	
CO 3	Interpret complete orthonormal sets in Hilbert space					U	C, P	15	3	
CO 4	Explain Fourier transform and convolutions					U	C, P	15	2	
CO 5	Explain wavelets and Fourier transform on ℝ					U	C, P	25	3	

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

Module 3

Wavelets on R : $L^2(R)$ 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.

MODEL QUESTION PAPER

I/II/III/IV SEMESTER M.Sc. DEGREE EXAMINATION (CBCSS), Month & Year

M.Sc. Mathematics
Course Code: Course Name

Time : 3 hrs | Maximum Weightage: 30

Part A (Answer all the questions. Weightage 1 for each question)

1. from Module 1
2. from Module 1
3. from Module 2
4. from Module 2
5. from Module 3
6. from Module 3
7. from Module 1/2/3
8. from Module 1/2/3

Part B (Answer any six questions. Weightage 2 for each question)

9. from Module 1
10. from Module 1
11. from Module 1
12. from Module 2
13. from Module 2
14. from Module 2
15. from Module 3
16. from Module 3
17. from Module 3

Part C (Answer any two questions. Weightage 5 for each question)

18. from Module 1
19. from Module 2
20. from Module 3
21. from Module 1/2/3

Model question paper

FIRST SEMESTER M.Sc. (CBCSS) DEGREE EXAMINATION

M.Sc. Mathematics

MTH1C04: DISCRETE MATHEMATICS

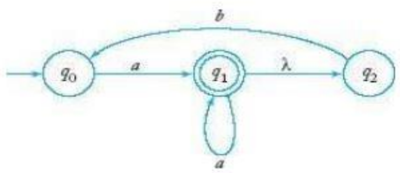
Time: Three Hours Maximum: 30 Weightage

Part A (Answer all the questions. Weightage 1 for each question)

1. Prove that every connected graph contains a spanning tree.
2. Give an example of a nonsimple disconnected graph with $\delta \geq \frac{n-1}{2}$.
3. Prove that if $\delta(G) \geq 2$, then G contains a cycle.
4. Define dual of a plane graph.
5. Find the characteristic numbers of the symmetric function $f(x_1, x_2, x_3) = x_1x_2 + x_2x_3 + x_3x_1$.
6. State why there does not exit a Boolean algebra having 22 elements.
7. Describe the language generated by the grammar with productions, $S \to Aa, A \to B, B \to Aa$.
8. Define extended transition function δ^* with an example.

Part B (Answer any six questions. Weightage 2 for each question)

9. Prove that the set $\Gamma(G)$ of all automorphisms of a simple graph G is a group with respect to the composition of mappings as the group operation.
10. A connected graph G with at least two vertices contains at least two vertices that are not cut vertices.
11. Prove that a graph G with at least three vertices is 2-connectedif, and only if, any two vertices of G are connected by at least two internally disjoint paths.
12. Prove that a graph is planar if and only if it is embeddable on a sphere.
13. Draw the Hasse Diagram for the lattice$(D_{20}, \leq)$. Where D_{10} is the set of all divisors of 10 and $\leq$ be the relation 'divides'.
14. Let X be a finite set and $\leq$ be a partial order on X . Also R is a relation on X defined by xRy if and only if y $covers$ $x(w.r.t. \leq)$. Show that $\leq$ is generated by R.
15. Express the function $f(x_1, x_2, x_3) = x_1x_2 + x_2'x_3$ in its C.N.F.
16. Find a grammar that generates $L = \{a^{n+2}b^n : n \geq 0\}$.
17. Convert the given nfa to equivalent dfa



Part C (Answer any two questions. Weightage 5 for each question)

$(2 \times 5 = 10$ Weightage)

18. Prove that for any loopless connected graph G, $\kappa(G) \leq \lambda(G) \leq \delta(G)$.
19. Prove that K_n is planar if and only if $n \leq 4$.
20. (a). Prove that every finite Boolean algebra is isomorphic to a power set Boolean algebra

    (b). Prove that the characteristic numbers of a symmetric Boolean function completely determine it.
21. Find dfa for the following languages.

