<u>P.G Syllabus</u>

<u>To be implemented from session 2025-26.</u>

Please note that the syllabus is divided into two parts: one for subjects with substantial practical components, and the other for subjects with little or no practical content. The departments may opt for any one of the two Curriculum frameworks.

## Contents

1. <u>Curriculum Framework and Credit Allocation for Subjects with Minimal or No Practical Component</u>

    *The following course structure under NEP 2020 is designed for subjects which have practical based courses or have relatively larger offerings of practical course-based learning.*

    1 (a) Course structure for 2-Year P.G. program
    1 (b) Course structure for 1-Year P.G. program

**Note:** *Out of the courses offered across the four semesters of 2-year P.G. programme, in each semester, at least two courses should be skill-based. If the department is unable to offer the minimum of two skill-based courses in a given semester, it may compensate by offering additional/extra skill-based courses in the other semester."*

*Note: Out of the courses offered across the two semesters of 1-year P.G. programme, in each semester, at least two courses should be skill-based. If the department is unable to offer the minimum of two skill-based courses in a given semester, it may compensate by offering additional/extra skill-based courses in the other semester."*

*Note: Research based courses such as Research methodology, Research writing and ethics, project work, dissertation, field visit, community engagement etc may be offered in the P.G. programme.*

# Course structure under each framework

1. <u>Curriculum Framework and Credit Allocation for Subjects withminimal or No Practical Component</u>
    *The following course structure under NEP 2020 is designed for subjects which have practical based courses or have relatively larger offerings of practical course-based learning.*

## 1 (a) Course structure for 2-Year P.G. program

<table>
<tr><td colspan="6"><strong>First Semester for 2-year P.G. program</strong></td></tr>
<tr><td rowspan="2"><strong>Semester</strong></td><td rowspan="2"><strong>Course category</strong></td><td rowspan="2"><strong>Course title</strong></td><td colspan="2"><strong>Credits</strong></td><td rowspan="2"><strong>Total Credit</strong></td></tr>
<tr><td><strong>T</strong></td><td><strong>P</strong></td></tr>
<tr><td rowspan="6"><strong>I</strong></td><td rowspan="4"><strong>Discipline Specific Core</strong></td><td><strong>DSC-1<br>Abstract Algebra-I</strong></td><td>5</td><td>-</td><td>5</td></tr>
<tr><td><strong>DSC -2<br>Complex Analysis</strong></td><td>5</td><td></td><td>5</td></tr>
<tr><td><strong>DSC -3<br>Operations Research-I</strong></td><td>5</td><td>-</td><td>5</td></tr>
<tr><td><strong>DSC-4<br>Number Theory</strong></td><td>5</td><td>-</td><td>5</td></tr>
<tr><td rowspan="2"><strong>Discipline Specific Elective<br>(Any 1 out of 4 electives)</strong></td><td><strong>DSE-1</strong><br>1.    <strong>Mathematical Methods</strong><br>2.    <strong>Mathematical Python (T-2+P-2)<br>    (04 credits)</strong><br>3.    <strong>Data Structures</strong><br>4.    <strong>Advanced Linear Algebra</strong></td><td>4</td><td>-</td><td>4</td></tr>
<tr><td><strong>Total</strong></td><td></td><td>24/22</td><td>0/2</td><td>24</td></tr>
</table>

**Note:** *In lieu of elective ( Practical= 4 credits) the department may offer any one course i.e. dissertation/project work of 4 credits*

