Scheme and Syllabi

of

MSc Mathematics

(wef 2025-26)

as per

NEP-2020, NCrF, NHEQF

Central University of Haryana, Mahendergarh

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	✓	✓	✓
Approval Date :	02.06.2025	11.06.2025	30.6.2025

Scheme for 2-year PG Degree (MSc Mathematics)

<table>
<tr><td rowspan="2">I
(400)</td><td>I</td><td>Real Analysis</td><td>Abstract Algebra</td><td>Linear Algebra</td><td>ODEs</td><td>Prog. In C LTPC:2044</td><td>MDC-1</td><td>24</td><td rowspan="2">48</td><td rowspan="2">Exit:
PG-Dip
NHEQF:
6</td><td rowspan="7">**2-yr MSc**
NHEQF:
6.5</td></tr>
<tr><td>II</td><td>Numerical Analy. (300)

NA Lab(002)</td><td>PDEs</td><td>Complex Analysis</td><td>LaTeX (102)

Seminar(004)</td><td>Topology</td><td>MDC-2</td><td>24</td></tr>
<tr><td></td><td colspan="10">*Summer Internship# (4 credits) of 4-6 weeks*</td></tr>
<tr><td rowspan="4">II
(500)</td><td>III</td><td>Functional Analysis</td><td>DSE-1</td><td>DSE-2</td><td>DSE-3</td><td>DSE-4</td><td rowspan="2">MDC*</td><td>20</td><td rowspan="4">40
+4*</td><td rowspan="4">1-yr
MSc
NHEQF:
6.5</td></tr>
<tr><td rowspan="2">IV</td><td>DSE-5</td><td>DSE-6</td><td>DSE-7</td><td>DSE-8</td><td>DSE-9</td><td>20</td></tr>
<tr><td colspan="7">Dissertation(20)</td></tr>
<tr><td colspan="8">*Year-long Dissertation (40)*</td></tr>
</table>

Note: * One MDC course required for students directly entering 2nd year of MSc after 4-year UG.

Summer Internship, though optional, must be approved by the Dept well before its start.

1. All courses have same LTPC:3104 structure, unless otherwise specified.
2. DSE course offering would depend upon the resources.
3. Alternatively, department may approve suitable courses from SWAYAM.
4. **Criterion for Semester-long Dissertation**: at least 7 CGPA, with no back-log.
5. **Criterion for Year-long Dissertation**: at least 7.5 CGPA, with no back-log.

<table>
<tr><td rowspan="5">**DSE-1:4**</td><td>Wavelet Analysis</td><td>Measure and Integration</td></tr>
<tr><td>Operations Research</td><td>Fuzzy Set Theory</td></tr>
<tr><td>Applied Discrete Mathematics</td><td>Mathematical Statistics</td></tr>
<tr><td>Fluid Dynamics</td><td>Python Programming</td></tr>
<tr><td>Advanced Algebra</td><td>Integral Equations and Calculus of Variation</td></tr>
<tr><td rowspan="7">**DSE-5:9**</td><td>Differential Geometry</td><td>Number Theory</td></tr>
<tr><td>Mathematical Modelling</td><td>Mechanics</td></tr>
<tr><td>Advanced Numerical Analysis</td><td>Information Theory</td></tr>
<tr><td>Finite Element Methods</td><td>Mathematics for Finance and Insurance</td></tr>
<tr><td>Advanced Complex Analysis</td><td>Theory of Elasticity</td></tr>
<tr><td>Introduction to Cryptography</td><td>MATLAB and Maple Programming</td></tr>
<tr><td>Module Theory</td><td></td></tr>
</table>

Index

Title: **Real Analysis**
Code: **MAT 401 DM 40**
LTPC: **3104**

Objectives: The course will develop a deep and rigorous understanding of real line $\mathbb{R}$ and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. The course will also develop the understanding of metric spaces and convergence, compactness, sequential compactness and connectedness in metric spaces. These concepts have wide range of applications in real life scenario.

Outcomes: After completing this course, students will be able to:

- Understand the properties of the real number line and define sequences in terms of functions from N to subsets of R.
- Recognize and analyze bounded, convergent, divergent, Cauchy, and monotonic sequences. Calculate limit superior, limit inferior of sequences, and the limit of bounded sequences.
- Recognize functions of bounded variation, total variation, directional derivatives, partial derivatives, and understand derivatives as linear transformations.
- Understand properties of metric spaces, convergence, compactness, sequential compactness, and connectedness in metric spaces.

Contents:

Unit-I

Real number system as a complete ordered field, Archimedean property, Supremum, Infimum, Bolzano-Weierstrass property, Sequences and Series, Convergence, limsup, liminf, Continuity, Uniform continuity.

Unit II

Space of continuous functions, Sequence and Series of functions, Uniform and Pointwise convergence, Riemann sums and Riemann integral, Monotonic functions, Types of discontinuity.

Unit III

Function of bounded variation, Total variations, Expressing functions of bounded variation as differences of increasing functions, Functions of several variables, Directional derivatives, Partial derivatives, Derivatives as linear transformations, Inverse and Implicit function theorems.

Unit IV

Metric spaces and examples, Open sets, Closed sets, Sequences in metric spaces and Convergence, Compactness, Sequential compactness, Heine-Borel theorem, Connected and path-connected spaces, Components, Continuity and Connectedness.

References:

1. Walter, R. *Principles of Mathematical Analysis*. 3rd edition, McGraw-Hill, 2017.
2. Kumaresan, S. *Topology of Metric Spaces*. Narosa Publishing House, 2011.
3. Terence T. *Analysis II*. Hindustan Book Agency, 2009.
4. Malik, S. C. and Arora, S. *Mathematical Analysis*. 2nd edition reprint. New Age International Publishers 2005.
5. Apostol, T. M. *Mathematical Analysis*. 2nd edition. *Wesley Publishing Co.* 2002.
6. Somasundram, D. and Chaudhary, B. *A First Course in Mathematical Analysis*. Narosa Publishing House, 1996.
7. Royden, H. L. *Real Analysis,* Macmillan Pub. Co., Inc. 4th edition, New York, 1993.

Title: **Abstract Algebra**
Code: **MAT 403 DM 40**
LTPC: **3104**

Objectives: This course introduces the basic concepts of modern algebra such as groups and rings. The philosophy of this course is that modern algebraic notions play a fundamental role in mathematics itself and in applications to areas such as physics, computer science, economics and engineering.

Outcomes: After completing this course, students are expected to learn the following:

- Explain the fundamental concepts of advanced algebra such as groups and rings and their role in modern mathematics and applied contexts.
- Demonstrate accurate and efficient use of advanced algebraic techniques.
- Demonstrate capacity for mathematical reasoning through analyzing, proving, and explaining concepts from advanced algebra.
- Apply problem-solving using advanced algebraic techniques applied to diverse situations in physics, engineering, and other mathematical contexts.

Contents:

Unit I
Groups, Subgroup, Normal subgroup, Quotient group, Homomorphism and isomorphism, Cyclic group, Permutation group, Cayley's theorem, Lagrange theorem.

Unit II
Class equation, Cauchy's theorem, Sylow p-subgroups and their applications, Sylow theorems, Direct product of groups, Structure of finitely generated abelian groups, Description of group of order pq and p^2, where p and q are distinct primes (general survey of groups up to order 15).

Unit III
Rings, Examples (including polynomial rings, formal power series rings, matrix rings, and group rings), Integral domains, Division rings, Fields, Ideals, Prime and maximal ideals, Homomorphism and isomorphism of rings.

Unit IV
Factorization in domains, Euclidean domains, Principal ideal domains and Unique factorization domains, Polynomial rings over UFD, Polynomial rings over fields, Irreducibility criteria.

References:

1. Gallian, J. A. *Contemporary Abstract Algebra. 9th* edition. Cengage Learning, *2015.*
2. Lang, S. Algebra. 3rd edition, Springer 2012.
3. Herstein, I. N. *Topics in Algebra*. 2nd edition. John Wiley and Sons, 2006.
4. Bhattacharya, P. B. Jain, S. K. and Nagpaul, S. R. *Basic Abstract Algebra*. 2nd edition, Cambridge University Press, 2003.
5. Khanna, V. K. and Bhammbri, S. K. *A Course in Abstract Algebra*. Vikas Publishing house, 1999.
6. Cohn, P. M. Algebra. Vols. I & II, John Wiley & Sons, 1991.
7. Luther, S. and Passi, I. B. S. *Algebra*. Vol. I-Groups, Vol. II-Rings, Narosa Publishing House (Vol. I – 1996, Vol. II –1990).

Title: **Linear Algebra**
Code: **MAT 405 DM 40**
LTPC: **3104**

Objectives: To give a brief introduction of vector spaces, linear transformation, matrix representation and various linear operators, which can be used by student for further applications in their respective fields of interest.

Outcomes: After completing this course, students are expected to learn the following:

- Describe the concepts of the terms basis, dimension, and apply these concepts to various vector spaces and subspaces.
- Use the concept of linear transformations, matrix representation and change of basis, including kernel and range.
- Understand the notion of bilinear forms, triangularization and primary decomposition theorem.
- Compute inner products and determine orthogonality on vector spaces, applying Gram-Schmidt orthogonalization process to find the orthonormal basis.

Contents:

Unit I

System of linear equations, vector spaces: definition and examples, subspaces, linear dependence, basis and dimension, sum and direct sum, quotient spaces, linear transformations: kernel and image, rank and nullity, matrix mappings.

Unit II

Linear mappings and matrices: matrix representation of linear transformation, change of basis, similarity, polynomial of matrices, characteristic polynomial, Cayley-Hamilton theorem, diagonalization, minimal polynomial, companion matrix.

Unit III

Canonical and bilinear forms: triangular form, invariance, primary decomposition, Jordan canonical form, rational canonical form, bilinear and quadratic forms, reduction and classification of quadratic forms.

Unit IV

Inner product spaces, examples and properties, norms and distances, orthonormal basis, Gram-Schmidt orthogonalization, orthogonal complements, adjoint of a linear operator, normal and self-adjoint operators, unitary operators.

References:

1. Hoffman, K. and Kunze, R. *Linear Algebra*. 2nd edition, Pearson India, 2015.
2. Axler, S. *Linear Algebra Done Right*. 2nd edition, Springer-Verlag, 2014.
3. Lang, S. *Linear Algebra*. 3rd edition, Springer-Verlag, New York, 2013.
4. Lipschutz, S. and Lipson, M. *Linear Algebra*. 3rd edition, Tata McGraw-Hill, 2005.
5. Friedberg, S. H., Insel, A. J. and Spence, L. E. *Linear Algebra*. 4th edition, 2002.

Title: **Ordinary Differential Equations**
Code: **MAT 407 DM 40**
LTPC: **3104**

Objectives: The objective of this course is to introduce ordinary differential equations, fundamental theorems for existence and uniqueness. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations.

Outcomes: After completing this course, students are expected to learn the following:

- Understand ordinary differential equations of various types, their solutions, and fundamental concepts about their existence.
- Apply various power series methods to obtain series solutions of differential equations.
- Understand the Stability of linear systems, almost linear systems, stability of periodic solutions.
- Interpret the concepts of Autonomous systems, Transition matrix, Phase-Space of two-dimensional systems

Contents:

Unit I

Orthogonality of functions, orthonormal set of functions, Regular and singular points, power series solution at regular and irregular singular points, Bessel's and Legendre's functions/equations and their properties, Recurrence relations, Green's function method.

Unit II

System of Differential Equations: Existence and uniqueness of solution for systems and higher order equations, dependence of the solution on initial conditions, and the function $f(x,y)$, Wronskian, Abel's formula.
Linear systems: Autonomous systems, Transition matrix, Phase-Space of two-dimensional systems, time-varying systems, Fundamental matrix and its properties, linear system with periodic coefficients. Matrix Method for homogeneous linear systems with constant coefficients.