    (a) $L = \{w: |w| \, mod \, 5 \neq 0\}$ on $\Sigma = \{a, b\}$.

    (b) $L = \{vwv: v, w \in \{a, b\}^*, |v| = 2\}$

Model question paper

SECOND SEMESTER M.Sc. (CBCSS) DEGREE EXAMINATION

M.Sc. Mathematics

MTH2C09: ODE & calculus variations

Time: 3hrs Maximum Weightage: 30

Part A (Answer all the questions. Weightage 1 for each question)

1. Find the power series solution of $y' + y = 1$.
2. Determine the nature at $x = 0$ of $x^3y'' + (sinx\ )y = 0$.
3. Show that $\frac{d}{dx}\{x^pJ_p(x)\} = x^pJ_{p-1}(x)$.
4. Express $J_3(x)$ in terms of $J_0(x)$ and $J_1(x)$.
5. State Picard's Theorem
6. find the normal form of Bessel differential equation.
7. Show that $(1 + x\ )^p = F(-p, b, b, -x)$.
8. Find the critical points of $\frac{d^2x}{dt^2} + \frac{dx}{dt} - (x^3 + x^2 - 2x) = 0$.

Part B (Answer any six questions. Weightage 2 for each question)

9. Find the general solution of $(1 + x^2)y'' + 2xy' - 2y = 0$ in terms of power series in x.
10. Find the general solution of Hermite's equation in terms of power series in x.
11. Determine the nature of the point $x = \infty$ for Legendre's equation
$(1 - x^2)y'' - 2xy' + p(p + 1)y = 0$.
12. Show that $J_{-\frac{1}{2}}$(x) = $\sqrt{\frac{2}{\pi x}}\ Cos\ x$
13. Solve $\begin{cases} \frac{dx}{dt} = 5x + 4y \\ \frac{dy}{dt} = -x + y \end{cases}$
14. Verify that (0,0) is a simple critical point of the system $\begin{cases} \frac{dx}{dt} = x + y - 2xy \\ \frac{dy}{dt} = -2x + y + 3y^2 \end{cases}$ determine the nature of the critical point
15. Find the exact solution of $y' = 2x\ (1 + y)$ with $y(0) = 0$. Starting with $y_0(x) = 0$.

Calculate $y_1(x), y_2(x), y_3(x) \& \, y_4(x)$ and compare these results with the exact solution.

16. State and prove Sturm separation theorem.

17. Find the extremal of the integral $\int_{x_1}^{x_2} \frac{\sqrt{1+y'^2}}{y} \, dx$.

Part C (Answer any two questions. Weightage 5 for each question)

18. Find two independent Frobenius series solution of $x^2 y'' + xy' + \left(x^2 - \frac{1}{4}\right) y = 0$.

19. Show that if there exist a Lyapunov function E (x, y) for the system $\begin{cases} \frac{dx}{dt} = F(x,y) \\ \frac{dy}{dt} = G(x,y) \end{cases}$

the critical point (0,0) is stable. Furthermore if $\frac{dE}{dt}$ is negative definite then the critical point (0,0) is asymptotically stable.

20. Let y(x) and z(x) be non-trivial solution of $y'' + q(x)y = 0 \; and \; z'' + r(x)z = 0$ where $q(x)$ and $r(x)$ be positive functions such that $q(x) > r(x)$ then $y(x)$ vanishes at least once between any two successive zeroes of z(x).