<table>
<tr><td colspan="6"><strong>Second Semester for 2-year P.G. program</strong></td></tr>
<tr><td rowspan="5"><strong>II</strong></td><td rowspan="4"><strong>Discipline Specific Core</strong></td><td><strong>DSC-1<br>Abstract Algebra-II</strong></td><td>5</td><td>-</td><td>5</td></tr>
<tr><td><strong>DSC -2<br>Calculus of Several Variables</strong></td><td>5</td><td></td><td>5</td></tr>
<tr><td><strong>DSC -3<br>Operations Research-II</strong></td><td>5</td><td>-</td><td>5</td></tr>
<tr><td><strong>DSC-4<br>Advanced Differential Equations</strong></td><td>5</td><td>-</td><td>5</td></tr>
<tr><td><strong>Discipline Specific Elective<br>(Any 1 out of 4 electives)</strong></td><td><strong>DSE-1</strong><br>1.    <strong>Mathematical Methods</strong><br>2.    <strong>Mathematical Python (T-2+P-2)<br>    (04 credits)</strong><br>3.    <strong>Data Structures</strong><br>4.    <strong>Advanced Linear Algebra</strong></td><td>4</td><td>-</td><td>4</td></tr>
<tr><td><strong>Total</strong></td><td></td><td></td><td>24</td><td>-</td><td>24</td></tr>
<tr><td><strong>NHEQF Level-6</strong></td><td colspan="5"><em>Student on exit after successfully completing first year of two-year PG programme (i.e., securing minimum required 48 credits will be awarded "Postgraduate Diploma" of one year, in related field/discipline/subject.</em></td></tr>
</table>

## Third Semester for 2-year P.G. program

| Semester | Course category | Course title | Credits | | Total Credit |
|---|---|---|---|---|---|
| | | | T | P | |
| III | Discipline Specific Core | DSC-1<br>Real Analysis | 5 | - | 5 |
| | | DSC -2<br>Functional Analysis | 5 | | 5 |
| | | DSC -3<br>Theory of PDE | 5 | - | 5 |
| | | DSC-4<br>Differential Geometry | 5 | - | 5 |
| | Discipline Specific Elective<br>(Any 1 out of 4 electives) | DSE-2<br>1. Mathematical Statistics<br>2. Commutative Algebra<br>3. Dynamics of Linear Operators<br>4. Operator Theory | 4 | | 4 |
| Total | | | 24 | | 24 |

## Fourth Semester for 2-year P.G. program

| Semester | Course category | Course title | Credits | | Total Credit |
|---|---|---|---|---|---|
| | | | T | P | |
| IV | Discipline Specific Core | DSC-1<br>Measure Theory | 5 | - | 5 |
| | | DSC -2<br>Topology | 5 | | 5 |
| | | DSC -3<br>Fuzzy Set Theory | 5 | - | 5 |
| | | DSC-4<br>Integral Transforms | 5 | - | 5 |
| | Discipline Specific Elective<br>(Any 1 out of 4 electives) | DSE-2<br>1. Mathematical Statistics<br>2. Commutative Algebra<br>3. Dynamics of Linear Operators<br>4. Operator Theory<br>Or<br>5. The Project Work<br>(Based on Merit) | 4 | - | 4 |
| Total | | | 24 | - | 24 |
| NHEQF Level-6.5 | *Student on successfully completing two-year PG programme (i.e., securing minimum required 96 credits will be awarded "Postgraduate Degree", in related field/discipline/subject.* | | | | |

*Note: Out of the courses offered across the four semesters of 2-year P.G. programme, in each semester, at least two courses should be skill-based. If the department is unable to offer the minimum of two skill-based courses in a given semester, it may compensate by offering additional/extra skill-based courses in the other semester."*

# 1 (b) Course structure for 1-Year P.G. program

## Curriculum Framework and Credit Allocation for Subjects with Practical Component

| One-year P.G. program | | | | | |
|---|---|---|---|---|---|
| **First Semester for 1-year P.G. program** | | | | | |
| Semester | Course category | Course title | Credits | | Total Credit |
| | | | T | P | |
| I | Discipline Specific Core | DSC-1 Real Analysis | 5 | - | 5 |
| | | DSC -2 Functional Analysis | 5 | | 5 |
| | | DSC -3 Theory of PDE | 5 | - | 5 |
| | | DSC-4 Differential Geometry | 5 | - | 5 |
| | Discipline Specific Elective (Any 1 out of 4 electives) | DSE-2 1. Mathematical Statistics 2. Commutative Algebra 3. Dynamics of Linear Operators 4. Operator Theory | 4 | | 4 |
| Total | | | 24 | | 24 |

