Syllabus of U.G. 7th & 8th Semester and P.G.(one year & two years) under NEP-2020

Fourth Year-Under Graduate program (FYUP), NEP

VII & VIII Semesters, Mathematics Fourth Year- (U.G. with Honours)

Entry requirement	(After completing the requirements of a 3-year bachelor's degree (120 credits) and 2 additional credits under SSD, the candidate will be allowed to continue studies in the fourth year of the undergraduate programme leading to the four-year bachelor's degree (with Honours).					
Course Type	Semester-VII			Semester-VIII		
	Subject/Title	No. of paper	Credits	Subject /Title	No. of paper	Credits
Core Major Subject (Four)	Core Major -I Abstract Algebra I	1	4	Core Major -I Abstract Algebra II	1	4
	Core Major –II Calculus of Several Variables	1	4	Core Major –II Complex Analysis	1	4
	Core Major –III O.R.-I	1	4	Core Major-III O.R.-II	1	4
	Core Major Elective-IV (Anyone) 1. Fluid Dynamics 2. Advanced Linear Algebra 3. Number Theory 4. Data Structures	1	4	Core Major Elective-IV (Anyone) 1. Fluid Dynamics 2. Advanced Linear Algebra 3. Number Theory 4. Data Structures	1	4

Minor (Interdisciplinary)	Minor Elective- I 1. Elementary Differential Calculus 2. Computational Number Theory 3. Ancient Indian Mathematics 4. Quantitative Aptitude	1	4	Minor Elective–II 1. Elementary Differential Calculus 2. Computational Number Theory 3. Ancient Indian Mathematics 4. Quantitative Aptitude	1	4
Total		5	20		5	20
Student on exit after successfully completing four years (i.e., securing minimum required 160 credits along with securing additional 2 credits under SSD course work) will be awarded "Four years Bachelor's Degree (Honours)", in related field/discipline/subject						

Note: In the case of electives (Major or Minor), departments must offer a minimum of two electives, out of which students will select one.

Fourth year (U.G. Honours with Research)

Entry requirement	(After completing requirements of a 3-year bachelor's degree (120 credits) and 2 additional credits under SSD, candidates who meet a minimum CGPA of 7.5 will be allowed to continue studies in the fourth year of the undergraduate programme leading to the four years bachelor's degree (Honours with Research).					
Course Type	Semester-VII			Semester-VIII		
	Subject/Title	No. of paper	Credits	Subject /Title	No. of paper	Credits
Core Subject (Three)	Core Major -I Abstract Algebra I	1	4	Core Major -I Abstract Algebra II	1	4
	Core Major –II Calculus of Several Variables	1	4			
	Core Major Elective– III (Anyone) 1. Complex Analysis 2. Fluid Dynamics 3. Advanced Linear Algebra 4. Data Structures 5. OR -I	1	4	Core Major Elective– II (Anyone) 1. Complex Analysis 2. Fluid Dynamics 3. Advanced Linear Algebra 5. Data Structures 6. OR -II	1	4
Core Course (ResearchBased)	Research Methodology	1	6	Dissertation /Project	1	12
	Research Writing & Ethics	1	2	--	--	-
Total		5	20		3	20

Student on exit after successfully completing four years (i.e., securing minimum required 160 credits along with securing additional 2 credits under SSD course work) will be awarded "Four years Bachelor's Degree "Honours with Research", in related field/discipline/subject

Note: Research Methodology and Research Writing & Ethics: Both papers are to be prepared by the Departments.

P.G. First Year (for Two-year P.G. program)

(For non-practical based subjects)

P.G. (First Year)- First semester

Entry requiremen t	3-year bachelor's degree (120 credits), and candidates who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations.			
Semester	Course category	Course title	Credits T	Total Credit
I	Core (4 papers)	Core-1 Abstract Algebra I	4	4
		Core-2 Calculus of Several Variables	3	3
		Core-3 O.R.-I	4	4
		Core-4 Elementary Number Theory	2	2
	Elective (Choose any one)	1. Advanced Numerical Methods with MATLAB 2. Mathematical Python 3. Data Structures 4. Differential Equations with Mathematica/Maxima/Maple	Theory 4+ Practical 3	7
Total			20	20

P.G. (First Year)- Second semester

Semester	Course category	Course title	Credits	Total Credit
			T	
II	Core (4 papers)	Core-1 Abstract Algebra II	4	4
		Core-2 Complex Analysis	4	4
		Core-3 O.R.-II	3	3
		Core-4 Matrix Analysis	2	2
	Elective (Choose any one)	1. Advanced Numerical Methods with MATLAB 2. Mathematical Python 3. Data Structures 4. Differential Equations with Mathematica/Maxima/Maple	4+3	4+3
Total			20	20
Semester	Course category	Course title	Credits	Total Credit

Note: 1. In lieu of elective (Theory and practical= 4+3 credits) the departments may offer any one course i.e. dissertation/project work of 7 credits

2. In lieu of only Elective Practical (3 credits) the departments may offer 3 credit additional course (Field work/Project).

P.G. Second Year (for Two-year P.G. program)

And

1-year P.G. program for (4-year U.G. passed students)

- Third semester (for two-year program-P.G. first year passed students)
- First semester (For one year program-U.G. 4 years passed students)

4-year bachelor's degree (160 credits), and candidates who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations Or P.G. First year with 40 credits				
Semester	Course category	Course title	Credits T	Total Credit
III/I	Core	Core-1 Real Analysis	4	4
		Core-2 Topology	4	4
		Core 3 Mathematical Methods	4	4
	Elective (Any 2 out of the Minimum 4 electives)	1. Differential Geometry 2. Linear Chaos 3. Mathematical Statistics 4. Commutative Algebra 5. Theory of ODE 6. Non-Linear Analysis	Elective-I 4	4
			Elective-2 4	4

Total			20	20

Note: 1. In lieu of elective (Theory and practical= 4+3 credits) the departments may offer any one course i.e. dissertation/project work of 7 credits
2. In lieu of only Elective Practical (3 credits) the departments may offer 3 credit additional course (Field work/Project).

P.G. (Second Year)-

- Fourth semester (for two-year program)
- Second semester (For one year program)

4-year bachelor's degree (160 credits), and candidates who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations Or P.G. First year with 40 credits				
Semester	Course category	Course title	Credits T	Total Credit
IV/II	Core	Core-1 Measure Theory	4	4
		Core-2 Theory of PDE	4	4
		Core 3 Functional Analysis	4	4
	Elective (Any 2 out of the Minimum 5 electives) OR	1.Integral Transforms 2.Fuzzy Set Theory	Elective-I 4	4
		3.Field theory 4.Dynamics of Linear Operators 5.Algebraic Number Theory	Elective-II 4	4

		The Project work/Dissertation (based on merit)		8
Total			20	20
Semester	Course category	Course title	Credits	Total Credit

Note: 1. In lieu of elective (Theory and practical= 4+3 credits) the departments may offer any one course i.e. dissertation/project work of 7 credits

2. In lieu of only Elective Practical (3 credits) the departments may offer 3 credit additional course (Field work/Project).

SEMESTER- VII (UG-Hons & Res) & SEMESTER- I (PG)

Paper-Core Major-I ABSTRACT ALGEBRA- I

I. Simple groups, Conjugacy, Normalization, Centre of a group, Class equation of a group and its consequences, Theorems for finite groups, Cauchy's theorem, Sylow's theorem.
II. Homomorphism, Endomorphism, Automorphism, Inner automorphism, Kernel of a homomorphism, Fundamental theorem on homomorphism of group, Group of automorphisms, Results on group homomorphism.