21. State and prove orthogonal property of Legendre polynomial.

Model question paper

THIRD SEMESTER M.Sc. (CBCSS) DEGREE EXAMINATION

M.Sc. Mathematics

MTH3C11: Multivariable Calculus and Geometry

Time: 3 hrs | Max.Weight: 30

Part A

*Answer **all** questions. Each question carries 1 weightage* $(8 \times 1 = 8$ Weightage)

1. Prove that a linear operator A on a finite dimensional vector space X is one-to- one if and only if the range of A is all of X
2. Prove that to every $A \in L(\mathbb{R}^n, \mathbb{R}^1)$, corresponds a unique $y \in, \mathbb{R}^n$ such that $Ax = x.y$
3. Show that if $A \in L(\mathbb{R}^n, \mathbb{R}^m)$ and if $x \in \mathbb{R}^n$,then $A'(x) = A$
4. Show that a linear operator A on $\mathbb{R}^n$ is invertible if and only if $\det[A] \neq 0$
5. If $f(0,0) = 0$ and $f(x,y) = \frac{xy}{x^2+y^2}$ if $(x,y) \neq (0,0)$.Prove that $(D_1 f)(x,y)$ and $(D_2 f)(x,y)$ exist at every point of $\mathbb{R}^2$, although f is not continuous at $(0,0)$
6. State and prove contraction principle.
7. Prove that if the tangent vector of a parametrized curve is constant, the image of the curve is a straight line.
8. If $\gamma(t)$ is a regular curve prove that its arc length s starting at any point of γ is a smooth function of t

Part B

*Answer any **six** questions. Each question carries 2 weightage.* $(6 \times 2 = 12$ Weightage)

9. Prove that $L(\mathbb{R}^n, \mathbb{R}^m)$ is a metric space with the metric $d(A,B) = \|A - B\|$; $A, B \in L(\mathbb{R}^n, \mathbb{R}^m)$
10. Prove that Ω,the set of all invertible linear operator on $\mathbb{R}^n$ is an open set in $(\mathbb{R}^n)$. Also prove that the mapping $A \to A^{-1}$ is continuous on Ω.
11. Suppose f maps an open set $E \subset \mathbb{R}^n$ into $\mathbb{R}^m$. Then prove that $f \in C'(E)$ if and only if the partial derivatives $D_j f_i$ exist and continuous on E for $1 \leq i \leq m, 1 \leq j \leq n$.
12. Prove that the sphere of radius 1 with center at the origin is a surface.
13. Let $\gamma: (\alpha, \beta) \to \mathbb{R}^2$ be a unit speed curve, let $s_0 \in (\alpha, \beta)$ and φ_0 be such that $\dot{\gamma}(s_0) = (\cos\varphi_0, \sin\varphi_0)$.Then prove that there exist a unique smooth function $\varphi: (\alpha, \beta) \to \mathbb{R}$ such that $\varphi(s_0) = \varphi_0$ and that $\dot{\gamma}(s) = (\cos\varphi(s), \sin\varphi(s))$ for every $s \in (\alpha, \beta)$
14. Compute κ, τ, t, n and b for the the curve $\gamma(t) = \left(\frac{4}{5}\cos t, 1 - \sin t, -\frac{3}{5}\cos t\right)$ and verify that the Frenet-Serret equations are satisfied.

15. Let $f: S_1 \to S_2$ be a diffeomorphism. If σ_1 is an allowable surface patch on S_1 , then prove that $f \circ \sigma_1$ is an allowable surface patch on S_2
16. State and prove Euler's theorem for oriented surface.
17. Show that the normal curvature of any curve on a sphere of radius r is $\pm\frac{1}{r}$

Part C

*Answer any **two** questions. Each question carries 5 weightage.* $(2 \times 5 = 10$ Weightage)

18. State and prove inverse function theorem
19. State and prove implicit function theorem
20. Define signed curvature of a curve in $\mathbb{R}^2$. Let $k: (\alpha, \beta) \to \mathbb{R}$ be any smooth function , prove that there is a unit speed curve $\gamma: (\alpha, \beta) \to \mathbb{R}^2$ whose signed curvature is k.If $\bar{\gamma}: (\alpha, \beta) \to \mathbb{R}^2$ is any unit speed curve whose signed curvature is k , how does γ and $\bar{\gamma}$ are related? Also prove that any regular curve whose curvature is a positive constant is part of a circle.
21. Let $\sigma: U \to \mathbb{R}^3$ be a surface patch. Let $(u_0, v_0) \in U$ and $\delta > 0$ be such that the closed disc $R_\delta = \{(u, v) \in \mathbb{R}^2 : (u - u_0)^2 + (v - v_0)^2 \leq \delta^2\}$ with centre (u_0, v_0) and radius δ is contained in U.Then prove that's $\lim_{\delta \to 0}\left(\frac{\mathcal{A}_N(R_\delta)}{\mathcal{A}_\sigma(R_\delta)}\right) = |K|$ where K is the Gaussian curvature of σ at $\sigma(u_0, v_0)$.