Unit III

Theory of Homogeneous and Non-homogeneous linear systems, theory of nth-order homogeneous and non-homogeneous linear differential equations, Reduction of order, self-adjoint differential equation of second order, Sturm theory, Sturm separation theorem, Sturm's Comparison Theorem, Sturm-Liouville Problems.

Unit IV

Stability of differential systems: Stability of linear systems, almost linear systems, stability of periodic solutions, Lyapunov Stability theorems for nonlinear systems, limit cycles Poincaré-Bendixson Theorem, Lienard Systems, Constructions of Lyapunov function, Bifurcations (Transcritical, Saddle-node, Pitchfork, Hopf, Sotomayor Theorem).

References:

1. Simmons, G. F. *Differential Equations with Applications and Historical Notes*. 2nd edition, Tata McGraw Hill, New Delhi, 2016.
2. Lebedev, N. N. *Special Functions and Their Applications*. Revised, Courier Corporation, 2012.
3. Ross, S. L. *Differential Equations*. 3rd edition, Wiley India, 2007.
4. Bell, W. W. *Special Functions for Scientists and Engineers*. Courier Corporation, 2004.
5. Raisinghania, M. D. *Advanced Differential Equations*. S. Chand & Company Ltd., New Delhi, 2001.
6. Reid, W. T. *Ordinary Differential Equations*. John Wiley and Sons, New York, 1971.

Title: **Programming in C**
Code: **MAT 409 SE 40**
LTPC: **2044**

Objectives: The course objective is to familiarize the students with problem solving through C-programming. The course aims to give exposure to basic concepts of the C-programming. The lab component of this course is designed to provide hands-on-training with the concepts.

Outcomes: After completing this course, students are expected to learn the following:

- Classify and overview programming languages and develop basic C programs; define data types and use them in simple data processing.
- Use various C operators, expressions, and input/output statements.
- Understand control flow using conditional branching and loop structures and apply arrays in problem-solving.
- Interpret the concepts of pointers and classify functions and their usage.

Contents:

Unit I

Overview of programming and languages; program development in C; anatomy of a C function; variables, constants, expressions; assignment statements; formatting source files; continuation character; the pre-processor; scalar data types – declarations, integer types and constants, floating point types, initialization, type mixing, type casting.

Unit II

Operators and expressions – precedence and associativity; unary, binary arithmetic, arithmetic assignment, increment/decrement, comma, relational, logical, bit manipulation, bitwise assignment, cast, sizeof, conditional and memory operators; input/output functions.

Unit III

Control flow – conditional branching, switch, loops, nested loops, break/continue, goto, infinite loops; arrays – declaration, memory, initialization, encryption/decryption, multidimensional arrays; strings.

Unit IV

Functions – argument passing, declarations, calls, recursion, the main() function, passing arrays as arguments; pointers – pointer arithmetic, accessing arrays via pointers, passing pointers to functions, arrays of pointers.

References:

1. Balagurusamy, E. *Programming in ANSI C*. 3rd edition. TATA McGraw Hill, 2016.
2. Brain W. K. and Ritchie D. M. *C Programme Language.* 2nd edition, Pearson, 2015.
3. Darnell, P. A. and Margolis, P. E. *C: A Software Engineering Approach*. Narosa Publishing, House (Springer International Student Edition), 2012.
4. Yashavant, P. K. *Let Us C.* BPB Publication, 2008.
5. Byrons, G. *Programming With C.* 2nd edition, Schaum's Series, 1996.

Title: **Numerical Analysis**
Code: **MAT 402 DM 30**
LTPC: **3003**

Objectives: The rapid growth of science and technology during last few decades has made a tremendous change in the nature of various mathematical problems. It is very difficult and almost impossible to get analytical solutions in case of many of these problems. The course objective is to acquaint the students with a wide range of numerical methods to solve algebraic and transcendental equations, linear system of equations, interpolation and curve fitting problems, numerical integration, initial and boundary value problems, etc.

Outcomes: After completing this course, students are expected to:

- Overview the types of computational errors and understand how they are measured.
- Apply numerical methods to obtain approximate solutions to complex mathematical problems.
- Solve nonlinear equations, systems of linear equations, interpolation, numerical differentiation and integration problems, and initial/boundary value problems using numerical techniques.
- Understand the convergence, advantages, and limitations of various numerical techniques.

Contents:

Unit I

Errors in approximation – absolute, relative, and percentage errors; round-off error. Solution of algebraic and transcendental equations – bisection method, Regula Falsi method, Secant method, method of iteration, Newton-Raphson method, order of convergence. Systems of simultaneous equations – Gauss elimination method, Gauss-Jordan method, LU decomposition method; Iterative methods – Jacobi method and Gauss-Seidel method.

Unit II

Finite differences, Interpolation techniques for equal intervals – Newton forward and backward, Gauss forward and backward, Stirling, Bessel formulae, Interpolation for unequal intervals – Newton's divided difference method, Lagrange method, Hermite interpolation, Power method for eigenvalue problems.

Unit III

Numerical differentiation using Newton forward and backward formulae, Numerical integration – Newton-Cotes formulas, trapezoidal rule, Simpson's rule, Gauss-Legendre and Gauss-Chebyshev formulas, Romberg's integration, Curve fitting – straight line, parabolic, exponential, and other curves; cubic splines.

Unit IV

Solutions of ordinary differential equations – Taylor series method, Picard's method, Euler's method, Modified Euler method, Runge–Kutta methods, Milne's and Adams predictor-corrector methods.
Finite difference methods for boundary value problems.

References:

1. Gupta, R. K. *Numerical Methods: Fundamentals and Applications.* 1st edition, Cambridge University Press, 2019.
2. Thangaraj, P. *Computer Oriented Numerical Methods*. PHI Learning Pvt. Ltd, 2013.
3. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. *Numerical Methods for Scientific & Engineering Computation*. New Age International, 2012.
4. Burden R. L. and Faires J. D. *Numerical Analysis*. 9th edition, Cengage Learning, 2011.
5. Chapra, S. C. and Canale, R. P. *Numerical Methods for Engineers*. McGraw Hill, International Edition, 1998.
6. Mathews, J. H. *Numerical Methods for Mathematics, Science and Engineering*. Prentice- Hall, International Editions, 1992.

Title: **Numerical Analysis Lab**
Code: **MAT 402 DMP 10**
LTPC: **0021**

Course Objective: The lab component of this course is aimed to design the programs using C/C++/MATLAB/Python for various numerical methods studied in the theory course.

Course Outcomes:

After completing this course, student is expected to learn the following:

- Write efficient and well documented codes for various numerical methods and present outputs in an informative way.
- Able to solve problems covered in the theory paper (Numerical Analysis) with more accuracy using computer code.

The students are required to design the programs using C//MATLAB/Python for the following numerical problems based on methods studied in the theory course. This list is merely indicative, and can be expanded to include other numerical problems.

1. To detect the interval(s) which contain(s) root of equation f(x)=0 and implement bisection method to find root of f(x)=0 in the detected interval.
2. To find the root of f(x)=0 using Regula Falsi and Secant methods
3. To find the root of f(x)=0 using Newton -Raphson and fixed point iteration methods.
4. To solve linear system of equations using Gauss elimination (without pivoting) method.
5. To solve linear system of equations using Gauss Jordan method.
6. To solve linear system of equations using Jacobi and Gauss-Seidel methods
7. To compute the intermediate value using the Newton's forward difference interpolation formula.
8. To implement Lagrange interpolation formula
9. To compute Newton divided difference (NDD) table and use it compute interpolating value with NDD formula.
10. To integrate a function numerically using trapezoidal and Simpson's rules.
11. To compute integration numerically from a data set using trapezoidal and Simpson's rules
12. To fit a straight line to a given data set
13. To solve the initial value problem using Euler and modified Euler's methods.
14. To apply Milne's and Adam's predictor and corrector methods for solution of initial value problems
15. To solve the initial value problem using Runge-Kutta methods.
16. To apply finite difference method for boundary value problems

Title: **Partial Differential Equations**
Code: **MAT 404 DM 40**

LTPC: **3104**

Objectives: This course provides a foundation in partial differential equations (PDEs), focusing on both first and second order equations and their applications in wave propagation, heat conduction, and boundary value problems.

Outcomes: After completing this course, students will be able to:

- Understand the mathematical foundation of first order partial differential equations.
- Classify and solve second order partial differential equations, focusing on wave propagation and vibrational analysis.
- Solve boundary value problems using Laplace's equation in different contexts, such as engineering and physics.
- Analyze heat conduction problems and apply these concepts to real-world thermal systems.

Contents:

Unit I
Curves and surfaces, Genesis of first-order PDE, classification of integrals, Compatible systems, Charpit's method, integral surfaces through a given curve, Quasi-linear equations, Method of separation of variables.

Unit II
Genesis of second-order PDE, Classification of second-order PDE, One-dimensional wave equation: vibrations of an infinite string, Vibrations of a semi-infinite string, Vibrations of a string of finite length.

Unit III
Boundary value problems, maximum and minimum principles, The Cauchy problem, Dirichlet problem for upper half-plane, Neumann problem for upper half-plane, Dirichlet problem for a circle, Dirichlet exterior problem for a circle, Neumann problem for a circle, Dirichlet problem for a rectangle.

Unit IV
Heat conduction – Infinite rod case, Heat conduction – finite rod case, Duhamel's principle, Heat Conduction Equation, Classification in the case of n-variables, Families of equipotential surfaces, Kelvin's inversion theorem.

References:

1. E.T. Copson, *Partial Differential Equations* (Cambridge University Press, 1975)
2. I.N. Sneddon, *Elements of Partial Differential Equations* (McGraw Hill Book Company, 1957)
3. Peter V O'Neil, *Advanced Engineering Mathematics* (7th edition)
4. T. Amarnath, *An Elementary Course in Partial Differential Equations* (Narosa Publishing House, 2nd edition, 2003)
5. W.E. Williams, *Partial Differential Equations* (Charendon Press, Oxford, 1980)

Title: **Complex Analysis**
Code: **MAT 410 DM 40**
LTPC: **3104**

Objectives: In this course students will learn about the algebra and geometry of complex numbers, analyticity, contour integration and conformal mapping.

Outcomes: After completing this course, students will be able to:

- Analyze differentiability and analyticity of complex functions, and understand Cauchy-Riemann equations and harmonic functions.
- Apply contour integration methods and the Cauchy Integral Theorem in solving complex integrals.
- Develop power series expansions, identify singularities, and compute residues.
- Understand and utilize bilinear (Mobius) transformations and conformal mappings.

Contents:

Unit I
Complex number system, stereographic projection, limit, Continuity and differentiability of complex functions, Cauchy-Riemann equations, harmonic functions, analytic functions, analytic mappings, exponential, trigonometric, hyperbolic and logarithmic functions, branch points and branch cuts.

Unit II
Power series representation of analytic functions, zeros of analytic functions, index of a closed curve, Cauchy's theorem and integral formula, homotopy version of Cauchy's theorem, simple connectivity, counting zeros, Rouche's theorem, Liouville's theorem, open mapping theorem, Goursat's theorem, Morera's theorem.

Unit III
Taylor's and Laurent's series, classification of singularities, calculation of residues, argument principle and applications, evaluation of contour integrals.

Unit IV
Maximum modulus theorem, Schwarz's lemma and applications, Mobius transformations, conformal mappings.