**Note:** *In lieu of elective ( Practical= 4 credits) the department may offer any one course i.e. dissertation/project work of 4 credits*

| Second Semester for 1-year P.G. program | | | | | |
|---|---|---|---|---|---|
| II | Discipline Specific Core | DSC-1 Measure Theory | 5 | - | 5 |
| | | DSC -2 Topology | 5 | | 5 |
| | | DSC -3 Fuzzy Set Theory | 5 | - | 5 |
| | | DSC-4 Integral Transforms | 5 | - | 5 |
| | Discipline Specific Elective (Any 1 out of 4 electives) | DSE-2 1. Mathematical Statistics 2. Commutative Algebra 3. Dynamics of Linear Operators 4. Operator Theory Or 5. The Project Work (Based on Merit) | 4 | - | 4 |
| Total | | | 24 | - | 24 |
| NHEQF Level- 6.5 | *Student on successfully completing two-year PG programme (i.e., securing minimum required 96 credits will be awarded "Postgraduate Degree", in related field/discipline/subject.* | | | | |

**Paper-DSC-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.
3.       Topics in Algebra: I. N. Herstein, John Wiley & Sons, New York.

**Paper-DSC-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.

**Paper –DSC-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.

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 of India, 2011.

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

**Paper- DSC-IV**                           **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 conjecture.
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.

**Discipline Specific Elective (Any one of out of 4 electives)**

**PG SEMESTER I/II**

**DSE-I   (Paper-I)**                        **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

**PG SEMESTER I/II**

**DSE-I (Paper-II)                      MATHEMATICAL PYTHON**

I.      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.

II.     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,

III.    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.

IV.     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.

Books Recommended:

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

**DSE-I (Paper-III)**                              **DATA STRUCTURES**

I.    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.

II.   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.

III.  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.

IV.   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)

## PG SEMESTER I/II

**DSE-I   (Paper-IV)              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

# Second Semester for 2-year P.G. program

**Paper-DSC-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.


**Paper –DSC-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.


**Paper-DSC-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.

## Paper-DSC-IV      ADVANCED DIFFERENTIAL EQUATIONS

I.      Well posed problems, Existence, uniqueness and continuity of solution of ODEs of first order, Picard's method, Existence and uniqueness of solution of simultaneous differential equations of first order and ODEs of higher order I.V.Ps, Global existence Theorem.

II.      Homogeneous and non-homogeneous linear systems, Linear systems with constant coefficients and their solution by matrix method, linear equations with periodic coefficients.

III.      Stability of autonomous−function, Sturm system of differential equations, Critical point of an autonomous system and their classification as stable, Asymptotically stable, Strictly stable and unstable, Stability of linear systems with constant coefficients, Linear plane autonomous systems, Perturbed systems, Method of Lyapunov for nonlinear systems.

IV.      Wave equation, Helmholtz's first and second theorems, Green's function for wave equation, Duhamel's principles for wave equation, Diffusion equation, Solution of initial boundary value problems for diffusion equation, Green's function for diffusion equation.

Books Recommended:
1. E.A. Coddington, An Introduction to Ordinary Differential Equations, Dover Publications, 2012.
2. T. Myint-U, Ordinary Differential Equations, Elsevier, North-Holland, 1978.
3. S.L. Ross, Differential Equations, Second Edition, John Wiley & Sons, India, 2007.
4. I.N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006.
5. Dharmaiah, V. , Introduction to Theory of Ordinary Differential Equations, PHI

## Third Semester for 2-year P.G. program

**Paper-DSC-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.    Functions of several variables, Concept of functions of two variables, Continuity,Partial derivatives, Differentiability, Change of variables, The inverse function theorem, The implicit function theorem, Chain rule.

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.