III. Maximal subgroups, Composition series, Jordan-Holder theorem, Solvable groups, Commutator subgroups, Direct products
IV. Ideals, Algebra of ideals, Principal ideal ring, Units and associates, Polynomials ring, Division and Euclidean algorithm for polynomials, Unique factorization theorem

Books Recommended:

1. Contemporary Abstract Algebra: Josheph A. Gallian, Narosa Pub. House P. Ltd.

2. A First Course in Abstract Algebra: John. B. Fraleigh, Pearson Edu. Inc., 2003. 3.

Abstract Algebra: V.K. Khanna and S.K. Bhambri, Vikash Pub. House P. Ltd.

4. Topics in Algebra: I. N. Herstein, John Wiley & Sons, New York.

SEMESTER- VII (UG-Hons & Res) & SEMESTER- I (PG)

Paper –Core-Major-II CALCULUS OF SEVERAL VARIABLES

I. Functions of two or more variables, limit and continuity, partial derivatives, differentiability, chain rule,implicit function theorem, inverse function theorem.

II. Directional derivatives and gradient vectors, Tangent planes and normal lines, Extrema of functions of two variables, Lagrange multipliers.

III. Double integrals, Applications of double integrals, Surface area, Surface area, Triple integrals.

IV. Vector fields, Divergence and curl, Line integrals, Green's theorem.

Books Recommended:

1. Mathematical Analysis by S C Malik & Savita Arora, New Age International Publishers, New Delhi, 2020.

2. Calculus of Several Variables by E K McLachlan, Prentice Hall, Cambridge University Press.

3. Calculus of Several Variables, Third Edition by Serge Lang, Springer.

SEMESTER- VII (UG-Hons & Res) & SEMESTER- I (PG)

Paper –Core-Major-III OPERATIONS RESEARCH –I

I. Lines and Hyperplanes, convex sets and their properties, extreme points, Convex Functions, Quadratic Forms, Linear programming models: Basic feasible solution, Infeasible and unbounded solution, alternate optima; graphical method, simplex method, two-phase methods.

II. Revised simplex method, Duality theory, weak duality and strong duality, Dual Simplex methods, Sensitivity Analysis.

III. Transportation problems: Balanced and unbalanced transportation problems, Initial basic feasible solution of balanced transportation problems (least cost method, north-west corner rule, Vogel's approximation method, modified distribution method, assignment problems, The travelling salesman problem.

IV. Introduction to Game Theory, Two person Zero-sum game, Dominance rule, Mixed strategy, Graphical and Algebraic methods and formulation to Linear Programming Problem (LPP). Graphical solutions, Integer programming, Branch and bound Techniques. Gomory's cutting plane algorithm.

TEXT/REFERENCE BOOKS

1. Operations Research: Kanti Swarup, P.K. Gupta & Man Mohan, S. Chand, 1978.

2. Operations Research: Theory and Applications: J.K. Sharma, Trinity Press, 2016.

3. Operations Research: H.A. Taha, Prentice Hall of India, 2011.

4. Operations Research: R. Bronson, Schaum's Outline Series. McGraw Hill, 1982.

Paper-Core Major Elective-I FLUID DYNAMICS

I. Kinematics of fluids, Lagrangian and Eulerian methods, Local and individual time rates of change, Equation of continuity, Boundary surface.

II. Equation of motion of inviscid fluids, Euler's equation of motion, Bernoulli's equation, Lagrange's equation, Conservative field of force, Cauchy's Integral, Helm- Holtz's equation.

III. Impulsive motion of a fluid, Energy equation of inviscid fluid, General theory of irrotational motion, Connectivity, Flow and circulation, Kelvin's circulation theorem, Stokes's theorem, Permanence of irrotational motions, Green's theorem, Kinetic energy of finite and infinite liquid, Kelvin's minimum energy theorem, Mean value of the velocity potential over a spherical surface.

IV. Motion in two dimensions, Stream function, Complex potential, Source, Sink, Doublet, Complex potential and images with respect to straight line and circle, Milne- Circle theorem, Blausius theorem.

Books Recommended:

1. Foundation to Fluid Mechanics: S.W. Yuan, Prentice Hall Pvt. Ltd., 1960.
2. Text book of Fluid Dynamics: F. Chorlton, CBS Pub. & Dist. , 2004.
3. Theoretical Hydro-Dynamics: BansiLal, Skylark Pub., 1999.
4. A text book of Fluid – Dynamics: M. Ray & Sharma, S. Chand & Co. Ltd. 2005.

SEMESTER-VII/VIII-Hons & Res

Paper-Core Major Elective-I ADVANCED LINEAR ALGEBRA

I. Linear functionals and the Dual spaces, Second dual space, Annihilators, Hyperspaces, Dual of linear transformations.

II. Inner product spaces, Orhtogonality and orthonormality, Operators on inner product spaces.

III. Triangularizable operators, Diagonalizable operators, Cayley-Hamilton theorem and minimal polynomial, Normal operators on inner product spaces.

IV. Bilinear forms and their matrices The effect of change of basis, Orthogonality and reflexive forms, Non-degenerate bilinear forms, Quadratic forms associated with bilinear forms, Diagonalization of quadratic forms.

Books Recommended:

1. Advanced Linear Algebra with Applications by M. Ashraf, V. De Filippis, M.A. Siddeeque, Springer Verlog Singapore Pte Ltd.
2. Advanced Linear Algebra by Nicholas A Loehr, CRC Press
3. Linear Algebra with Applications by Otto Bretscher, Pearson.
4. Linear Algebra, Kenneth Hoffman, Ray Alden Kunze,Pearson India Education Services, 2015

SEMESTER-VII/VIII-Hons

Pape- Core Major Elective-I NUMBER THEORY

I. The division algorithm, The g.c.d, The Euclidean algorithm, Diophantine equation ax + by=c, The fundamental theorem of arithmetic, The sieve of Eratosthenes, Goldbach conjucture.
II. The theory of congruence's, Binary and decimal representation of integers, Linear congruence and Chinese remainder theorem, Fermat's theorem, Wilson's theorem.
III. Number theoretic function, Tau and sigma function, the Mobius inversion formula, The greatest integer function, Euler's phi function, Properties of phi function, Euler theorem. IV. The order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots, The theory of indices, Continued fraction, Approximation of irrationals by rational.