References:

1. Saff, E. B. and Snider, A. D. *Fundamentals of Complex Analysis with Applications to Engineering and Sciences*. Pearson Education, 2014.
2. Conway, J. B. *Functions of One Complex Variable*, Springer, 2012.
3. Mathews, J. H. and Howell, R. W. *Complex Analysis for Mathematics and Engineering.* Jones & Bartlett Publishers, 2012.
4. Brown, J. B. and Churchill, R. V. *Complex Variables and Applications*. 8th edition, Tata McGraw-Hill Education, 2009.
5. Ponnusamy, S. *Foundations of Complex Analysis.* Alpha Science International, 2005.
6. Copson, E. T. *Theory of Functions of Complex Variables*. Oxford University Press, 1970.

Title: **Typesetting in LaTeX**
Code: **MAT 420 SE 20**
LTPC: 1022

Objectives: The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting, beamer presentation and drawing graphs.

Outcomes: After completing this course, students will be able to:

- Typeset mathematical formulas, use nested lists, tabular & array environments.
- Create or import graphics into documents.
- Use alignment commands, multiline formulas, bibliographies, citations, and create indices and glossaries.
- Use Beamer to create presentations and typeset mathematical projects, dissertations, theses, and books.

Contents:

Unit I
Preparing an input file, writing sentences and paragraphs, selecting document class, sectioning, display material, running LaTeX, changing type styles, producing mathematical symbols and formulae, arrays, delimiters, multiline formulae, superscripts/subscripts, and spacing in math mode.

Unit II
Defining commands and environments, producing and including graphics, figures and floating bodies, multi-column layouts, generating table of contents, cross-referencing, bibliographies and citations, creating index and glossary, slides, overlays, notes, and letters.

Unit III
Custom document design: document class, page style, title page, style customization, line/page breaking, numbering, lengths, spacing, boxes, list-making environments, font size changes, special symbols, picture environments, objects, boxes, straight lines, arrows, stacks, circles, ovals, framing, curves, grids, and pattern repetition.

Unit IV
Creating Beamer class presentations, Beamer styles and dynamic slides. Postscript macros for generic TeX (pstricks): arguments, dimensions, coordinates, angles, line styles, fill styles, custom styles/graphics, picture tools, text manipulation, nodes and connections, basics of MathJax, and MathJax configuration options.

Seminar: Every student is required to select a relevant research paper of good quality, gain good understanding by reproducing the work reported as much as possible. Student is also required to present mid-term progress and end-term progress through slides prepared in Latex.

References:

1. Kottwitz, S. *LaTeX Beginner's Guide*. Packt Publishing Ltd., UK, 2011.
2. Leslie L. *A Document Preparation System User's Guide and Reference Manual*, Addison-Wesley Publishing Company, 2001.
3. Tantau,T. *User Guide to the Beamer Class*, http://latex-beamer.sourceforge.net.
4. Oetiker,T. *The Not So Short Introduction to LATEX2E*, https://tobi.oetiker.ch/lshort/lshort.pdf.

Title: **Seminar**
Code: **MAT 430 SE 20**
LTPC: 0042

Objectives: The purpose of this course is to acquaint students with the basics of research articles, which shall prepare them to document research work and learn the art of presenting it. Seminar will be based on some research paper(s) in the relevant field and of student's choice. The assessment shall be based on continuous internal assessment and end-term presentations.

Title**: Topology**
Code: **MAT 430 DM 40**
LTPC: **3104**

Objectives: This course aims to teach the fundamentals of point set topology and constitute an awareness of need for the topology in Mathematics. It is a central of modern analysis, and many further interesting generalizations of metric space have been developed.

Outcomes: After completing this course, students will be able to:

- Construct topological spaces from metric spaces and describe neighbourhoods, open sets, closed sets, basis and sub-basis.
- Apply topological concepts such as open and closed sets, interior and limit points, and derived sets to prove various theorems.
- Understand countability and separability in topological spaces.
- Explore compactness and connectedness in topological spaces and apply related theorems.

Contents:

Unit I

Definition and examples of topological spaces, basis and sub-basis, open and closed sets, interior points, limit points, boundary and exterior points of a set, closure, derived set.

Unit II

Subspace topology, continuous functions, metric topology, convergence of sequences, sequential continuity, open and closed mappings, homeomorphism, pasting lemma, product topology, Tychonoff theorem.

Unit III

Connectedness, continuity and connectedness, connected subsets of the real line, components, path connectedness, local connectedness and local path connectedness, Compactness: characterizations, compact subsets of the real line, compactness and continuity, finite intersection property.

Unit IV

Countability and separation axioms – T_0, T_1, T_2 spaces; Lindelöf spaces; regular and normal spaces. Urysohn Lemma, Tietze extension theorem, compactification.

References:

1. Joshi, K. D. *Introduction to General Topology*. 2nd edition, New Age International Private Limited, 2017.
2. Munkres, J. R. *Topology*. Pearson Education, 2017.
3. Simmons, G. F. *Introduction to Topology and Modern Analysis*. Tata McGraw-Hill Education, 2016.
4. Pervin, W. J. *Foundations of General Topology*. Academic Press, 2014.
5. Singh, T. B. *Elements of Topology*. CRC Press, Taylor Francis, 2013.
6. Kelley, J. L. *General Topology*. 2nd edition, Springer, New York, 1991.

Title: **Functional Analysis**
Code: **MAT 500 DM 40**
LTPC: **3104**

Objectives: To familiarize with the basic tools of Functional Analysis involving normed spaces, Banach spaces and Hilbert spaces, their properties dependent on the dimension and the bounded linear operators from one space to another**.**

Outcomes: After completing this course, students will be able to:

- Understand and verify properties of normed and complete metric spaces, analyze compactness, boundedness, and convergence of linear operators, and compute dual spaces.
- Distinguish between Banach and Hilbert spaces, and apply orthogonality and decomposition in Hilbert spaces.
- Represent bounded functionals using inner products, classify operators (self-adjoint, unitary, normal), and analyze convergence behavior.
- Apply major theorems like Hahn-Banach, uniform boundedness, open mapping, and closed graph theorem; extend functionals and analyze projections and reflexivity.

Contents:

Unit I

Overview of Metric spaces, sequences and Cauchy sequences, completeness and examples of complete metric spaces, Baire's theorem, Cantor intersection theorem, Banach fixed point principle, normed linear spaces, Banach spaces and subspaces.

Unit II

Continuity of linear maps, equivalent norms, normed spaces of bounded linear maps, dual spaces, reflexivity, Hilbert spaces and examples, orthogonality and orthonormal sets, Bessel's inequality, Parseval's theorem, conjugate space of a Hilbert space.

Unit III

Representation of bounded linear functionals, adjoint operators, self-adjoint, normal, and unitary operators, weak and strong convergence, completely continuous operators.

Unit IV

Hahn-Banach theorem and its applications, uniform boundedness principle, open mapping theorem, projections in Banach spaces, and closed graph theorem.

References:

1. Simmons, G. F. *Introduction to Topology and Modern Analysis*. McGraw-Hill Pvt. Ltd. 2016.
2. Bachman, G. and Narici, L. *Functional Analysis*. Courier Corporation, 2012.
3. Conway, J. B. *A Course in Functional Analysis*. Springer, 2010.
4. Kreyszig, E. *Introductory Functional Analysis with Applications*. John Wiley, 2007.
1. Royden, H. L. *Real Analysis*. MacMillan Publishing Co., Inc., New York, 4th edition, 1993.

Title: **Wavelet Analysis**
Code: **MAT 501 DS 40**
LTPC: **3104**

Objectives: The course aim is to introduce a flexible system which provide stable reconstruction and analysis of functions (signals) and the construction of variety of orthonormal bases by applying operators on a single wavelet function.

Outcomes: After completing this course, student is expected to learn the following:
- Understand the approximation of functions (signals) by frame theory.
- Use the applications of frames in stable analysis and decompositions of functions.
- Learn the applications of wavelets in the construction of orthonormal bases by wavelets.
- Analyse different types of transforms in terms of operators.

Content:

Unit I
Review of inner product spaces, orthonormal systems, frames in C^n, frames algorithms, frames and Bessel sequences in infinite dimensional Hilbert spaces, frame sequence, the Gram matrix associated with Bessel sequences.

Unit II
Frames and operators, characterization of frames, dual frames, tight frames. Riesz bases, frames versus Riesz bases, conditions for a frame being a Riesz basis, frames containing a Riesz basis, perturbation of frames.

Unit III
Wavelets, Haar wavelets, basic properties of the Haar scaling function, Haar decomposition and reconstruction algorithms, the Daubechies wavelets, wavelet bases, scaling function. Multi-resolution analysis (MRA), construction of wavelets from MRA.

Unit IV
Windowed Fourier transform (WFT), continuous Fourier transform (CFT), continuous wavelet transform (CWT), comparison between CFT and CWT, continuous wavelet transform as an operator, inversion formula for continuous wavelet transform.

References:

1. Boggess, A. and Narcowich, F.J. *A First Course in Wavelets and Fourier Analysis,* John Wiley & Sons, 2010.
2. Mallat, S. A. *Wavelet Tour of Signal Processing*. Academic Press, 2009.
3. Han, D., Kornelson, K., Larson, D. and Weber, E. *Frames for Undergraduates*, Student Math. Lib., (AMS) Vol. 40, 2007.
4. Christensen, O. *An Introduction to Frames and Riesz Bases,* Birkhauser, 2003.
5. Harnendez, E. and Weiss, G. A. *First Course on Wavelets*, CRC Press, 1996.

Title: **Operations Research**
Code: **MAT 503 DS 40**
LTPC: **3104**

Objectives: This course is designed to introduce basic optimization techniques in order to get best results from a set of several possible solutions of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc.

Outcomes: After completing this course, student is expected to learn the following:

- Understand linear programming problems and to find their solutions by using different method.
- Find optimal solution of transportation problems and assignment problems
- Understand and solve different queuing models.
- Find optimal solution of linear programming model using Game Theory. Also learn about sequencing problems.

Content:

Unit I

Operations research: origin, definition and scope. linear programming: formulation and solution of linear programming problems by graphical, simplex methods, Big-M and two phase methods, degeneracy, duality in linear programming, sensitivity analysis.

Unit II

Transportation problems: basic feasible solutions, optimum solution by stepping stone and modified distribution methods, unbalanced and degenerate problems, transhipment problem. Assignment problems: solution by Hungarian method, unbalanced problem, case of maximization, travelling salesman and crew assignment problems.

Unit III

Queuing models: basic components of a queuing system, general birth-death equations, steady-state solution of Markovian queuing models with single and multiple servers (M/M/1. M/M/C, M/M/1/k, M/M/C/k)

Unit IV

Game theory: two persons zero sum game, game with saddle points, rule of dominance; algebraic, graphical and linear programming, concept of mixed strategy. sequencing problems: processing of n jobs through 2 machines, n jobs through 3 machines, 2 jobs through m machines, n jobs through m machines.

References:

1. Sharma, S. D. *Operation Research*, Kedar Nath Ram Nath Publications, 2012.
2. Swarup, K. and Gupta, P.K. *Operations Research*. S. Chand publisher, 2010.
3. Taha, H. A. *Operation Research: An Introduction*.9th edition, Pearson, 2010.
4. Gupta, P.K. and Hira, D.S. *Introduction to Operations Research*, S. Chand & Co. 2008.
5. Sharma, J. K. *Mathematical Model in Operation Research*, Tata McGraw Hill, 1989.

Title: **Applied Discrete Mathematics**
Code: **MAT 505 DS 40**
LTPC: **3104**

Objectives: The main objective of the course is to introduce concepts of mathematical logic, Lattice and graph theory and to give a brief introduction of Boolean algebra, bipartite graphs and trees and studying for their applications in real life.

Outcomes: After completing this course, student is expected to learn the following:

- Analyze logical propositions using truth tables.
- Understand the concept of lattice.
- Learn about the applications of Boolean algebra in switching theory.
- Use the concept of planar graphs, trees and study for their properties.