**Paper-DSC-II**                    **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.



**Paper-DSC-III        THEORY OF PARTIAL DIFFERENTIAL EQUATIONS**

I.    Finite difference methods for 2D and 3D elliptic boundary value problems (BVPs) of second approximations, Finite difference approximations to Poisson's equation in cylindrical and spherical polar coordinates, Solution of large system of algebraic equations corresponding Seidel and SOR), Alternating−to discrete problems and iterative methods (Jacobi, Gauss direction methods.

II.    Different 2- and 3-level explicit and implicit finite difference approximations to heat conduction equation with Dirichlet and Neumann boundary conditions, Stability analysis, compatibility, consistency and convergence of the difference methods, ADI methods for 2- & 3-D parabolic equations, Finite difference approximations to heat equation in polar coordinates.

III.    Methods of characteristics for evolution problem of hyperbolic type, explicit and implicit difference schemes for first order hyperbolic equations in 1D and 2D dimension and their stability and consistency analysis, System of equations for first order hyperbolic equations.

IV.     Finite element methods for second order elliptic BVPs, Finite element equations, Variational problems, Triangular and rectangular finite elements, Standard examples of finite elements, Finite element methods for parabolic initial and boundary value problems.

Books Recommended:

1. A.J. Davies, The Finite Element Method: An Introduction with Partial Differential Equations, Second Edition, Oxford University Press, 2011.
2. C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Methods, Dover Publications, 2009.
3. K.W. Morton and D.F. Mayers, Numerical Solution of Partial Differential Equations, Second Edition, Cambridge University Press, 2011.
4. J.C. Strikwerda, Finite Difference Schemes & Partial Differential Equations, Second Edition, SIAM, 2004.
5. J.W. Thomas, Numerical Partial Differential Equations: Finite Difference Methods, Springer, 2013.
6. J.W. Thomas, Numerical Partial Differential Equations: Conservation Laws and Elliptic Equations, Springer-Verlag, Berlin, 1999.

**Paper-DSC-IV               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.

**Discipline Specific Elective (Any one of out of 4 electives)**

**Paper-DSE-I**                  **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. 2$^{nd}$ Edition (1970)
**4.**    Mood, A.M. and Graybill, F.: Introduction to the Theory of Statistics, McGraw Hill Education; 3$^{rd}$ edition (2017).
**5.**    Hogg, R.V., Craig, A. and McKean, Joseph W.: Introduction to Mathematical Statistics, Pearson Education, .8$^{th}$ Edition New Delhi (2019)

## P.G. (SEMESTER- III/IV)

**Paper-DSE-II**                **COMMUTATIVE ALGEBRA**

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.

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

III.    Integral dependence, Going up theorem, Going down theorem, Integrally closed domains, Valuation rings, Hilbert's Nullstellensatz theorem.

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/IV)

**Paper-DSE-III**                    **DYANAMICS OF LINEAR OPERATORS**

I.     Dynamical systems, Topologically transitive maps, Chaos, Mixing maps, Weakly mixing maps, Universality
II.    Hypercyclic and chaoticoperators, 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.
III.   Criteria for chaos and mixing, Weak mixing and the Hypercyclicity Criterion, Equivalent formulations of the Hypercyclicity Criterion, Hypercyclic sequences of operators
IV.    Hypercyclicity everywhere,Mixing operators, Existence of hypercyclic operators, operators with prescribed orbits,There are many hypercyclic operators,There are few hypercyclic operators, Sums of hypercyclic operators,

Books Recommended:
1.  Devaney, Robert L. A first course in chaotic dynamical systems: theory and experiment. CRC Press, 2018.
2.  Grosse-Erdmann, Karl-G., and Alfred Peris Man Guillot. Linear chaos. Springer Science& Business Media, 2011.
3.  Bayart, Frédéric, and Étienne Matheron. Dynamics of linear operators.No.179.Cambridge university press, 2009.