Books Recommended

1. Elementary Number Theory: David M. Burton, McGraw-Hill.

2. Theory of Numbers: George Andrews, Courier Corporation, 1994.

3. Elementary Number Theory with Applications: Thomas Koshy, Harcourt Acad. Press.

4. Fundamental of Number Theory: William J. Lereque, Dover Pub. Inc. New York.

SEMESTER-VII/VIII-Hons & Res

Paper-Core Major Elective-I DATA STRUCTURES

1. Introduction to data structure and Array: Introduction: Basic Terminology: Elementary Data Organization, Data Structure Operations, Algorithms Complexity, Time-Space Trade off. Array Definition and Analysis, Representation of Linear Arrays in Memory, Traversing of Linear Arrays, Insertion and Deletion, Single Dimensional Arrays, Two Dimensional Arrays, Bubble Sorting, Selection Sorting, Linear Search, Binary Search, Multidimensional Arrays, Function Associated with Arrays, Character String in C, Character String Operations, Arrays as parameters, Implementing One Dimensional Array.
2. Stacks, Queues and Sorting: Introduction to Operations Associated with Stacks Push & Pop, Array representation of stacks, Operation associated with stacks: Create, Add, Delete, Application of stacks recursion polish expression and their compilation conversion of infix expression to prefix and postfix expression, Tower of Hanoi problem, Representation of Queues, Operations of queues: Create, Add, Delete, Front, Empty, Priority of Queues, Sorting: Insertion Sort, Quick sort, two-way Merge sort, Heap sort.
3. Linked Lists and Trees: Singly linked lists: Representation of linked lists in memory, Traversing, Searching, and Insertion into, Deletion from linked list, Polynomial Addition, More on linked list, Header nodes, Doubly linked list, Generalized

list.Trees: Basic Terminology, Binary Trees and their representation, expression evaluation, Complete Binary trees, Extended binary trees, traversing binary trees, Searching, Insertion and Deletion in binary search trees, Complexity of searching algorithm, Path length, Huffman's algorithm, General trees, AVL trees, Threaded trees, B trees.

4. File Structure: The standard C Library: Input/Output: fopen, fread, etc. String handling functions, Math functions: log, sin etc. Other Standard C functions. Physical storage media, File organization, Organization records into blocks, Sequential blocks, Indexing & Hashing, Primary Indices. Secondary Indices, B+ tree index files, Static, Hash functions, Indexing & hashing comparisons.

Books Recommended:

1. Horowitz and Sahani, "Fundamentals of Data structures", Galgotia publications
2. Kruse, R.L., Leary, B.P., Tondo, CL., "Data structure and program design in C", PHI
3. Tannenbaum, "Data Structures", PHI
4. Tremblay, Jean Paul & Sorenson, Pal G. An introduction to data structures and application by (McGraw Hill)

SEMESTER-VII/VIII-Hons

Minor (Interdisciplinary) (Any one out of these)

Paper-Manor Elective-I ELEMENTARY DIFFERENTIAL CALCULUS

I. Limits, Continuity , Types of discontinuity, Differentiation and examples.

II. Successive differentiation, Leibnitz theorem.

III. Expansion of functions using Maclaurin's Taylor's theorems.

IV. Indeterminate forms, L'Hopital's rule.

Books Recommended:

1. Differential Calculus by Gorakh Prasad, Pothishala Private Limited, Allahabad.
2. Differential Calculus by Shanti Narayan, S Chand & Company Private Ltd. New Delhi.

SEMESTER-VII/VIII-Hons

Paper-Manor Elective-I COMPUTATIONAL NUMBER THEORY

I. Greatest Common Divisor (GCD) algorithms, Chinese Remainder Theorem, Fast polynomial multiplication techniques.

II.Fast integer multiplication and division, Fast GCD computation, Fast matrix multiplication methods, Tensor rank and its applications.

III. Factorization over finite fields, Berlekamp and Cantor-Zassenhaus factoring algorithms, ReedSolomon error-correcting codes, List decoding techniques, Bivariate and multivariate polynomial factorization.

IV. Lattice-based cryptography, Lenstra-Lenstra-Lovász (LLL) algorithm and shortest vector problem, Primality testing methods, RSA cryptosystem and Diffie-Hellman key exchange, Discrete logarithm problem, Integer factorization techniques, including Pollard's rho method and quadratic sieve.

Books Recommended:

1. Victor Shoup - A Computational Introduction to Number Theory and Algebra.

2. Henri Cohen - A Course in Computational Algebraic Number Theory.

3. Richard Crandall & Carl Pomerance - Prime Numbers: A Computational Perspective

4. J. von zur Gathen & J. Gerhard - Modern Computer Algebra.

SEMESTER - VII/VIII-Hons

Paper-Minor Elective-I ANCIENT INDIAN MATHEMATICS

I. Mathematics in Vedic period, Significance of Sulba Sutras and their geometric contributions. II. Contributions of Aryabhata and Brahmagupta on arithmetic, algebra and astronomy. III. Contributions of Varahamihir and Sridharacharya. IV. Works of Bhaskaracharya-I, II.

Books Recommended:

1. Studies in Indian Mathematics & Astronomy by A. Kolachana, K. Mahesh K. Ramasubbramanian. Springer, Singapore.

2. The History of Maths and Mathematicians of India by V D Haroor, Vidya Bharati, Banglore, 2006.

SEMESTER-VII/VIII-Hons.

Paper-Manor Elective-I QUANTITATIVE APTITUDE

I. Simplifications, Percentage, Profit & Loss, Simple Interest, Compound Interest, H.C.F.& L.C.M., Mixed Problems

II. Introduction of Equations, Simple Equation, Problems on S.E., Linear Equations, Problems on L.E., Quadratic Equations, Problems on Q.E.

III. Problems On Number, Problems on Ages, Number System, Applications of Number System.

IV. Height &Distance, Progressions, Arithmetic Progression, Geometric Progression, Harmonic Progression, Applications of Progressions

Books Recommended:

1.Aggarwal, R.S., Quantitative Aptitude for Competitive Exam, (S. Chand)

2.Guha, Abhijit., Quantitative Aptitude for Competitive Exam, (Mc, Graw. Hill Education)

UG SEMESTER-VIII-Hons. & Res and PG Semester II

Paper-Core Major-I ABSTRACT ALGEBRA-II

I. Embedding of rings, Ring of residue classes, Fundamental theorem on homomorphism of ring , Prime ideals, Maximal ideal.
II. Euclidean ring, Properties of Euclidean ring, Module, sub-module, Module homomorphism, Linear sum and direct sum of sub-module
III. Extension fields, Simple field extension, Algebraic field extension, Minimal polynomial, Roots of polynomials, Multiple roots, Splitting field.
IV. Automorphism of field, Fixed field, Normal extension, Galois group: Examples and characterizations, Construction with straight edge and compass.

Books Recommended:

1. Contemporary Abstract Algebra :Josheph A. Gallian, Narosa Pub. House P. Ltd.

2. A First course in Abstract Algebra : John. B. Fraleigh, Pearson Edu. Inc. , 2003.

3. Abstract Algebra : V.K. Khanna and S.K. Bhambri, Vikash Pub. House P. Ltd.

4. Topics in Algebra : I. N. Herstein, John Wiley & Sons, New York.

SEMESTER-VIII-Hons & Res and PG Semester II

Paper-Core Major-II COMPLEX ANALYSIS

I. Power series of analytic functions, Convergence of power series, Radius of convergence, Taylor's and Laurent's series, Residue and poles, Singularities, Classification of singularities.
II. Residues, Residue at infinity, Cauchy residue theorem, Applications of residue theorem in evaluation of improper real integrals.
III. Conformal mapping: properties, Mobius transformation, Elementary examples.
IV. Maximum modulus theorem, Mittag-Leffler theorem, Rouche's theorem, Concept of entire functions with simple example, Analytic continuation.

Books Recommended:

1. Complex Analysis: J.W. Brown and R.V. Churchill, McGraw-Hill Ed. Private Ltd.2015.
2. Complex Analysis: Dennis G. Zill, Jones &Bartlet Learning,2016.
3. Complex Analysis: H. S. Kasana, PHI Learning.
4. Foundation of Complex Analysis: S. Ponnusamy, Alpha Int. Sci.