Content:

Unit I

Formal Logic: Statements, proposition, symbolic representation and tautologies, quantifiers, proposition logic.

Unit II

Lattices: Lattices as partially ordered sets, their properties, lattices as algebraic systems, some special lattices, e.g., complete, complemented and distributive lattices, some special lattices, e.g., bounded, complemented & distributive lattices.

Unit III

Boolean Algebra: Boolean algebra as lattices, various Boolean identities, the switching algebra example, join - irreducible elements, atoms and minterms, Boolean Forms and their equivalence, minterm Boolean forms, sum of products canonical forms, minimization of Boolean functions, applications of Boolean algebra to switching theory (using AND, OR and NOT gates).

Unit IV

Graph Theory: Definition of graphs, paths, circuits, cycles and subgraphs, induced subgraphs, degree of a vertex, connectivity, planar graphs and their properties, Euler's formula for connected planar graph, complete and complete bipartite graphs. Trees.

References:

1. Tremblay, J.P. and Manohar, R. *Discrete Mathematical Structures with Applications to Computer Science*. 1st edition McGraw-Hill Book Co., 2017.
2. Lepschutz, S. and Lipson, M. *Linear Algebra*. 5th edition, Tata McGraw-Hill 2012.
3. Ram, B. *Discrete Mathematics*. Pearson Education, 2012.
4. Kenneth H. R. *Discrete Mathematics and Its Applications*, 7th edition, Tata McGraw-Hill, 2011.
5. Liu, C. L. *Elements of Discrete Mathematics.* Tata McGraw-Hill, 2000.

Title: **Fluid Dynamics**
Code: **MAT 507 DS 40**
LTPC: **3104**

Objectives: The objective of this course is to provide a treatment of topics in fluid dynamics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems. The objective is to provide the student with knowledge of the fundamentals of fluid dynamics and an appreciation of their application to world problems.

Outcomes: After completing this course, student is expected to learn the following:
- Understand the basic principles of fluid dynamics, such as Lagrangian and Eulerian approach etc.
- Use the concept of stress in fluids with applications.
- Analyse Irrotational and rotational flows in fluids and some of their properties
- Find analytical solution of Navier Stokes equation and solutions of some benchmark problems.

Content:

Unit I

Concept of fluids, physical properties of fluids, continuum hypothesis, density, specific weight, specific volume, viscosity, kinematics of fluids, Eulerian and Lagrangian methods of description of flows, equivalence of Eulerian and Lagrangian method, general motion of fluid element, integrability and compatibility conditions, strain rate tensor, streamline, path line, streak lines, stream function¸ vortex lines, circulation.

Unit II

Stresses in Fluids: stress tensor, symmetry of stress tensor, transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor conservation laws: equation of conservation of mass (continuity equation), equation of conservation of momentum, Euler’s equation of motion, Navier Stokes equation, equation of moments of momentum, equation of energy.

Unit III

Irrotational and rotational flows: Bernoulli’s equation, Bernoulli’s equation for irrotational flows, two-dimensional irrotational incompressible flows, circle theorem, sources and sinks, sources, sinks, and doublets in two-dimensional flows, methods of images.

Unit IV

Approximate (analytical) solutions of Navier Stoke equation, order of magnitude analysis, use of similarity variables in analytical solution techniques, solutions of some benchmark problems like: Couette flow, axi-symmetric flows, creeping flows.

References:

1. Besaint, W.H. and Ramsey, A.S. *A Treatise on Hydromechanics Part I Hydrostatics*, Andesite Press, 2017.
2. Kundu, P.K., Cohen, I. M. and Dowling, R. D. *Fluid Mechanics*, 6th edition, Academic Press, 2015.
3. O’Neil, M. E., and Chorlton, F. *Ideal and Incompressible Fluid Dynamics*. Ellis Horwood Ltd, 1986.
4. Yuan, S.W. *Foundations of Fluid Mechanics*. Prentice Hall of India Private Limited, New Delhi, 1976.
5. Curle, N. and Davies, H. J. *Modern Fluid Dynamics*.Vol1, D Van Nostrand Company Ltd, London, 1968.

Title: **Advanced Algebra**
Code: **MAT 509 DS 40**
LTPC: **3104**

Objectives: The main objective of this course is to encourage students to develop a working knowledge of the central ideas of Linear Algebra like linear transformations, Vector space, Modules, canonical forms and Field Theory like field extensions, splitting field and Galois theory.

Outcomes: After completing this course, student is expected to learn the following:

- Write abstract mathematical proofs in a clear and logical manner
- Apply theorems to solve problems in number theory and theory of polynomials over a field
- Demonstrate ability to think critically by interpreting theorems and relating results to problems in other mathematical disciplines
- Think critically by recognizing patterns and principles of algebra and relating them to the number system

Content:

Unit I

Field, structure of finite fields, finite, algebraic, and transcendental extensions, splitting fields, simple and normal extensions, perfect fields, primitive elements, algebraically closed fields.

Unit II

Automorphisms of extensions. Galois extensions, fundamental theorem of Galois theory, solution of polynomials by radicals, Galois group over the rationals.

Unit III

Vector spaces, modules, direct products and direct sums, quotients and monomorphisms of modules, modules over PIDs and applications, various canonical forms.

Unit IV

Simple and semisimple modules, semisimple rings, Wedderburn-Artin structure theory.

References:

1. Lang, S. *Algebra*. Springer, 2012.
2. Herstein, I. N. *Topics in Algebra*. Wiley Eastern Ltd., New Delhi, 2006.
3. Dummit, D.S. and Foote, R.M.*Abstract Algebra* (3rd revised edition). Wiley, 2003.
4. Bhattacharya, P. B. Jain, S. K. and Nagpaul, S. R. *Basic Abstract Algebra*, 2nd edition. Cambridge University Press, 1997.
5. Anderson, F. W. and Fuller, K. R. *Rings and Categories of Modules*. Springer-Verlag New York, 1992.
6. Cohn, P. M. *Algebra*. John Wiley & Sons, Vols. I: 1982, Vols. II: 1989, Vols. III: 1991.

Title: **Measure and Integration**
Code: **MAT 510 DS 40**
LTPC**: 3104**

Objectives: Measure theory provides a foundation for many branches of mathematics such as harmonic analysis, ergodic theory, theory of partial differential equations and probability theory. It is a central, extremely useful part of modern analysis, and many further interesting generalizations of measure theory have been developed.

Outcomes: After completing this course, student is expected to learn the following:

- Use the concepts of measurable set and measurable function
- State and explain the construction of the Lebesgue integral and use it
- Apply the theorems of monotone and dominated convergence and Fatou's lemma
- Describe the construction of product measure and to apply Fubini's theorem

Content:

Unit I

Length of an open set, concept of measure, Lebesgue outer measure and measurable sets, example of non-measurable set, Sigma algebra, Borel sets, G_δ and F_σ–sets, Outer and inner regularity of Lebesgue measure.

Unit II

Set function, abstract measure spaces, properties of measures, some examples of measures, measurable spaces, measurable functions, combinations of measurable functions, and limits of measurable functions.

Unit III

Review of Riemann integral, integrable simple functions, the Lebesgue integration of a measurable function, integration with respect to a measure.

Unit IV

Almost everywhere convergence, convergence in measure, Fatou's Lemma, monotone and dominated convergence theorems.

References:

1. Berberian, S. K. *Measure and Integration*. AMS Chelsea Publications, 2011.
2. Royden, H. L. and Fitzpatrick P. M. *Real Analysis*. 4th edition, Pearson India, 2010.
3. Barra, G. de. *Measure Theory and Integration*. New Age International (P) Ltd., 2009.
4. Rana, I. K. *An Introduction to Measure and Integration*. 2nd edition, Narosa Publishing House, 2004.
5. Folland, G. B. *Real Analysis*. John Wiley & Sons, Inc., New York, 1999.
6. Hewitt, E. and Stromberg, K. *Real and Abstract Analysis*. Springer-Verlag, New York, 1975.

Title: **Fuzzy Set Theory**
Code: **MAT 511 DS 40**
LTPC: **3104**

Objectives: The course aims to introduce students to fundamental concepts in fuzzy sets, fuzzy relations, arithmetic operations on fuzzy sets, probability theory, fuzzy logic and its applications.

Outcomes: After completing this course, student is expected to learn the following:

- Construct appropriate fuzzy numbers corresponding to uncertain and inconsistent collected data.
- Understand the basic concepts of t- norms, t- conforms and operation of – cut interval.
- Use the concepts of approximation of triangular fuzzy number, operations of trapezoidal fuzzy number, bell shape fuzzy number, crisp function and its applications.
- Analyse the Integration and differentiation of fuzzy function product set, and understand the basic concepts of composition of fuzzy relation, fuzzy graph, projection and cylindrical extension.

Content:

Unit I

Concepts of fuzzy set, standard operations of fuzzy set, fuzzy complement, fuzzy union, fuzzy intersection, other operations in fuzzy set, t- norms and t- conorms. Interval, fuzzy number, operation of interval, operation of – cut interval, examples of fuzzy number operation.

Unit II

Definition of triangular fuzzy number, operation of triangular fuzzy number, operation of general fuzzy numbers, approximation of triangular fuzzy number, operations of trapezoidal fuzzy number, bell shape fuzzy number, function with fuzzy constraint, propagation of fuzziness by crisp function, fuzzifying function of crisp variable, maximizing and minimizing set, maximum value of crisp function.

Unit III

Integration and differentiation of fuzzy function product set, definition of relation, characteristics of relation, representation methods of relations, operations on relations, path and connectivity in graph, fundamental properties, equivalence relation, compatibility relation, pre-order relation, order relation, definition and examples of fuzzy relation, fuzzy matrix, operations on fuzzy relation.

Unit IV

Composition of fuzzy relation, - cut of fuzzy relation, projection and cylindrical extension, extension by relation, extension principle, extension by fuzzy relation, fuzzy distance between fuzzy sets, graph and fuzzy graph, fuzzy graph and fuzzy relation, - cut of fuzzy graph.

References:

1. Mohan, C. *An Introduction to Fuzzy Set Theory and Fuzzy Logic*. Anshan Publishers, 2015.
2. Lee, K. H. *First Course on Fuzzy Theory and Applications*. Springer International Edition, 2005.
3. Yen, J., Langari, R. *Fuzzy Logic - Intelligence, Control and Information*. Pearson Education, 1999.
4. Zimmerman, H.J. *Fuzzy Set Theory and its Applications*. Allied Publishers Ltd., New Delhi, 1991.

Title: **Mathematical Statistics**

Code: **MAT 513 DS 40**

LTPC: **3104**

Objectives: The aim of the course is to enable the students with understanding of various types of measures, various types of probability distributions and testing of hypothesis problems. It aims to equip the students with standard concepts of statistical techniques and their utilization.

Outcomes: After completing this course, students will be able to:

- Understand measures of central tendency, dispersion, skewness, kurtosis, and basic probability theory.
- Demonstrate a solid grasp of discrete random variables, mathematical expectations, and standard discrete distributions such as binomial, Poisson, and geometric.
- Analyze continuous probability distributions like uniform, exponential, gamma, and normal, and understand the Central Limit Theorem.
- Formulate hypotheses and conduct hypothesis testing using t, F, and Chi-Square distributions.

Content:

Unit I

Measures of central tendency and dispersion, moments, skewness, and kurtosis, correlation and regression. Axiomatic approach to probability, sample space, laws of probability, conditional probability. Random variables: discrete and continuous, probability mass and density functions, distribution functions. Introduction to bivariate random variables.

Unit II

Mathematical expectation, its properties, variance and covariance, moment generating functions and their properties. Discrete distributions: Binomial, Poisson, and geometric distributions with properties and applications.