## P.G. (SEMESTER III/IV)

**Paper-DSE-IV   OPERATOR THEORY/THE PROJECT WORK**

### (Based on Merit only in IV Sem.)

I.     Operators on Hilbert space, eigenvalues and eigenvector of a linear operator, spectrum of bounded operators, resolvent, spectral properties of bounded operators.
II.    Compact linear operators, Basic properties, adjoint of compact operators, Spectral properties of compact operators, Fredholm alternative.
III.   Spectral theory of self-adjoint operators, Spectral properties of self-adjoint operators, Positive operators and their properties, Spectral representation of a self-adjoint compact operator, Spectral family of a self-adjoint operator and its properties, Spectral representation of a self-adjoint operator, Continuous functions of self-adjoint operators.
IV.    Banach Algebra, Regular and Singular elements, Topological division of zero, spectral mapping theorem for polynomials and spectral radius formula, Ideals in

Banach algebra, Commutative Banach algebra with examples, Gelfand transform, Maximal-ideal space with examples.

Reference Books:

1. B. V. Limaye, Functional Analysis, 3rd ed., New Age International Ltd., 2014.
2. J. B. Conway, A Course in Operator Theory: A Graduate Studies in Mathematics, Springer, 1985.
3. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, India, 2006.
4. E. Kaniuth, A Course in Commutative Banach Algebras, Springer-Verlag, 2009.

# Fourth Semester for 2-year P.G. program

**Paper-DSC-I**                 **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, Jordan-decomposition 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.

**Paper-DSC--II**                 **TOPOLOGY**

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

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

III.      Countability axioms, First and second countable spaces, Lindelof's theorem, Separable spaces, Second countable and separability, Separable axioms: $T_0, T_1, T_2, T_3, T_3, T_4$ and their characterizations.

IV.      Compactness, Continuity and compact sets, Basic properties of compactness, Compactness and finite intersection property,Sequentially and countably 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.


**Paper-DSC-III**                    **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




**Paper-DSC-IV**                    **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.

## 1 (b) Course structure for 1-Year P.G. program

## First Semester for 1-year P.G. program

**Paper-DSC-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. Functions of several variables, Concept of functions of two variables, Continuity,Partial derivatives, Differentiability, Change of variables, The inverse function theorem, The implicit function theorem, Chain rule.

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.

**Paper-DSC-II**                          **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.

**Paper-DSC-III**      **THEORY OF PARTIAL DIFFERENTIAL EQATIONS**

I.       Finite difference methods for 2D and 3D elliptic boundary value problems (BVPs) of second approximations, Finite difference approximations to Poisson's equation in cylindrical and spherical polar coordinates, Solution of large system of algebraic equations corresponding Seidel and SOR), Alternating−to discrete problems and iterative methods (Jacobi, Gauss direction methods.

II.     Different 2- and 3-level explicit and implicit finite difference approximations to heat conduction equation with Dirichlet and Neumann boundary conditions, Stability analysis, compatibility, consistency and convergence of the difference methods, ADI methods for 2- & 3-D parabolic equations, Finite difference approximations to heat equation in polar coordinates.

III.    Methods of characteristics for evolution problem of hyperbolic type, explicit and implicit difference schemes for first order hyperbolic equations in 1D and 2D dimension and their stability and consistency analysis, System of equations for first order hyperbolic equations.

IV.   Finite element methods for second order elliptic BVPs, Finite element equations, Variational problems, Triangular and rectangular finite elements, Standard examples of finite elements, Finite element methods for parabolic initial and boundary value problems.

Books Recommended:

a.   A.J. Davies, The Finite Element Method: An Introduction with Partial Differential Equations, Second Edition, Oxford University Press, 2011.

b.   C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Methods, Dover Publications, 2009.

c.   K.W. Morton and D.F. Mayers, Numerical Solution of Partial Differential Equations, Second Edition, Cambridge University Press, 2011.

2. J.C. Strikwerda, Finite Difference Schemes & Partial Differential Equations, Second Edition, SIAM, 2004.
3. J.W. Thomas, Numerical Partial Differential Equations: Finite Difference Methods, Springer, 2013.
4. J.W. Thomas, Numerical Partial Differential Equations: Conservation Laws and Elliptic Equations, Springer-Verlag, Berlin, 1999.