SEMESTER-VIII-Hons & Res and PG-Sem II

Paper-Core Major-III OPERATIONS RESEARCH-II

I. Inventory control, Functional role of inventory control, Classification of EOQ models with shortages and without shortages, problems of EOQ with price breaks, multi-item deterministic problems.
II. Queuing theory, Characteristics of Queuing system, Probability distribution in queuing system, Single served queuing model, M|M|1 queuing models, Multiple server queuing models.
III. Markov chain, State and transition probabilities, Steady state conditions, Application of Markov analysis, Sequencing problems, Processing n jobs through two and three machines. IV. Dynamic programming, Dynamic programming under certainty, Non-linear programming methods, Quadratic programming, Kuhn- Tucker conditions.

Books Recommended:

1. Operations Research: Kanti Swarup, P.K. Gupta & Man Mohan, S. Chand, 1978.
2. Operations Research: Theory and Applications: J.K. Sharma, Trinity Press, 2016.
3. Operations Research: H.A. Taha, Prentice Hall, 2011.
4. Operations Research: R. Bronson, McGraw Hill, 1982.

UG SEMESTER VII

Fourth Year- (U.G. research)

Core Course (research-based) RESEARCH METHODOLOGY

I. Perception of research, meaning of research, objective of research, different approaches to research, empirical and theoretical research, qualities of a research work, inductive and deductive logics.
II. The scientific method, examples of scientific methods, different phases in scientific method, the use of computers in obtaining proofs of mathematical results, valid and invalid generalization.
III. Problem posing, the soul of research methodology, chains of open ended problems, the art of solving problems, Polya's scheme for solving problems, model building in mathematics.
IV. Basic idea of probability distribution, Elementary sampling theory (a brief introduction), test of significance T, F, Z and Chi-square distribution (a brief introduction).
V. Perception & Definition of Research, Objectives & Motivations of Research, Importance of Research, Types of Research, Research Methods versus Methodology, Process of Research,

Review of Literature, Formulation of the Research Problem, Sources and Identification of a Research Problem, Status of the Research Problem, Formulation of Hypothesis, Research Design, Ethics in Research.

VI. Synopsis, Funding Agencies in India for Research in Physical Sciences, Project Proposal, Project Report Writing, Research Paper Writing, Thesis Writing, Referencing, Formats of Writing References, Bibliography, Plagiarism, IPR, Technology Development and Transfer.

Suggested Readings:

1. Research Methodology for Scientists and Engineers: J.N. Kapur, Mathematical Sciences Trust Society.

2. Fundamentals of Research Methodology and Statistics : Y.K. Singh, New Age International.

3. Thesis and Assignment Writing : Anderson and Jonathon. Wiley Eastern Bombay.

4. How to write Assignments, Research papers, Dissertation and Thesis : V.H. Bedkar, Karak publication New Delhi.

5. Creswell. W.: Research Design, Qualitative, Quantitative and Mixed Methods Approaches (3rdEdition), SAGE, Inc., 2018.

6. Gupta. S: Research Methodology: Methods and Statistical Techniques, Deep & Deep Publications, 2010.

7.Gupta. S.P.: Statistical Methods, Sultan Chand &Sons, 2014.

8. Kumar. R: Research Methodology: A Step-by-Step Guide for Beginners (3rd Edition), SAGE, Inc., 2011.

9.Melville. S. and Goddard. W.: Research Methodology: An Introduction (2nd edition),Juta Academic, 2004.

10.Shortis, T.: The Language of ICT: Information and Communication Technology, Taylor & Francis, 2016.

UG SEMESTER VII

Fourth Year- (U.G. research)

Core Course (research-based) RESEARCH WRITING AND ETHICS

I. LaTeX Typesetting, MS Word: Handling graphics tables and charts, Formatting in MS-Word, MS Power point: Creating Slide Show, Research and Publication Ethics: Theory: - Philosophy and ethics, Scientific conduct, Publication ethics.

II. Research and Publication Ethics: Practice: - Open access publishing, Publication misconduct, Databases and research metrics, Subject Classification Index, Citation, Citation Index, Impact Factor, h-index, i-10index, INFLIBNET, Introduction to Peer Reviewed and Open Access Journals, e-Journals, e-Library, Research Databases in Physical Sciences: Web of Science, Scopus, Science-Direct etc.

Books recommended

[1] Martin J. Erickson and Donald Bindner, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, Boca Raton, FL, 2011.

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

3. Ethics in Research Practice and Innovation, Antonio Sandu, Ana Frunza and Elena Unguru, IGI Global.

4. An Introduction to Programming and Numerical Methods in MATLAB: S.R. Otto and J.P. Denier, Springer. 3.Numerical Methods with MATLAB for Engineers and Scientists : S. Chapra, Mc-Graw-Hill.

PG SEMESTER I

Credit 2 Core-4 ELEMENTARY NUMBER THEORY

I. The division algorithm, The G.C.d, The Euclidean algorithm, Diophantine equation ax + by=c, The fundamental theorem of arithmetic, The sieve of Eratosthenes, Goldbach conjucture.

II. The theory of congruences, Binary and decimal representation of integers, Linear congruence and Chinese remainder theorem, Fermat's theorem, Wilson's theorem.

Books Recommended

1. Elementary Number Theory: David M. Burton, McGraw-Hill.

2. Theory of Numbers: George Andrews, Courier Corporation, 1994.

3. Elementary Number Theory with Applications: Thomas Koshy, Harcourt Acad. Press.

4. Fundamental of Number Theory: William J. Lereque, Dover Pub. Inc. New York.

PG SEMESTER I/II

Paper –Elective ADVANCED NUMERICAL METHODS WITH MATLAB

Unite-1: Basic Matlab- The History and the Product, Creating Variables and Using Basic Arithmetic, Standard Functions, Vectors and Matrices, M-Files, The colon Notation and the for Loop, The if Construct, The while Loop, Plotting, Formatted Screen Output, File Input and Output, Basics of MATLAB:

Unite 2: Roots Finding Methods- Graphical Methods, Bisection, False Position Method, Simple Fixed-Point iteration, Newton-Raphson method. Solution of System of Equations, Eigenvalues and Eigenvectors: The Characteristic Polynomial, Power Method: Theory, Eigenvalues of Special Matrices, Eigenvalues, Diagonal Matrix, Eigenvalues, Upper Triangular Matrix

Unite 3: Ordinary Differential Equations: Introduction, First-Order Equations, Euler’s Method, Runge–Kutta Methods, Fourth-Order Runge–Kutta, Systems of First-Order Equations, Higher Order Equations,

Unite 4: Numerical Solution of ODE E: Shooting Method, Finite Difference Methods, Finite Difference Method for PDE – Elliptic Type PDE, Parabolic Type PDE, Hyperbolic Type PDE.