Unit III

Continuous distributions: uniform, exponential, gamma, and normal distributions with properties. Central Limit Theorem (statement only).

Unit IV

Statistical estimation. Hypothesis testing: null and alternative hypotheses, simple and composite hypotheses, Type I and II errors. Sampling distributions: t, F, and Chi-Square distributions and their applications in testing hypotheses.

References:

1. Meyer, P. L. *Introductory Probability and Statistical Applications*. 2nd edition, Addison-Wesley Publishing Company, 2017.
2. Gupta, S. C. and Kapoor, V. K. *Fundamentals of Mathematical Statistics.* Sultan Chand & Sons, 2014.
3. Mood, A. M., Graybill, F. A. and Boes, D. C. *Introduction to the Theory of Statistics*, Tata McGraw Hill, 2014.
4. Spiegel, M. R., Schiller, J. J. and Srinivasan, R. A. *Probability and Statistics*. Tata McGraw-Hill, 2014.
5. Baisnab, A. P. and Jas, M. *Element of Probability and Statistics*, Tata McGraw Hill, 1993.

Title: **Python Programming**
Code: **MAT 515 DS 40**
LTPC: **2044**

Objectives: The main objective is to provide exposure to the students on the basics of programming in Python, writing code and debugging, and develop simple applications.

Outcomes: After going through this course the students will be able to

- Solve general problem using iterative, looping concepts of Python
- Implement functions and modules in Python
- Handle common operations with files and with data structures
- Develop simple applications

Contents:

Unit-I

Installation, Running and debugging programs, Syntax, Basic data types, Variables, Input-Output

Unit-II

Arithmetic, assignment, comparison, logical, and bitwise operators; Decision making statements, Iterative statements, break and continue.

Unit-III

Working with lists, tuples, sets, and dictionaries, working with files (reading, writing, appending)

Unit-IV

Definition and use, passing arguments and return values, block structure, scope, recursion, importing modules and packages, Using built-in modules (e.g., math, datetime)

Laboratory Work: To implement general problems in Python; and develop simple applications.

References:

1. Y. Kanatkar, *Let Us Python*, BPB, 2019.
2. Martin C. Brown, *Python: The Complete Reference*, McGraw Hill, 2018.
3. Allen B. Downey, *Think Python*, O'Reilly, 2016

Title: **Integral Equations and Calculus of Variations**
Code: **MAT 520 DS 40**
LTPC: **3104**

Objectives: In this course we study in detail about integral equations and calculus of variations. Integral equations find numerous applications in real life physical problems. The main objective of the course is to make the learner familiarize with resolvent kernel, successive approximation, solution of homogeneous Fredholm integral equation for solving integral equations and variational problems. Differential equations can be studied for their solutions by transforming them into integro-differential equations using Laplace transform.

Outcomes: After completing this course, students will be able to:

- Apply different kernel types and solve various integral equations using suitable techniques.
- Solve Volterra integral equations using the Neumann series and related methods.
- Understand the transformation between differential and integral equations using Laplace transforms.
- Formulate and analyze variational problems, and derive and apply conditions for extrema of functionals.

Contents:

Unit I

Volterra and Fredholm integral equations, basic identities, types of kernels: symmetric, separable, iterated, and resolvent kernels. Initial value problems reduced to Volterra integral equations. Solutions using resolvent kernel, successive approximation, and Neumann series methods.

Unit II

Boundary value problems reduced to Fredholm equations. Solutions using separable and resolvent kernels, methods of successive approximation and substitution for second-kind Fredholm equations. Homogeneous Fredholm equations, eigenvalues, and eigenfunctions.

Unit III

Properties and applications of Laplace transforms. Solution of Abel's equation using Laplace transform. Volterra integral equations with convolution-type kernels. Solving integro-differential equations using Laplace transforms. Fourier Transform, Fourier sine and cosine transforms.

Unit IV

Extrema of functionals and Euler's equation. Sufficient conditions for extremum, extended variational methods. Applications including the Brachistochrone problem and geodesics.

References:

1. Wazwaz, A. M. *A First Course in Integral Equations*. 2nd edition World Scientific Publishing Co. 2015.
2. Kanwal, R. P. *Linear Integral Equation. Theory and Techniques*. Academic Press, 2014.
3. Gelfand, I. M. and Fomin, S. V. *Calculus of Variations*. Courier Corporation, 2012.
4. Hildebrand, F. B. *Method of Applied Mathematics*, Courier Corporation, 2012.
5. Raisinghania M. D. *Integral Equation & Boundary Value Problem.* S. Chand Publishing, 2007.
6. Jerri, A. *Introduction to Integral Equations with Applications*, John Wiley & Sons, 1999.

Title: **Differential Geometry**
Code: **MAT 502 DS 40**
LTPC: **3104**

Objectives: In this course, students will be imparted knowledge to enable them to understand several concepts of Differential Geometry such as space curves, surfaces, curvatures, torsion, developables and geodesics.

Outcomes: After completing this course, student is expected to learn the following:

- Learn about the concepts of curvature, torsion, involutes and evolutes.
- Familiarize with several concepts of tangent plane, Helicoids, metric and direction coefficients.
- Understand the concepts of developable surfaces.
- Use the several notions of curvatures such as geodesic curvature and Gaussian curvatures.

Content:

Unit I

Curves with torsion: tangent, principal normal, curvature, binormal, torsion, Serret-Frenet formulae, locus of centre of spherical curvature, helix, involutes and evolutes.

Unit II

Curvilinear co-ordinates: first order magnitude, directions on a surface, second order magnitudes, derivative of unit normal, principal directions and curvatures.

Unit III

Envelopes: surfaces, tangent plane, envelope, characteristics, edge of regression, developable surfaces, osculating, polar and rectifying developable.

Unit IV

Geodesics: geodesic property, equations of geodesics, torsion of a geodesic. Bonnet's theorem, Joachimsthal's theorems, geodesic parallels, geodesic ellipses and hyperbolas, Liouville surfaces.

References:

1. Weatherburn, C. E. *Differential Geometry of Three Dimensions*, Cambridge University Press, 2016.
2. Graustein, W. C. *Differential Geometry.* Courier Corporation, 2012.
3. Wilmore T. J. *An Introduction to Differential Geometry*, Dover Publications Inc., 2012.
4. Pressley, A. *Elementary Differential Geometry*. Springer, 2002.

Title: **Mathematical Modelling**
Code: **MAT 504 DS 40**
LTPC: **3104**

Objectives: The objectives of this course are to:

- Enable students understand how mathematical models are formulated, solved and interpreted.
- Make students appreciate the power and limitations of mathematics in solving practical real-life problems.
- Equip students with the basic mathematical modelling skills.

Outcomes: After completing this course, student is expected to learn the following:

- Understand what a mathematical model is and explain the series of steps involved in a mathematical modeling process.
- Use applications of mathematical modeling through difference equations.
- Understand and apply the concept of mathematical modeling through difference equations in population dynamics, genetics and probability theory.
- Apply the concept of mathematical modeling through graph theory.

Content:

Unit I

Mathematical modeling overview: need, basic principles, techniques, limitations, classifications and simple illustrations.

Unit II

Compartmental models (Growth and decay models): Introduction, Exponential decay and radioactivity, Lake pollution models, Drug assimilation into the blood; Models of single populations: Exponential growth, Density-dependent growth, Limited growth with harvesting, Discrete population growth and chaos.

Unit III

Interacting population models: Introduction, An epidemic model for influenza, Prey-Predator model, Competition model, Combat model; Introduction to Phase-plane analysis, Phase-plane analysis of these models.

Unit IV

Linearization analysis: Introduction, Linear autonomous systems, Types of Critical Points and Stability for Linear Systems, Applications of linear theory (Harmonic Oscillators, Combat Model), Nonlinear autonomous systems, Applications of nonlinear theory (Predator-prey Model, Epidemic Model).

References:

1. Kapur, J. N., *Mathematical Modelling*, Wiley publication, 3*rd* edition, 2023. (Textbook)
2. Barnes, B. and Fulford, G. R., *Mathematical Modelling with Case Studies: A Differential Equations Approach Using Maple™ and MATLAB®*, 2nd edition, CRC Press, 2009. (Textbook)
3. Dym, C.L., *Principles of Mathematical Modeling*, 2nd edition, Academic Press.
4. Giordano F. R., Mawrice D W., William P. F., *A First Course in Mathematical Modeling*, 3rd edition, Thomson Brooks/Cole, 2003.
5. Braun, M., *Differential Equations and their Application: An Introduction to Applied Mathematics*, 3rd edition, Springer, 1991.
6. Law, A.M., *Simulation Modelling and Analysis*, 4th edition, McGraw Hill, 2006.
7. Davies, R. M. and O'Keefe, R. M., *Simulation Modelling with Pascal*, Prentice Hall, 1989

Title: **Advanced Numerical Analysis**
Code: **MAT 506 DS 40**
LTPC: **3024**

Objectives: After familiarizing the students with basic numerical techniques in numerical analysis course, this course aims to give exposure to some advanced numerical methods. The course objective is to acquaint the students with a wide range of advanced numerical methods to solve systems of algebraic and transcendental equations, linear system of equations, difference equations, eigenvalue problems.

Outcomes: After completing this course, student is expected to learn the following:

- Learn numerical technique to find the numerical solutions of system of linear and nonlinear equations and some curve fitting problems
- Solve bivariate interpolation problems, difference equations and eigen value problems.
- Understand finite difference methods for numerical solutions of partial differential equations especially heat, wave, Laplace and Poisson equations.
- Familiarize the students with advantages and limitations of numerical techniques

Content:

Unit I

General iterative method for the system: x = g(x) and its sufficient condition for convergence. Chebyshev method, Newton-Raphson method. Successive over relaxation (SOR) method for system of linear equations. Bivariate interpolation, B-Spline interpolation and Bezier curves.

Unit II

Review of finite difference operators, difference equations, order of difference equation, degree of difference equation, solution of difference equations, use of generating function in the solution of difference equation. Jacobi, Givens and Householder methods real symmetric matrix

Unit III

Numerical solutions of parabolic equations of second order in one space variable –two and three levels explicit and implicit difference schemes, truncation errors and stability. Numerical solution of parabolic equations of second order in two space variable-improved explicit schemes, implicit methods, alternating direction implicit (ADI) methods.

Unit IV

Numerical solution of hyperbolic equations of second order in one and two space variables with constant and variable coefficients-explicit and implicit methods. ADI methods. Numerical solutions of elliptic equations-approximations of Laplace and biharmonic operators, solutions of Dirichlet, Neumann and mixed type problems with Laplace and Poisson equations in rectangular, circular and triangular regions. ADI methods.

References:

1. Gupta, R. K. *Numerical Methods: Fundamentals and Applications*. 1st edition, Cambridge University Press, 2019.
2. Gupta. R. S., *Elements of Numerical Analysis*, 2nd edition, Cambridge University Press, 2015.
3. Atkinson, K. and Han, W. *Theoretical Numerical Analysis*, Springer Science & Business Media, 2010.
4. Bradie, B. *A friendly introduction to Numerical Analysis*. Pearson Education, 2007.
5. Bazaraa, M.S., Sherali, H.D., and Shetty, C.M. *Nonlinear Programming Theory and Algorithms*. John Wiley and Sons, 2004.
6. Smith, G. D. *Numerical Solution of Partial Differential Equations: Finite Difference Methods*, 3rd edition. Oxford University Press, 1985.

Title: **Finite Element Methods**
Code: **MAT 508 DS 40**
LTPC: **3104**

Objectives: The course aims to provide the fundamental concepts of the element method mainly including shape functions and general linear and higher order elements up to 3 dimensions. The course objective is to acquaint the students about application of finite element methods for solving various boundary value problems.