**Paper-DSC-IV**              **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.

<span style="color:red">**Discipline Specific Elective (Any one of out of 4 electives)**</span>

<span style="color:red">**PG SEMESTER I/II**</span>

**DSE-II (Paper-I)**          **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. 2$^{nd}$ Edition (1970)
4. Mood, A.M. and Graybill, F.: Introduction to the Theory of Statistics, McGraw Hill Education; 3$^{rd}$ edition (2017).
5. Hogg, R.V., Craig, A. and McKean, Joseph W.: Introduction to Mathematical Statistics, Pearson Education, .8$^{th}$ Edition New Delhi (2019)

## P.G.(SEMESTER- I/II)

**DSE-II (Paper-II)**          **COMMUTATIVE ALGEBRA**

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.

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

III. Integral dependence, Going up theorem, Going down theorem, Integrally closed domains, Valuation rings, Hilbert's Null stellensatz theorem.

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.

**DSE-II (Paper-III)          DYANAMICS OF LINEAR OPERATORS**

I.      Dynamical systems, Topologically transitive maps, Chaos, Mixing maps, Weakly mixing maps, Universality

II.     Hypercyclic and chaoticoperators, 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.

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

IV.     Hypercyclicity everywhere,Mixing operators, Existence of hypercyclic operators, operators with prescribed orbits,There are many hypercyclic operators,There are few hypercyclic operators, Sums of hypercyclic operators,

 Books Recommended:
1.  1.Devaney,RobertL.Afirstcourseinchaoticdynamicalsystems:theoryandexperiment.CRC Press, 2018.
2.  Grosse-Erdmann,Karl-G.,and Alfred Peris Manguillot.Linear chaos.Springer Science& Business Media, 2011.
3.  Bayart,Frédéric,and      Étienne      Matheron.Dynamics      of      linear operators.No.179.Cambridge university press, 2009.

**DSE-I   (Paper-IV)          OPERATOR THEORY/THE PROJECT WORK**

**(Based on Merit only in II Sem.)**

I.      Operators on Hilbert space, eigenvalues and eigenvector of a linear operator, spectrum of bounded operators, resolvent, spectral properties of bounded operators.

II.     Compact linear operators, Basic properties, adjoint of compact operators, Spectral properties of compact operators, Fredholm alternative.

III.    Spectral theory of self-adjoint operators, Spectral properties of self-adjoint operators, Positive operators and their properties, Spectral representation of a self-adjoint compact operator, Spectral family of a self-adjoint operator and its properties, Spectral representation of a self-adjoint operator, Continuous functions of self-adjoint operators.

IV.     Banach Algebra, Regular and Singular elements, Topological division of zero, spectral mapping theorem for polynomials and spectral radius formula, Ideals in Banach algebra, Commutative Banach algebra with examples, Gelfand transform, Maximal-ideal space with examples.


Reference Books:

1.  B. V. Limaye, Functional Analysis, 3rd ed., New Age International Ltd., 2014.
2.  J. B. Conway, A Course in Operator Theory: A Graduate Studies in Mathematics, Springer, 1985.
3.  E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, India, 2006.
4.  E. Kaniuth, A Course in Commutative Banach Algebras, Springer-Verlag, 2009.

# Second Semester for 1-year P.G. program

**Paper-DSC-I**                                **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, Jordan-decomposition 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.

**Paper-DSC--II**                              **TOPOLOGY**

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

II.     Continuous function, Homeomorphism, Connected and disconnected sets, Components, Locally 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 , T3 , T4 and their characterizations.

IV.     Compactness, Continuity and compact sets, Basic properties of compactness, Compactness and finite intersection property,Sequentially and countably 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.

**Paper-DSC-III**                              **FUZZY SET THEORY**

I.      Introduction: Basics concepts on crisp sets, Fuzzy sets, $\alpha$-cuts, Additional properties of $\alpha$-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

**Paper-DSC-IV**                    **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.