Practical in MATLAB

Practical No.	Description
P1.	How to Start MATLAB, Basic Calculation, How to Enter Vectors and Matrices
P2.	Matrix Computation: Solving System of Equation, Eigen Values and Eigen Vectors
P3.	Norm of Vector, Matrix, Condition number of Matrix
P4.	Plotting of Basic Functions: Plots with multiple functions – Subplots – Annotation: Title, axel title, colour, label, data value.
P5.	Eigen value and eigen vector of general eigen value system by different methods.
P6.	Finding roots of Equation by different methods
P7.	Solution of First-Order Equations by Euler's Method, Runge–Kutta Methods, Fourth-Order Runge–Kutta,
P8.	Systems of First-Order Equations, Higher Order Equations
P9.	Solution of ODE E: Shooting Method, Finite Difference Methods
P10.	Finite Difference Method for Heat, wave and Laplace Equations

Books Recommended:

1. C. Woodford and C. Phillips, Numerical Methods with Worked Examples: Matlab Edition, Springer

2. Steven .C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientist, Mc Graw Hill Education.

3. M.K. Jain, Numerical Solution of differential Equations, New Delhi : Wiley Eastern ; New York.

PG SEMESTER I/II

Paper –Elective MATHEMATICAL PYTHON

Unit 1 Drawing Shapes, Graphing and Visualization Drawing diverse shapes using code and Turtle; Using matplotlib and NumPy for data organization, Structuring and plotting lines, bars, markers, contours and fields, managing subplots and axes; Pyplot and subplots, Animations of decay, Bayes update, Random walk.

Unit – 2 Numerical and Symbolic Solutions of Mathematical Problems NumPy for scalars and linear algebra on n-dimensional arrays; Computing eigenspace, Solving dynamical systems on coupled ordinary differential equations, Functional programming fundamentals using NumPy; Symbolic computation and SymPy: Differentiation and integration of functions, Limits,

Unit -3 Solution of ordinary differential equations, Computation of eigenvalues, Solution of expressions at multiple points (lambdify), Simplification of expressions, Factorization, Collecting and canceling terms, Partial fraction decomposition, Trigonometric simplification, Exponential and logarithms, Series expansion and finite differences, Solvers, Recursive equations.

Unit – 4 Document Generation with Python and LaTeX Pretty printing using SymPy; Pandas API for IO tools: interfacing Python with text/csv, HTML, LaTeX, XML, MSExcel, OpenDocument, and other such formats; Pylatex and writing document files from Python with auto-computed values, Plots and visualizations.

Practical :

Software labs using IDE such as Spyder and Python Libraries.

Installation, update, and maintenance of code, troubleshooting.

- Implementation of all methods learned in theory.
- Explore and explain API level integration and working of two problems with standard Python code.

References

1. Farrell, Peter (2019). Math Adventures with Python. No Starch Press. ISBN Number: 978- 1-59327-867-0.
2. Farrell, Peter and et al. (2020). The Statistics and Calculus with Python Workshop. Packet Publishing Ltd. ISBN: 978-1-80020-976-3.
3. Saha, Amit (2015). Doing Math with Python. No Starch Press. ISBN: 978-1-59327-640-
   9
4. Morley, Sam (2022). Applying Math with Python (2nd ed.). Packet Publishing Ltd. ISBN: 978-1-80461-837-0

PG SEMESTER I/II

Core Major Elective-I DIFFERENTIAL EQUATIONS WITH MATHEMATICA/MATLAB/MAPLE

C4- Differential Equations (including practicals) Total marks: 150 Theory: 75 Practical: 50 Internal Assessment: 25 5 Lectures, 4 Practicals (each in the group of 15-20)

1.Differential equations and mathematical models, order and degree of a differential equation, exact differential equations and integrating factors of first order differential equations, reducible second order differential equations, application of first order differential equations to acceleration-velocity model, growth and decay model. [2]: Chapter 1 (Sections 1.1, 1.4, 1.6), Chapter 2 (Section 2.3) [3]: Chapter 2.

2.Introduction to compartmental models, lake pollution model (with case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills, case study of alcohol in the bloodstream), exponential growth of population, limited growth of population, limited growth with harvesting. [1]: Chapter 2 (Sections 2.1, 2.5-2.8), Chapter 3 (Sections 3.1-3.3)

3.General solution of homogeneous equation of second order, principle of superposition for a homogeneous equation, Wronskian, its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters [2]: Chapter 3 (Sections 3.13.5).

4.Equilibrium points, interpretation of the phase plane, predator-prey model and its analysis, competing species and its analysis, epidemic model of influenza and its analysis, battle model and its analysis. [1]: Chapter 5 (Sections 5.1, 5.3-5.4, 5.6-5.7), Chapter 6.

Practical / Lab work to be performed on a computer: Modeling of the following problems using Matlab / Mathematica / Maple etc.

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. (a) Lake pollution model (with constant/seasonal flow and pollution concentration). (b) Case of single cold pill and a course of cold pills. (c) Limited growth of population (with and without harvesting).
6. (a) Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator). (b) Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers). (c) Battle model (basic battle model, jungle warfare, long range weapons).

Books Recommended:

1. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach Using Maple, Taylor and Francis, London and New York, 2002.

2. C. H. Edwards and D. E. Penny, Differential Equations and Boundary Value Problems: Computing and Modeling, Pearson Education, India, 2005.

3. S. L. Ross, Differential Equations, John Wiley and Sons, India, 2004.

PG SEMESTER II

Credit 2 MATRIX ANALYSIS

1.Closed subgroups of general linear group, Examples and their compactness and connectedness, Matrix exponential, Norm for vectors and matrices

2. Analytic properties of vector norms, Geometric properties of vector norms, Matrix norms, Error in inverses and solution of linear systems, Location and perturbation of eigenvalues, Positive definite matrices.

Books Recommended:

[1] R. Bhatia, Matrix Analysis, Springer, 1997.

[2] B.C. Hall, Lie Groups, Lie Algebras, and Representations: An Elementary Introduction, Second Edition, Springer, 2015.

[3] R.A. Horn and C.R. Johnson, Matrix Analysis, Cambridge University Press, 2012.

[4] C.D. Meyer, Matrix Analysis and Applied Linear Algebra, SIAM, 2000.

[5] F. Zhang, Matrix Theory: Basic Results and Techniques, Springer Ve

P.G. SEMESTER-III/I

Core-I REAL ANALYSIS

I. The Riemann-Stieltjes Integral: Definition and existence of Riemann-Stieltjes integral, Properties of integrals, Integration and differentiation, Fundamental theorem of calculus, Integration of vector-valued functions.

II. Sequences and series of functions, Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Uniform convergence and continuity, Uniform convergence and

Riemann-Stieltjes integral, Uniform convergence and differentiation, Weierstrass approximation theorem.

III. Power series, Algebra of power series, Uniqueness theorem for power series, Abel's theorem, Taylor's theorem.

IV. Definition and examples of topology on the R, Closed sets, Closure, Dense subsets, Neighbourhoods, Interior, Exterior and accumulation points, Bases and sub bases, subspaces, Product spaces and relative topology.

Books Recommended:

1. Mathematical Analysis:S.C. Malik and Savita Arora, New Age Int. 1992. 2. Mathematical Analysis:T.M. Apostol, Pearson Edu. , Taiwan Ltd., 1974.

3. Real analysis: H.L. Royden, Pearson, 2017.
4. Real Analysis:Terence Tao, Springer.

P.G. (SEMESTER-III/I)

Core-II TOPOLOGY

I. Definition and examples of topological spaces, Metric topology, closed sets, Closure, Dense subsets, Neighborhoods, Interior, Exterior, and accumulation points, Bases and sub-bases, subspaces, Product spaces.