Outcomes: After completing this course, student is expected to learn the following:
- Understand the general theory of Finite Element method and its difference with finite difference method
- Use the role and significance of shape functions in finite element formulations and use of linear, quadratic, and cubic shape functions for interpolation
- Formulate some important 1, 2 and 3 dimensional elements
- Apply the weighted residual and variational approaches in solving some boundary value Problems

Content:

Unit I

General theory of finite element methods, difference between finite element and finite difference methods, review of some integral formulae, concept of discretization, different coordinates, one dimensional finite elements, concept of shape functions, stiffness matrix, connectivity, boundary conditions, and equilibrium equation.

Unit II

Numerical integration, construction of shape functions: linear elements (one dimensional bar element, two dimensional-triangular and rectangular elements, three dimensional tetrahedron element).

Unit III

Higher order elements: one dimensional quadratic element, two dimensional triangular element, rectangular element, three dimensional tetrahedron element: quadratic element and higher order elements

Unit IV

Weighted residual and variational approaches (Galerkin method, collocation method, Rayleigh Ritz method etc.), solving one-dimensional problems. Application of finite element methods for solving various boundary value problems, computer procedures for finite element analysis

References:

1. Rao, S. S. *The Finite Element Method in Engineering*. 5th edition, Butterworth-Heinemann, 2017.
2. Brenner S., Scott R. *The Mathematical Theory of Finite Element Methods*. Springer, 2007
3. Hughes, T. J. R. *The Finite Element Method (Linear Static and Dynamic Finite Element Analysis)*. Courier Corporation, 2007.
4. Zienkiewicz, O. C. and Taylor, R. L. *The Finite Element Method: The Basis*. Butterworth- Heinemann, 2000.
5. Smith, G. D. *Numerical solution of Partial Differential Equations: Finite difference methods.* Oxford Applied Mathematics and Computing Science Series, 1985.

Title: **Advanced Complex Analysis**
Code: **MAT 512 DS 40**
LTPC: **3104**

Objectives: The primary objective of this course is to understand the notion of logarithmically convex function and its fusion with maximum modulus theorem, the spaces of continuous, analytic and meromorphic functions, Runge's theorem and topics related with it, introduce harmonic function theory leading to Dirichlet's problem, theory of range of an entire function leading to Picard and related theorems.

Outcomes: After completing this course, student is expected to learn the following:

- Understand the basics of logarithmically convex function that helps in extending maximum modulus theorem.
- Be familiar with metric on spaces of analytic, meromorphic and analytic functions, equi-continuity and normal families leading to Arzela-Ascoli and related theorems.
- Appreciate the richness of simply connected region which connects various fields topology, analysis and algebra.
- Know how big the range of an entire function is as well as Picard and related theorems.

Contents:

Unit I

Maximum modulus principle, Schwarz's lemma, convex functions and Hadamard's three circles theorem, Phragmen-Lindelof theorem.

Unit II

The space of continuous functions, spaces of analytic functions, The Riemann mapping theorem, Weierstrass factorization theorem. Gamma function, Reimann zeta function.

Unit III

Analytic continuation, Runge's theorem, simple connectedness, Mittag-Leffier's theorem, Schwarz reflection principle, analytic continuation.

Unit IV

Basic properties of harmonic functions, harmonic functions on a disk, Jensen's formula, Bloch's theorem, The Little Picard theorem, Schottky's theorem, The Great Picard theorem.

References:

1. Ahlfors, L.V. *Complex Analysis*. 3rd edition, McGraw-Hill, 2017.
2. Alpay, D. *A Complex Analysis Problem Book*. Birkhäuser, 2016.
3. Churchill, R. V. and Brown, J. W. *Complex Variables and Applications*. 9th edition, McGraw Hill Education, 2014.
4. Edward,S. B. and Snider, Arthur D. *Fundamentals of Complex Analysis with Applications to Engineering and Sciences.* Pearson Education, 2014.
5. Lang, S. *Complex Variables*. Springer, 2013.
6. Conway J. B. *Functions of One Complex Variable*. Springer, 2000.

Title: **Introduction to Cryptography**
Code: **MAT 514 DS 40**
LTPC: **3104**

Objectives: The purpose of the course is to give a simple account of cryptography. Upon completion of the course, students will have a working knowledge of the fundamental definitions and theorems of elementary congruences, solve congruence equations and systems of equations with one and more variables. They will understand the language, notation of Caesar Cipher and explored to cryptography. We will also discussion on Diffie-Hellman RSA public key cryptosystem.

Outcomes: After completing this course, student is expected to learn the following:

- Understand the operations with congruence's, linear and non-linear congruence equations.
- Use the basics of RSA security and be able to break the simplest instances and analyze the basic concepts of remote coin flipping, elliptic curve based cryptography.
- Apply the theorems: Fermat's last theorem, prime number theorem and zeta function.
- Understand and use the numbers: Perfect numbers, Fermat numbers, Mersenne primes and amicable numbers, Fibonacci numbers.

Content:

Unit I

Modular arithmetic, congruence, primitive roots, cryptography introduction, Caesar Cipher, Diffie-Hellman RSA public key cryptosystem, Knapsack cryptosystem, application of primitive roots to cryptography.

Unit II

Applications of cryptography in primality testing and factorization of large composite numbers, remote coin flipping. Elliptic curve based cryptography.

Unit III

Perfect numbers, Fermat numbers, Mersenne primes and amicable numbers, Fibonacci numbers, representation of integers as sum of Squares.

Unit IV

Linear and non-linear Diophantine equations, Fermat's last theorem, prime number theorem and zeta function.

References:

1. Tilborg, H. C. A. *Fundamentals of Cryptology*. Springer, 2013.
2. Buchmann, J. A. *Introduction to Cryptology.Springer Science & Business Media*, 2012.
3. Burton , D. M. *Elementary Number Theory*, Tata McGraw Hill Publishing House, 2006.
4. Menezes, A. J., V.,Oorschot, P. C. and Vanstone,S. A. *Handbook of Applied Cryptography*. CRC Press, 1996.
5. Koblitz, N. *A Course in Number Theory and Cryptography*. 2nd edition Springer, 1994.
6. Simmons, G. J. *Contemporary Cryptology*, The Science of Information Integrity.New York, IEEE Press, 1992.

Title: **Module Theory**
Code: **MAT 516 DS 40**
LTPC: **3104**

Objectives: The main objective of this course is to encourage students to develop a working knowledge of the central ideas of modules like cyclic modules, simple, semi-simple modules uniform modules, primary modules and theory of Noetherian and Artinian modules.

Outcomes: After completing this course, student is expected to learn the following:
- Explain the fundamental concepts of modules and their role in modern mathematics and applied contexts.
- Demonstrate accurate and efficient use of finitely generated Abelian groups.
- Apply the theorems: fundamental structure theorem of finitely generated modules over principal ideal domain, Noether- Lasker theorem, Hilbert basis theorem and Wedderburn - Artin theorem, Maschk's theorem.
- Solve the problem using Nilradical and Jacobson radicals, operations on ideals, extension and contractions applied to diverse situations in physics, engineering and other mathematical contexts.

Content:

Unit I

Cyclic modules, simple and semi-simple modules, Schur's lemma, free modules, fundamental structure theorem of finitely generated modules over principal ideal domain and its applications to finitely generated Abelian groups.

Unit II

Uniform modules, primary modules and Noether-Lasker theorem, Noetherian and Artinian modules and rings with simple properties, and examples.

Unit III

Nilpotent ideals in Noetherian and Artinian rings, Hilbert basis theorem, Nakayama's lemma, Nilradical and Jacobson radicals, operations on ideals, extension and contraction.

Unit IV

Hom(R,R), opposite rings, Wedderburn-Artin theorem, Maschke's theorem, equivalent statement for left Artinian rings having non-zero nilpotent ideals.

References:

1. Rotman, J. J.*Advanced Modern Algebra*. 3rd edition. American Mathematical Soc., 2015.
2. Atiyah, M. F. and Macdonald, I. G. *Introduction to Commutative Rings*. Sarat Book House, 2007.
3. Curtis, C. W. and Reiner,I. *Representation Theory of finite Groups and Associative Algebras.* American Mathematical Society, 2006.
4. Lam, T. Y. *Lectures on Modules and Rings*. GTM Vol. 189, Springer-Verlag, 1999.
5. Bhattacharya,P. B., Jain, S. K. and Nagpaul, S. R. *Basic Abstract Algebra*. 2nd edition, Cambridge University Press, Indian edition, 1997.
6. Anderson, F. W. and Fuller, K. R. *Rings and Categories of Modules*. Springer-Verlag New York, 1992.
7. Cohn, P. M. *Algebra,* Vols. I, II & III, John Wiley & Sons, (Vol. I-1982, Vol. II- 1989, Vol-III-1991.

Title: **Number Theory**
Code: **MAT 518 DS 40**
LTPC: **3104**

Objectives: The purpose of the course is to give a simple account of classical number theory, prepare students to graduate-level courses in number theory and algebra, and to demonstrate applications of number theory. In this course, students will have a working knowledge of the fundamental definitions and theorems of elementary number theory, be able to work with congruence's, solve congruence equations and systems of equations with one and more variables, and be literate in the language and notation of number theory.

Outcomes: After completing this course, student is expected to learn the following:

- Understand the properties of divisibility and prime numbers, compute the greatest common divisor and least common multiples and handle linear Diophantine equations
- Use the operations with congruence's, linear and non-linear congruence equations
- Apply the theorems: Chinese Remainder Theorem, Lagrange theorem, Fermat's theorem, Wilson's theorem
- Analyse arithmetic functions in areas of mathematics

Content:

Unit I

Representation of the real numbers by decimals, divisibility, G.C.D and L.C.M., primes, Fermat numbers, congruences and residues, theorems of Euler, Fermat and Wilson, solutions of congruences, linear congruences, Chinese remainder theorem.

Unit II

Arithmetical functions $\varphi(n)$, $\mu(n)$ and $d(n)$ and $\sigma(n)$, Mobius inversion formula, congruences of higher degree, congruences of prime power modulli and prime modulus, power residue.

Unit III

Quadratic residue, Legendre symbols, lemma of Gauss and reciprocity law. Jacobi symbols, irrational numbers, irrationality of e and π. Finite continued fractions, simple continued fractions, infinite simple continued fractions.

Unit IV

Periodic continued fractions, approximation of irrational numbers by convergent, best possible approximation, Farey series, rational approximation, Pell's equations, Hurwitz theorem, Lagrange four square theorem.

References:

1. Apostol, T. M. *Introduction to Analytic Number Theory*. Springer 2014.
2. Niven, I. and Zuckerman, H. S. *Introduction to the Theory of Numbers*. John Wiley & Sons, 2008.
3. Burton, D. M. *Elementary Number Theory*. Tata McGraw Hill Publishing House, 2006.
4. Hardy, G. H. and Wright, E. M. *Theory of Numbers*. Oxford Science Publications, 2003.
5. Davenport, H. *Higher Arithmetic*. Cambridge University Press, 1999.

Title: **Mechanics**
Code: **MAT 522 DS 40**
LTPC: **3104**

Objectives: This course aims to impart knowledge in mechanics used for the derivation of important results and problems related to rigid bodies. The objective is to give the students a mechanical approach for solving the problems related to the mechanics.

Outcomes: After completing this course, student is expected to learn the following:

- Understand the notion of moment and product of inertia.
- Recognize the dynamics involved in projectile motion, pendulum motion, simple harmonic motion and related problems.
- Use the Lagrangian and Hamiltonian functions to formulate the equation of motion for mechanical systems.
- Evaluate canonical equations by means of generating functions and eventually develop Hamilton-Jacobi method to solve equations of motion.

Content:

Unit I

Moments and products of inertia, theorems of parallel and perpendicular axes, principal axes, the momental ellipsoid, equimomental systems, coplanar distributions.