Model question paper

FOURTH SEMESTER M.Sc. (CBCSS) DEGREE EXAMINATION

M.Sc. Mathematics

MTH4C15: Advanced Functional Analysis

Time : 3 hrs MaximumWeightage: 30

Part A

*Answer **all** questions. Each question carries 1 weightage* $(8 \times 1 = 8$ Weightage)

1. Find the spectrum of the operator $T: \mathbb{R}^2 \to \mathbb{R}^2$ defined by $T(x_1, x_2) = (5x_1 + 2x_2\,, 3x_1)$
2. If $dim\ X = \infty$, then prove that the identity operator $I: X \to X$ is not compact.
3. Let A be a self- adjoint operator. If $\lambda_1,\ \lambda_2 \in \sigma_p(A),\ \ \lambda_1 \neq \lambda_2$ and $Ax_1 = \lambda_1 x_1,\ Ax_2 = \lambda_2 x_2$, then prove that $x_1 \perp x_2$.
4. Prove that $-I \leq A \leq I$ implies $\| A \| \leq 1$.
5. If P is a projection operator, then the operator $Q = I - P$ is also a projection and $\ker Q = Im\ P$.
6. Define metric. Give an example with justification.
7. State Banach Steinhaus theorem.
8. Every closed subspace of a reflexive space is reflexive. True or False? Justify.

Part B

*Answer any **six** questions. Each question carries 2 weightage*. $(6 \times 2 = 12$ Weightage)

9. a) Show that the set of all regular points of A forms an open set.

   b) Prove that every $\lambda \in \mathbb{C}$ with $|\lambda| > \| A \|$ is a regular point of the operator A.
10. Define $C = \sup\limits_{x \neq 0} \frac{|\langle Ax, x\rangle|}{\|x\|^2}$. Then if A is a symmetric operator, prove that $C = \| A \|$
11. Let T be a compact operator, on an infinite dimensional Banach space X. Prove that for every $\varepsilon > 0$, there is only a finite number of linearly independent eigen vectors corresponding to eigen values λ_i with $|\lambda_i| \geq \varepsilon$.

12. Let $T: E \to E$ be any linear operator, $E_1 + E_2 = E$ and let P be the projection onto E_1 parallel to E_2. Then show that $PT = TP$ if and only if E_1 and E_2 are invariant subspaces of T.

13. Define $K[a, b]$. Let $\varphi_n(t)$ be a sequence of continuous functions such that $\varphi_n \searrow \varphi$ on $[m, M]$. Let A be such that $mI \leq A \leq MI$. Then prove that $\varphi_n(A) \to \varphi(A)$ strongly.

14. Describe spectral integral.
15. Show that any complete metric space is a set of second category.
16. State and prove Banach Open mapping theorem.
17. The Minkowski functional is sublinear. Justify.

Part C

*Answer any **two** questions. Each question carries 5 weightage.* ($2 \times 5 = 10$ Weightage)

18. State and prove First Hilbert Schmidt theorem.
19. Let $A \geq 0$. Then, prove that there exists a unique operator X such that $X^2 = A$ and $X \geq 0$. Also prove that $\forall\, B$ such that $AB = BA$, it is also true that $\sqrt{A}\, B = B\sqrt{A}$ where $\sqrt{A} = X$.

20. State and prove Hahn-Banach Theorem.
21. Let T be a compact operator, on an infinite dimensional Banach space X. Let $\lambda \neq 0$, then prove that $\Delta_\lambda = \overline{\Delta_\lambda}$.