II. Continuous function, Homeomorphism, Connected and disconnected sets, Components, Locally connected spaces, Totally connected spaces,

III. Countability axioms, First and second countable spaces, Lindelof's theorem, Separable spaces, Second countable and separability, Separable axioms: T0,T1, T2 ,T3 , $-T$, T4 and their characterizations.

IV. Compactness, Continuity, and compact sets, Basic properties of compactness, Compactness and finite intersection property, Sequentially and countably compact compact sets, Local compactness, Tychonoff's theorem

Books Recommended:

1. Topology: A First Course:James R. Munkres, Prentice Hall, Incorporated, 2000.
2. General Topology:J.L. Kelly, Springer, 1975.
3. Topology and Modern Analysis:G.F. Simmons, Tata McGraw-Hill.
4. General Topology: Seymour Lipchitz, Schaum Outline Series.

P.G. SEMESTER-III/I

Core-III MATHEMATICAL METHODS

I. Definitions of integral equations and their classification, Relation between integral and differential equations, Fredholm integral equations of second kind with separable kernels, Reduction to a system of algebraic equations.

II. Eigen values and eigen functions, iterated kernels, iterative scheme for solving Fredholm integral equation of second kind (Neumann series), Resolvent kernel, Application of iterative scheme to Volterra's integral equation of second kind.Hilbert Schmidt theory, symmetric kernels, Orthonormal systems of functions. Fundamental properties of eigenvalues and eigen functions for symmetric kernels. Solution of integral equations by using Hilbert Schmidt theory. III. Basic elements of the calculus of variations. Necessary condition for an extremum. Euler's equation with the cases of one variable and several variables. Variational problems for functional involving several dependent variables, Invariance of Euler's equations. Variational problems in parametric form. Functionals depending on higher order derivatives. Functional dependent on the functions of several independent variables, Variational problems with subsidiary conditions.

IV. Variational problems with moving boundaries, Variational problem with a moving boundary for a functional dependent on two functions, Jacobi condition, Weierstrass function, Legendre condition, Weak minimum and weak maximum

Books Recommended:

1. Kanwal,R. P., Linear Integral Equation, Theory and Technique, 2nd edition, 1996, Academic Press New York 1971.

2. Gupta,A.S., Calculus of Variations with Applications, Ist edition, PHI, India.

3. Hildebrand, F. B., Method of Applied Mathematics, 2nd edition, PHI, India

P.G.(SEMESTER- III/I)

Elective (Any 2 out of these elective papers)

Elective-1 DIFFERENTIAL GEOMETRY

I. Curves in space; Arc length, Order of contact, Tangent, Normal, Binormal, Osculating, Plane, Serret-Frenet formulae, Curvature and torsion. Osculating circle and osculating sphere, Helix, Bertrand curves.

II. Behaviour of a curve in the neighbourhood of a point. Concept of a surface, Envelope and developable surface, Parametric curves, Family of the surfaces, Edge of regression, Ruled surfaces, Central points.

III. Fundamental forms and curvature of surfaces: First fundamental form. Second fundamental form of the surfaces of revolution, Weingarten's equation, Direction coefficients, Family of curves.

IV. Local non-intrinsic properties of a surface Normal curvature, Principal directions, Principal curvatures, Minimal surface, Lines of curvature.

Rodrigues and Monge's theorem, Euler's theorem, Joachimisthal's theorem, Dupin's indicatrix, Third fundamental form.

Books Recommended:

1. Differential Geometry: T.J. Willmore, Dover Pub. Inc., New York.
2. Differential Geometry of Three Dimensions: C.E. Weathrburn, Cambridge Univ. Press.
3. Elements of Differential Geometry: R.S. Millman& G.D. Parket, Prentice Hall.
4. Introduction to Differential Geometry: A. Goctz, Addison Wesley Pub. Co., 1970.

P.G.(SEMESTER- III/I)

Elective-2 LINEAR CHAOS

UNIT I: Examples of Dynamical Systems, An Example from Finance, An Example from Ecology, Finding Roots and Solving Equations, Orbits, Iteration Orbits, Types of Orbits

UNIT II: Dynamical systems, Topologically transitive maps, Chaos, Mixing maps, Weakly mixing maps, Universality

UNIT III Hypercyclic and chaotic operators, Linear dynamical systems, Hypercyclic operators,
Linear chaos, Mixing operators, Weakly mixing operators, The set of hypercyclic vectors, Linear vs Nonlinear maps, and finite vs infinite dimension, Hypercyclicity and complex dynamics.

UNIT IV: Criteria for chaos and mixing, Weak mixing and the Hypercyclicity Criterion,

Equivalent formulations of the Hypercyclicity Criterion, Hypercyclic sequences of operators

Books Recommended:

Devaney, Robert L. A first course in chaotic dynamical systems: theory and experiment. CRC Press, 2018.

Grosse-Erdmann, Karl-G., and Alfred Peris Manguillot. Linear chaos. Springer Science & Business Media, 2011.

Bayart, Frédéric, and Étienne Matheron. Dynamics of linear operators. No. 179. Cambridge university press, 2009.

P.G.(SEMESTER- III/I)

Elective-3 MATHEMATICAL STATISTICS

I. Probability: Set theoretic approach, Sample spaces, Events; Dependent and Independent events, The concept of Probability, Statistical or empirical definition, Conditional probability, Bayes' theorem, Probability mass and density functions, Chebyshev's inequality, Random variables, Distribution functions, Joint probability distribution function, Conditional distribution function, Probability density function, Expectation, Covariance, Variance of variables, standard discrete and continuous univariate distributions, standard errors, marginal and conditional distributions.

II Basics concept of Moment generating function, Probability generating function and Universal generating function, Discrete distributions: Geometric, Bernoulli, Binomial, Poisson and uniform distributions, Continuous distributions: Normal, Exponential, Gamma, Chi-square, student's t and F, and Beta distributions.

III Sampling Methods: Random Sampling Methods, Simple Random sampling, Stratified Sampling, Systematic Sampling, Probability Proportional to size sampling, Test of Hypothesis and significance: Statistical Hypothesis (Simple and composite), Null and alternative hypotheses, N-P Lemma, Examples of MP and UMP tests, p-value, Tests for Significance, Testing the significance for population mean and variance for t-distribution and chi-square distribution.

IV Curve Fitting, Correlation and regression: Curve fitting, The Method of Least Squares, fitting of a straight Line and second-degree Parabola, Correlation coefficients, Simple and multiple linear Regression, lines of regression, regression coefficient, Scatter diagram, test for slop and correlation.

Books Recommended:

1. Rohatgi, V.K., Saleh, A.K. Md. Ehsanes: An Introduction to Probability and Statistics, Second Edition Wiley-Inderscience. (2008)
2. Kennedy and Gentle: Statistics Computing, Published by CRC Press. (2021)
3. Mayer, P.L.: Introductory Probability and Statistical Applications, IBH. 2nd Edition (1970)
4. Mood, A.M. and Graybill, F.: Introduction to the Theory of Statistics, McGraw Hill Education; 3rd edition (2017).
5. Hogg, R.V., Craig, A. and McKean, Joseph W.: Introduction to Mathematical Statistics, Pearson Education, .8th Edition New Delhi (2019)

P.G.(SEMESTER- III/I)

Elective-4 COMMUTATIVE ALGEBRA

Unit I: Extension and contraction of ideals, Prime spectrum of rings, Jacobson radical of a ring, Prime avoidance lemma, Rings of formal power series, Restriction and extension of scalars.