Unit II

Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations, generalized coordinates, holonomic and non-holonomic systems. scleronomic and rheonomic systems, Lagrange's equations for a holonomic system, Lagrange's equations for a conservative and impulsive forces, kinetic energy as quadratic function of velocities.

Unit III

Generalized potential, energy equation for conservative fields, Hamilton's variables. Donkin's theorem. Hamilton canonical equations, cyclic coordinates, Routh's equations. Poisson's bracket. Poisson's identity, Jacobi-Poisson theorem. Hamilton's principle, the principle of least action.

Unit IV

Poincare Cartan integral invariant. Whittaker's equations. Jacobi's equations. Statement of Lee Hwa Chung's theorem. Hamilton-Jacobi equation. Jacobi theorem. Method of separation of variables. Lagrange brackets, condition of canonical character of a transformation in terms of Lagrange brackets and Poisson brackets, invariance of Lagrange brackets and Poisson brackets under canonical transformations.

References:

1. Spiegel, M.R. Theory & *Problems of Theoretical Mechanics*, Schaum Outline Series McGrawHill, 2017.
2. Rana, N. C. and Joag, P. C. *Classical Mechanics*. McGraw Hill, 2013.
3. Rao,S. K. *Classical Mechanics*. PHI Learning Pvt. Ltd., 2005.
4. Chorlton, F. *Textbook of Dynamics.* CBS Publishers & Dist. Pvt. Ltd., 2004.
5. Louis N. H. and Janet D. F. *Analytical Mechanics*. Cambridge University Press, 1998.
6. Gantmacher, F. *Lectures in Analytical Mechanics*. Mir Publishers, Moscow, 1975.

Title: **Information Theory**
Code: **MAT 524 DS 40**
LTPC: **3104**

Objectives: The objective of this course is to introduce basic and advanced topics in information theory. This course further explains the different types of entropies, codes, discrete and continuous channels and their applications.

Outcomes: After completing this course, student is expected to learn the following:

- Understand the basic concepts of information theory, different types of entropies with their properties and applications.
- Analyse how different coding techniques will perform in different situations.
- Understand about discrete channels and their properties with applications.
- Understand about continuous channels and their properties with applications.

Content:

Unit I

Measure of information – axioms for a measure of uncertainty, the Shannon entropy and its properties, joint and conditional entropies, transformation and its properties, axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.

Unit II

Noiseless coding - ingredients of noiseless coding problem, uniquely decipherable codes, necessary and sufficient condition for the existence of instantaneous codes, construction of optimal codes.

Unit III

Discrete memory less channel - classification of channels, information processed by a channel, calculation of channel capacity, decoding schemes the ideal observer, the fundamental theorem of information theory and its strong and weak converses.

Unit IV

Continuous channels - the time-discrete Gaussian channel, uncertainty of an absolutely continuous random variable, the converse to the coding theorem for time-discrete Gaussian channel, the time-continuous Gaussian channel, band- limited channels.

References:

1. Ash, R. B. *Information Theory*. Courier Corporation, 2012.
2. Reza, F.M. *An Introduction to Information Theory*. Courier Corporation, 2012.
3. Hankerson, H. D., Harris, G. A. and Johnson, P. D. *Introduction to Information Theory and Data Compression*. Chapman and Hall/CRC, 2nd edition, 2003.
4. Aczel, J. and Daroczy, Z. *On Measures of Information and their Characterizations*. Academic Press, New York, 1975.

Title: **Mathematics for Finance and Insurance**
Code: **MAT 526 DS 40**
LTPC: **3104**

Objectives: This course introduces the basic concepts of Financial Management such as Insurance and Measurement of returns under uncertainty situations. The philosophy of this course is that Time value of Money - Interest rate and discount rate play a fundamental role in Life Insurance Mathematics – Construction of Morality Tables.

Outcomes: After completing this course, student is expected to learn the following:

- Demonstrate knowledge of the terminology related to nature, scope, goals, risks, and decisions of financial management.
- Predict various types of returns and risks in investments and take necessary protective measures to minimize the risk.
- Develop an ability to understand, analyze and solve problems in bonds, finance and insurance.
- Build skills for computation of premiums of life insurance and claims for general insurance using probability distributions.

Content:

Unit I

Financial Management –overview. Nature and scope of financial management. Goals and main decisions of financial management. Difference between risk, Speculation and gambling. Time value of Money - Interest rate and discount rate. Present value and future value discrete case as well as continuous compounding case. Annuities and its kinds.

Unit II

Meaning of return. Return as Internal Rate of Return (IRR). Numerical methods like Newton-Raphson method to calculate IRR. Measurement of returns under uncertainty situations. Meaning of risk. Difference between risk and uncertainty. Types of risks. Measurements of risk. Calculation of security and Portfolio Risk and Return-Markowitz Model. Sharpe Single Index Model- Systematic Risk and Unsystematic Risk.

Unit III

Taylor series and Bond Valuation. Calculation of Duration and Convexity of bonds. Insurance Fundamentals – Insurance defined. Meaning of loss. Chances of loss, Peril, Hazard, proximate cause in insurance. Costs and benefits of insurance to the society and branches of insurance-life insurance and various types of general insurance. Insurable loss exposures- feature of a loss that is ideal for insurance.

Unit IV

Life Insurance Mathematics – Construction of Morality Tables. Computation of Premium of Life Insurance for a fixed duration and for the whole life. Determination of claims for General Insurance Using Poisson Distribution and Negative Binomial Distribution the Polya Case. Determination of the amount of Claims of General Insurance – Compound Aggregate claim model and its properties, Claims of reinsurance. Calculation of a compound claim density function F, Recursive and approximate formulae for F.

References:

1. Ross, S. M. *An Introduction to Mathematical Finance*. Cambridge University Press, 2019.
2. Elliott, R. J. and Kopp, P. E. *Mathematics of Financial Markets.* Sprigner Verlag, New York Inc, 2018.
3. Damodaran, A. *Corporate Finance - Theory and Practice.* John Wiley & Sons, Inc, 2012.
4. Hull, J. C. *Options, Futures, and Other Derivatives*. Prentice-Hall of India Private Ltd, 2010.
5. Daykin, C. D., Pentikainen, T. and Pesonen, M. *Practical Risk Theory for Actuaries*. Chapman & Hall, 2008.

Title: **Theory of Elasticity**
Code: **MAT 528 DS 40**
LTPC: **3104**

Objectives: This course aims to familiarize the students with tensors and the principles and basic equations of elasticity. The course will expose the students to two dimensional problems in Cartesian and polar coordinates.

Outcomes: After completing this course, student is expected to learn the following:

- Use the indicial notation and knowledge of tensor
- Analyse strain, stress and deformation
- Understand the basic principles and field equations of linear elastic solids
- Formulate the solution strategies of various two dimensional problems

Content:

Unit I

Cartesian tensor: Coordinate transformation, Cartesian tensor of different order, sum or difference and product of two tensors. contraction theorem, quotient law, symmetric & skew symmetric tensors, Kronecker tensor, alternate tensor and relation between them, scalar invariant of second order tensor, eigen values & vectors of a symmetric second order tensor, gradient, divergence & curl of a tensor field. Analysis of strain: affine transformations, infinitesimal affine transformation, geometrical interpretation of the components of strain.

Unit II

Strain quadric of Cauchy, principal strains and invariants, general infinitesimal deformation. Saint-Venant's equations of compatibility. Analysis of stress: stress tensor, equations of equilibrium, transformation of co-ordinates, stress quadric of Cauchy, principal stress and invariants, maximum normal and shear stresses.

Unit III

Equations of elasticity: Generalized Hooke's law, homogeneous isotropic media, elastic moduli for isotropic media, equilibrium and dynamic equations for an isotropic elastic solid, strain energy function and its connection with Hooke's law, Beltrami-Michell compatibility equations.

Unit IV

Two-dimensional problems: Plane strain, plane stress, generalized plane stress, Airy's stress function, general solution of bi-harmonic equation, stresses and displacements in terms of complex potentials, propagation of waves in an isotropic elastic solid medium, waves of dilation and distortion, elastic surface waves such as Rayleigh and Love waves.

References:

1. Sadd, M. H. *Elasticity Theory, Applications and Numerics*. Academic Press, 2014.
2. Love, A. E. H. A *Treatise on Mathematical Theory of Elasticity*. Cambridge [Eng.] University Press, 2013.
3. Timoshenko, S. P. and Goodier, J. N. *Theory of Elasticity. New York*: McGraw-Hill, 2010.
4. Narayan, S. *Text Book of Cartesian Tensors*. S. Chand & Co., 1968.
5. Sokolnikoff, I. S. *Mathematical Theory of Elasticity*. McGraw-Hill Inc, 2nd edition, 1956.

Title: **MATLAB and Maple Programming**
Code: **MAT 532 DS 40**
LTPC: **2044**

Objectives: *The course objective is to familiarize the students with problem solving through MATLAB. The course aims to give exposure to basic concepts of the MATLAB programming. The course aims to design the MATLAB programs for various numerical methods.*

Outcomes: After completing this course, the students will be able to

- *Overview and display format of MATLAB programs*
- *Acquire knowledge of various elementary built-in functions, data types and Matrix operations*
- *Learn about control flow and loop structures*
- *Write MATLAB programs for various numerical methods use to solve nonlinear equations, system of linear equations, interpolation, numerical differentiation and integrations, differential equations.*

Contents:

Unit-I

Overview of MATLAB, operators, display format, elementary built-in functions, working with variables, general commands, data types, data import, arrays, operations with arrays, Matrices: eigenvalues and eigenvectors, similarity transformation and diagonalization, functions, script files, operators, loops and conditional statements

Unit-II

Programming in MATLAB, graphics- 2-D and 3-D plots, input and output. introduction to working with modules in MATLAB

Unit-III

Applications of MATLAB in numerical methods: bisection method, false position (Regula-Falsi) method, Newton–Raphson method, Gauss elimination method, Gauss Seidel method, Lagrange and Newton interpolations, Trapezoidal method and Simpson method, Runge–Kutta method.

Unit-IV

Overview of Maple software, commands and expressions, perform basic calculations, commands in various fields of mathematics like calculus, vector calculus, linear algebra, group theory, differential equations, numerical computations, optimization techniques and number theory, how to create more sophisticated graphics in Maple, including animations with multiple layers, 3-D models of physical systems, and statistical plots.