Unit II: Localisation, Local properties, Extended and contracted ideals in rings of fractions, Primary decomposition, First and second uniqueness theorem of primary decomposition.

Unit III: Integral dependence, Going up theorem, Going down theorem, Integrally closed domains, Valuation rings, Hilbert's Nullstellensatz theorem. Unit IV: Noetherian rings, Primary decomposition in Noetherian rings, Artin rings,

Structure theorem for Artin rings, Discrete valuation rings, Dedekind domains,

Fractional ideals.

Books Recommended:

[1] M.F. Atiyah and I.G. MacDonald, Introduction to Commutative Algebra,

CRC Press, Taylor & Francis, 2018.

[2] B. Singh, Basic Commutative Algebra, World Scientific, 2011.

[3] D. Eisenbud, Commutative Algebra with a View Towards Algebraic

Geometry, Springer, 2004.

[4] O. Zariski and P. Samuel, Commutative Algebra, Volume I & II, Springer,

1975.

[5] R.Y. Sharp, Steps in Commutative Algebra, Cambridge University Press,

2000.

P.G.(SEMESTER- III/I)

Elective-5 THEORY OF ODE

I. First-order ordinary differential equations, existence and uniqueness theorems for initial value problems, Lipschitz condition, Oscillations and Sturm Separation Theorem, Sturm Comparison Theorem. Sturm-liouville boundary value problem, Picard's method of successive approximation, Picard's Theorem.

II. Ordinary points, Singularities, Regular and Irregular singular points, Series solutions about ordinary points, Frobenius series solution Green function. Method of Laplace transforms for solving ordinary differential equations, series solutions (power series, Frobenius method).

III. Legendre and Bessel functions and their orthogonal properties; Systems of linear first-order ordinary differential equations, Sturm's oscillation and separation theorems.

IV. Sturm-Liouville eigenvalue problems, Planar autonomous systems of ordinary differential equations: Stability of stationary points for linear systems with constant coefficients, Linearized stability, Lyapunov functions.

Books Recommended:

1. Coddington, Earl A. & Levinson, Norman: Theory of Ordinary Differential equations, Tata McGraw-Hill Publication.

2. Rai,B., Chaudhary ,D.P. and Freedman, H.I.: A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi 2013.

3. Simmons, G.F.: Differential Equations with Applications and Historical Notes, Second Edition, Tata Mcgraw-Hill Publishing Company Ltd. New Delhi (2017).

P.G. (SEMESTER IV/II)

Elective-6 NON-LINEAR ANALYSIS

I: Contractions: Definition and examples, Strict Contractive maps, Non-expansive maps, Banach
Contraction Principle with some Applications, Extensions of BCP for single valued mappings, Caristi's Fixed point Theorem, Extensions of BCP under Generalized distances, Multivalued versions of BCP.

II: Generalization of Metric spaces: Fixed point theorems on b- Metric spaces, fixed point theorems on Partial Metric spaces, fixed point theorems on generalized Metric space.

III: Fixed point property, Fixed points of continuous maps in Banach spaces, Brouwer's Theorem, Schauder's Theorem, Theorems based on Convexity, Fixed points for Compact maps in Normed Linear spaces, Non-expansive maps in Hilbert Spaces.

IV: Some Iterative Methods for Fixed point problems: Picard Iterative Method, Mann Iterative Method, Ishikawa Iterative Method, Halpern Iterative Method, Noor Iterative Method, CQ Iteration Method.

Books Recommended:

1. M.A. Khamsi, Q.H. Ansari: Topics in Fixed point Theory, Springer, 2014.
2. E. Karapinar, R.P. Agarwal: Fixed point theory in Generalized Metric spaces, Springer, 2022.
3. A. Granas, J. Dugundji: Fixed point Theory, Springer, 2003.

P.G. (SEMESTER IV/II)

CORE-1 MEASURE THEORY

I. Lebesgue outer measure, Measure of open and closed sets,Borel sets, Measurable sets,Measure of cantor's ternary set, Non-measurable sets.
II. Measurable functions, Algebra of measurable functions, Step functions, Characteristic function, Simple functions, Convergence in measure, Egoroff's theorem, Reisz-Fisher theorem. III. Lebesgue Integral and their properties, General Lebesgue integrals, Lebesgue integrals for unbounded functions, Convergence theorems, Fatou Lemma.
IV. Functions of bounded variations, Absolutely continuity, Variation function, Jordandecomposition theorem, Indefinite integral and its characterizations, Differentiation of an integral, Lebesgue differentiation theorem.
Books Recommended:

1. Real Analysis: H.L. Royden, Pearson, 2017.

2. Measure and Integration: S.K. Berberian, The Macmillan Company, 1965.

3. Lebesgue Measure and Integration: P.K. Jain and V.P. Gupta, Wiley, 1986.

4. Measure Theory and Integration: G. De. Barra, Horwood, 2003.

P.G. (SEMESTER IV/II)

CORE-II THEORY OF PDE

Unit I First order equations - Cauchy problem for quasi-linear equation - weak solution of - non-linear first order PDE - method of characteristics.

II Cauchy problem for higher order equation - classification of second order equation by characteristics - linear equations and generalized solutions.

III Distributions - convolution and fundamental solutions.

IV Wave equation - spherical means - energy methods. Laplace equation - existence theory -eigen value and eigenfunctions. Heat equation - existence and uniqueness - regularity.

Reference Books:-

R.C. McOwen, Partial Differential equations, Pearson Education, 2004.

Fritz John, Partial Differential Equations, Narosa, 1979.

P.G. (SEMESTER IV/II)

CORE-III FUNCTIONAL ANALYSIS

I. Normed linear spaces, Banach spaces, Subspaces, Quotient Spaces, Equivalent, Norms.
II. Bounded linear Transformation/operators, Hahn- Banach theorem, Open mapping theorem, Closed graph theorem, Uniform boundedness principle.
III. Inner product spaces, Hilbert spaces, Orthogonality of vectors, Orthogonal complements and projection theorem, Riesz representation theorem, Orthonormal Sets.
IV. Operators on Hilbert Spaces, Self-adjoint, Normal and unitary operators, Orthogonal projection operators.

Books Recommended:

1. Functional Analysis:P.K. Jain, O.P. Ahuza and Khalil Ahamad, Wiley, 1996.
2. Topology and Modern Analysis: G.F. Simmons, Tata McGraw-Hill.
3. Introductory functional Analysis with Applications: E. Kreyszig, Wiley, 1989.
4. Functional Analysis: B.V. Limaye, New Age Int. Pvt. Ltd.

P.G. (SEMESTER IV/II)

Elective (Any two out of these papers)

Elective-I INTEGRAL TRANSFORMS

I: Orthogonal set of functions, Fourier series, Fourier sine and cosine series, Half range expansions, Fourier integral Theorem, Fourier Transform and their Basic Properties.

II: Fourier Cosine Transform, Fourier Sine Transform, Transforms of Derivatives, Fourier Transforms of simple Functions, Fourier Transforms of Rational Functions, Convolution Integral, Parseval's Theorem for Cosine and Sine Transforms, Inversion Theorem, Solution of Partial Differential Equations using Fourier Transforms, Solution of Laplace and Diffusion equations.

III: Laplace Transform: Definition, Transform of some elementary functions, rules of manipulation of Laplace Transform, Transform of Derivatives, Relation involving Integrals, The error function, Transform of Bessel functions, Periodic functions, Convolution of two functions.

IV: Inverse Laplace Transform and their Properties, First & Second Shifting Properties, Inverse Laplace Transforms of Derivative and Integrals, Tauberian Theorem, Solution of Initial value problems for linear equations with constant coefficients, Linear differential equations with variable coefficients.

Books Recommended:

1. Integral Transforms and Their Applications by Lokenath Debnath & Dambaru Bhatta, Chapman & Hall/CRC, Taylor and Francis Group , London, Newyork, 2007.

2. Integral Transforms in Applied Mathematics by John W. Miles, Cambridge University Press, 2010.

3. Ian N. Sneddon, Fourier Transforms , Dover Publications,2010 .

4. Advanced Engineering Mathematics by H.K. Dass, S. Chand , New Delhi,2015.

P.G. (SEMESTER IV/II)

Elective-II FUZZY SET THEORY

I. Introduction: Basics concepts on crisp sets, Fuzzy sets, α-cuts, Additional properties of α-cuts, Level sets, Cardinality of Fuzzy Sets, Types of fuzzy sets, L-Fuzzy Sets, Convex fuzzy sets, Decomposition Theorems, Extension principle for fuzzy sets.

II. Operations of Fuzzy Sets: Fuzzy complement, Fuzzy union. Fuzzy intersection, T-norms, T-conorms, combination of operations, General aggregation Operations. Fuzzy numbers: Concept of Fuzzy Number, Types of Fuzzy Numbers (Triangular and Trapezoidal), Arithmetic operations on Fuzzy Numbers.

III. Fuzzy Relations: Fuzzy relations, Projections and Cylindric extensions, Binary fuzzy relations, binary relations on single set, Fuzzy equivalence relations, Fuzzy partial order relations, Fuzzy ordering relations. Fuzzy ranking method.

IV. Fuzzy logic : Fuzzy propositions, Fuzzy quantifiers, Linguistic hedges, Inference from conditional fuzzy propositions, Inference from conditional and qualified propositions, Fuzzy measures; description of axioms, properties of fuzzy measure, Fuzzy Controller and Fuzzy Inference System: Fuzzification, Defuzzification (Center of area (COA), Center of maxima

(COM), Min of max method (MOM), Center of sums, Weighed average method) Fuzzy rules, Fuzzy controller, Fuzzy inference systems (Mamdani, Sugeno's and Tsukamoto), Fuzzy linear programming.

Books Recommended:

1. Klir . Georage. J and Yuan Bo, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi. 2009.

2. Lee, Kwang H., First Course on Fuzzy Theory and Applications, Springer International Edition, 2009.

3. Ross, Timothy J., Fuzzy Logic with Engineering Applications, McGraw Hills inc., 2004 New Delhi

4. Roger, Jyh-Shing; Sun, Chuen-Tsai; Mizutani, Eiji, Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, MATLAB curriculum series, illustrated, reprint, Prentice Hall, 1997

5. Zimmermann,H.J. Fuzzy Set Theory & its Applications, Allied Publishers Ltd. New Delhi,2006

6. Dubosis Didler and Prade, Henri, Fuzzy Sets and systems Theory and Applications, Academioc Press, NewYork, 1980

P.G. (SEMESTER IV/II)

Elective-III FIELD THEORY

I. Fields and their extensions, Splitting fields, Normal extensions, Algebraic closure of a field.

II. Separability, Perfect fields, Automorphisms of field extensions, Artin's theorem, Galois extensions, Fundamental theorem of Galois theory.

III. Roots of unity, Cyclotomic polynomials and extensions, Finite fields, Theorem of primitive element and Steinitz's theorem.

IV. Galois theory of equations, Theorem on natural irrationalities, Radical extensions and solvability by radicals.

Books Recommended:

[1] P.M. Cohn, Classic Algebra, John Wiley & Sons Ltd., 2000.

[2] P.M. Cohn, Basic Algebra: Groups, Rings and Fields, Springer, 2005.

[3] D.S. Dummit and R.M. Foote, Abstract Algebra, Third Edition, Wiley India Pvt. Ltd., 2011.

[4] N. Jacobson, Basic Algebra, Volumes I & II, Second Edition, Dover Publications, 2009.

[5] T.W. Hungerford, Algebra, Springer-Verlag, 1981.

P.G. (SEMESTER IV/II)

Elective-IV DYANAMICS OF LINEAR OPERATORS

I. Hypercyclic and supercyclic operators, How to prove that an operator is hypercyclic, Some spectral properties, What does the set of hypercyclic vectors look like?, Three examples.

II. The Hypercyclicity Criterion, Criteria for chaos and mixing, Weak mixing and the Hypercyclicity Criterion, Equivalent formulations of the Hypercyclicity Criterion, Hypercyclic sequences of operators.

III. Classes of hypercyclic and chaotic operators, Weighted shifts, Differential operators, Composition operators.

IV. Hypercyclicity everywhere, Mixing operators, Existence of hypercyclic operators, Operators with prescribed orbits, There are many hypercyclic operators, There are few hypercyclic operators, Linear dynamics is complicated, Sums of hypercyclic operators,

Books Recommended:

Devaney, Robert L. A first course in chaotic dynamical systems: theory and experiment. CRC Press, 2018.

Grosse-Erdmann, Karl-G., and Alfred Peris Manguillot. Linear chaos. Springer Science & Business Media, 2011.

Bayart, Frédéric, and Étienne Matheron. Dynamics of linear operators. No. 179. Cambridge university press, 2009.

M. Brin and G. Stuck, Introduction to Dynamical Systems, Cambridge

University Press, 2004.

P.G. (SEMESTER IV/II)

Elective-VI ALGEBRAIC NUMBER THEORY

I. Algebraic numbers, Conjugates and discriminants, Algebraic integers, Integral bases, Norms and traces, Rings of algebraic integers, Quadratic and cyclotomic fields.

II. Trivial factorization, Factorization into irreducibles, Examples of non-unique factorization into irreducibles, Prime factorization, Euclidean domains, Euclidean quadratic fields, Consequence of unique factorization the Ramanujan−Nagell theorem.

III. Prime factorization of ideals, Norm of an ideal, Non-unique factorization in cyclotomic fields, Lattices, Quotient torus, Minkowski's theorem, Two-Squares theorem, Four-Squares theorem.

IV. Space Lst, Class-group and class-number, Finiteness of the class-group, factorization of a rational prime, Minkowski's constants, Some class-number calculations.

Books Recommended:

[1] Ş. Alaca and K.S. Williams, Introductory Algebraic Number Theory, Cambridge University Press, Cambridge, 2003.

[2] K. Ireland and M. Rosen, A Classical Introduction to Modern Number Theory, Second Edition, Springer-Verlag, 1990.

[3] S. Lang, Algebraic Number Theory, Springer, 1994. [4] D.A. Marcus, Number Fields, Springer, 2018.

[5] I. Stewart and D. Tall, Algebraic Number Theory and Fermat's Last Theorem, Fourth Edition, CRC Press, Taylor & Francis, 2016.

RESOLUTION: After deliberation, the Bos committee has unanimously recommended and approved the syllabus of U.G. 7th & 8th Semester and P.G.(one year & two years) under NEP2020, attached (Annexure-II).