References:

1. Kumar, S. S. and Lenina, S. V. B. Matlab: Easy Way of Learning. PHI Learning Pvt. Ltd., 2016.
2. Pratap, R. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers. Oxford University Press, 2016.
3. Chapman, S. J. Matlab Programming for Engineers, 5th edition, Cengage Learning, 2015.
4. Otto, S.R. and Denier, J.P. An Introduction to Programming and Numerical Methods in MATLAB. Springer-Verlag, 2005.
5. Yang, W. Y., Cao, W., Chung, T. and Morris, J. Applied Numerical Methods using MATLAB. John Wiley Interscience, 2005.
6. Getting Started with MATLAB, Maths Works Inc. www. in.mathsworks.com.
7. Philip Anton de Saint-Aubain; Philip Michael, The Maple Syntax, Polyteknisk Forlag, 2013
8. https://www.maplesoft.com/documentation_center

SDG Mapping

Course Name	SDG Name	Rationale
Real Analysis	Quality Education (SDG 4)	Fundamental for advanced mathematics and scientific research.
	Industry, Innovation and Infrastructure (SDG 9)	Fundamental for advanced mathematics and scientific research.
Abstract Algebra	Quality Education (SDG 4)	Abstract thinking, cryptography, and secure communications.
	Industry, Innovation and Infrastructure (SDG 9)	Abstract thinking, cryptography, and secure communications.
Linear Algebra	Quality Education (SDG 4)	Essential for AI, modeling, and urban data analysis.
	Industry, Innovation and Infrastructure (SDG 9)	Essential for AI, modeling, and urban data analysis.
	Sustainable Cities and Communities (SDG 11)	Essential for AI, modeling, and urban data analysis.
Ordinary Differential Equations	Good Health and Well-being (SDG 3)	Modeling diseases, water systems, and environmental change.
	Clean Water and Sanitation (SDG 6)	Modeling diseases, water systems, and environmental change.
	Climate Action (SDG 13)	Modeling diseases, water systems, and environmental change.
Programming in C	Quality Education (SDG 4)	Core programming skills used across industries.
	Decent Work and Economic Growth (SDG 8)	Core programming skills used across industries.
	Industry, Innovation and Infrastructure (SDG 9)	Core programming skills used across industries.
Numerical Analysis	Affordable and Clean Energy (SDG 7)	Simulations in energy, engineering, and climate systems.
	Industry, Innovation and Infrastructure (SDG 9)	Simulations in energy, engineering, and climate systems.
	Climate Action (SDG 13)	Simulations in energy, engineering, and climate systems.
Topology	Quality Education (SDG 4)	Important in data science, network analysis, and physics.
	Industry, Innovation and Infrastructure (SDG 9)	Important in data science, network analysis, and physics.
Complex Analysis	Quality Education (SDG 4)	Key for applications in electromagnetism and fluid mechanics.
	Industry, Innovation and Infrastructure (SDG 9)	Key for applications in electromagnetism and fluid mechanics.
Partial Differential Equations	Good Health and Well-being (SDG 3)	Crucial in medical imaging, environmental modeling, and physics.
	Clean Water and Sanitation (SDG 6)	Crucial in medical imaging, environmental modeling, and physics.
	Climate Action (SDG 13)	Crucial in medical imaging, environmental modeling, and physics.
Typesetting in LaTeX & Seminar	Quality Education (SDG 4)	Enhances academic communication and global collaboration.
	Partnerships for the Goals (SDG 17)	Enhances academic communication and global collaboration.

Integral Equations & Calculus of Variation	Affordable and Clean Energy (SDG 7)	Used in mechanics, optimization, and engineering design.
	Industry, Innovation and Infrastructure (SDG 9)	Used in mechanics, optimization, and engineering design.
	Climate Action (SDG 13)	Used in mechanics, optimization, and engineering design.
Functional Analysis	Quality Education (SDG 4)	Core to systems theory and quantum mechanics.
	Industry, Innovation and Infrastructure (SDG 9)	Core to systems theory and quantum mechanics.
Mathematical Statistics	Zero Hunger (SDG 2)	Informs evidence-based policy, medical and social sciences.
	Good Health and Well-being (SDG 3)	Informs evidence-based policy, medical and social sciences.
	Reduced Inequalities (SDG 10)	Informs evidence-based policy, medical and social sciences.
	Partnerships for the Goals (SDG 17)	Informs evidence-based policy, medical and social sciences.
Wavelet Analysis	Good Health and Well-being (SDG 3)	Used in signal processing, image compression, and environmental data analysis.
	Industry, Innovation and Infrastructure (SDG 9)	Used in signal processing, image compression, and environmental data analysis.
	Climate Action (SDG 13)	Used in signal processing, image compression, and environmental data analysis.
Information Theory	Industry, Innovation and Infrastructure (SDG 9)	Fundamental to data transmission, networks, and communication systems.
	Partnerships for the Goals (SDG 17)	Fundamental to data transmission, networks, and communication systems.
Operations Research	Decent Work and Economic Growth (SDG 8)	Optimization in logistics, transportation, and resource allocation.
	Industry, Innovation and Infrastructure (SDG 9)	Optimization in logistics, transportation, and resource allocation.
	Sustainable Cities and Communities (SDG 11)	Optimization in logistics, transportation, and resource allocation.
Applied Discrete Mathematics	Industry, Innovation and Infrastructure (SDG 9)	Useful in computer science, networks, and urban planning.
	Sustainable Cities and Communities (SDG 11)	Useful in computer science, networks, and urban planning.
Theory of Elasticity	Industry, Innovation and Infrastructure (SDG 9)	Models structural integrity in engineering and construction.
	Sustainable Cities and Communities (SDG 11)	Models structural integrity in engineering and construction.
Advance Algebra	Quality Education (SDG 4)	Advanced mathematical reasoning relevant to digital systems.
	Industry, Innovation and Infrastructure (SDG 9)	Advanced mathematical reasoning relevant to digital systems.
Fuzzy Set Theory	Good Health and Well-being (SDG 3)	Models uncertainty in medical diagnosis, AI, and decision-making.
	Industry, Innovation and Infrastructure (SDG 9)	Models uncertainty in medical diagnosis, AI, and decision-making.
Differential Geometry	Industry, Innovation and Infrastructure (SDG 9)	Used in robotics, general relativity, and modern architecture.

	Sustainable Cities and Communities (SDG 11)	Used in robotics, general relativity, and modern architecture.
Mathematical Modelling	Good Health and Well-being (SDG 3)	Core to real-world problem-solving in public health, environment, and technology.
	Clean Water and Sanitation (SDG 6)	Core to real-world problem-solving in public health, environment, and technology.
	Climate Action (SDG 13)	Core to real-world problem-solving in public health, environment, and technology.
Advanced Numerical Analysis	Affordable and Clean Energy (SDG 7)	Efficient simulation of physical systems and engineering designs.
	Industry, Innovation and Infrastructure (SDG 9)	Efficient simulation of physical systems and engineering designs.
	Climate Action (SDG 13)	Efficient simulation of physical systems and engineering designs.
Finite Element Methods	Industry, Innovation and Infrastructure (SDG 9)	Used in structural engineering, material science, and simulations.
	Sustainable Cities and Communities (SDG 11)	Used in structural engineering, material science, and simulations.
Advanced Complex Analysis	Industry, Innovation and Infrastructure (SDG 9)	Deepens tools for physics and engineering modeling.
	Quality Education (SDG 4)	Deepens tools for physics and engineering modeling.
Introduction to Cryptography	Industry, Innovation and Infrastructure (SDG 9)	Ensures secure digital communication, privacy, and e-governance.
	Peace, Justice and Strong Institutions (SDG 16)	Ensures secure digital communication, privacy, and e-governance.
Advanced Abstract Algebra	Quality Education (SDG 4)	Higher-level theory for secure algorithms and academic excellence.
	Industry, Innovation and Infrastructure (SDG 9)	Higher-level theory for secure algorithms and academic excellence.
Measure and Integration	Quality Education (SDG 4)	Foundation for probability, statistics, and advanced analysis.
	Industry, Innovation and Infrastructure (SDG 9)	Foundation for probability, statistics, and advanced analysis.
Mechanics	Industry, Innovation and Infrastructure (SDG 9)	Essential in physics-based modeling, engineering systems, and mobility.
	Sustainable Cities and Communities (SDG 11)	Essential in physics-based modeling, engineering systems, and mobility.
Number Theory	Industry, Innovation and Infrastructure (SDG 9)	Foundation of cryptography, internet security, and blockchain.
	Peace, Justice and Strong Institutions (SDG 16)	Foundation of cryptography, internet security, and blockchain.
Mathematics for Finance and Insurance	No Poverty (SDG 1)	Enables financial modeling, risk management, and inclusive economic planning.
	Decent Work and Economic Growth (SDG 8)	Enables financial modeling, risk management, and inclusive economic planning.
	Reduced Inequalities (SDG 10)	Enables financial modeling, risk management, and inclusive economic planning.
Fluid Dynamics	Clean Water and Sanitation (SDG 6)	Models ocean currents, weather, water systems, and environmental processes.
	Climate Action (SDG 13)	Models ocean currents, weather, water systems, and environmental processes.

	Life Below Water (SDG 14)	Models ocean currents, weather, water systems, and environmental processes.
Introduction To Mathematical Analysis	Quality Education (SDG 4)	Provides a foundation for logical reasoning and advanced STEM education.
	Industry, Innovation and Infrastructure (SDG 9)	Provides a foundation for logical reasoning and advanced STEM education.
Basic Mathematics for Social Sciences	No Poverty (SDG 1)	Equips students with quantitative tools for economics, policy analysis, and social equity studies.
	Reduced Inequalities (SDG 10)	Equips students with quantitative tools for economics, policy analysis, and social equity studies.
	Partnerships for the Goals (SDG 17)	Equips students with quantitative tools for economics, policy analysis, and social equity studies.
LaTeX & Seminar	Quality Education (SDG 4)	Promotes effective scientific communication, collaboration, and academic writing.
	Partnerships for the Goals (SDG 17)	Promotes effective scientific communication, collaboration, and academic writing.
Introduction To Numerical Methods	Affordable and Clean Energy (SDG 7)	Enables computational solutions in engineering, climate modeling, and energy systems.
	Industry, Innovation and Infrastructure (SDG 9)	Enables computational solutions in engineering, climate modeling, and energy systems.
	Climate Action (SDG 13)	Enables computational solutions in engineering, climate modeling, and energy systems.
Discrete Mathematics	Industry, Innovation and Infrastructure (SDG 9)	Key for computer science, cybersecurity, and infrastructure development.
	Sustainable Cities and Communities (SDG 11)	Key for computer science, cybersecurity, and infrastructure development.
	Peace, Justice and Strong Institutions (SDG 16)	Key for computer science, cybersecurity, and infrastructure development.

IKS Mapping

Course Name	IKS Mapping	Rationale
Real Analysis	Abstract Reasoning in Indian Philosophy	Supports abstract mathematical reasoning; Indian logic schools like Nyaya and Vedanta explore similar themes.
Abstract Algebra	Vedic Algebra and Number Systems	Indian mathematicians developed algebraic methods, including solving linear and quadratic equations.
Linear Algebra	Cosmological Dimensions in IKS	Indian cosmology describes space using multi-dimensional constructs, similar to vector space theory.
Ordinary Differential Equations	Ayurvedic Systems and Planetary Models	Indian thinkers modeled planetary and bodily dynamics in Ayurveda with differential methods.
Programming in C	Algorithmic Logic in Panini's Grammar	Panini's rules mirror logic used in modern programming structures.
Numerical Analysis	Jyotisha and Numerical Methods	Traditional Jyotisha used iterative numerical approximations.
Topology	Temple Geometry and Topological Designs	Sacred Indian geometries reveal topological thinking in designs.
Complex Analysis	Duality in Indian Metaphysics	Complex numbers relate to dualities (e.g., Purusha-Prakriti) in Indian thought.
Functional Analysis	Infinite-Dimensional Logic Models	Infinite-dimensional reasoning present in Indian metaphysical models.
Wavelet Analysis	Vedic Acoustics and Sound Theory	Time-frequency analysis has roots in Vedic sound theory.
Information Theory	Communication in Arthashastra	Strategies of information concealment in Arthashastra parallel modern information theory.
Operations Research	Optimization in Ancient Planning Texts	Indian planning texts focused on optimization of resources and logistics.
Theory of Elasticity	Stress-Strain in Temple Construction	Elastic properties noted in ancient Indian texts on architecture and materials.
Advanced Algebra	Historical Developments in Indian Algebra	Indian algebra evolved through Brahmagupta's and Bhaskara's works.
Fuzzy Set Theory	Jain Syadvada and Fuzzy Logic	Jain philosophy proposed multi-valued logic compatible with fuzzy logic.

Differential Geometry	Geometry in Sacred Architecture	Indian altars and architecture embedded principles of non-Euclidean geometry.
Mathematical Modelling	Holistic Modelling in Ancient Texts	Holistic systems modeling appears in Ayurveda and ancient city planning.
Advanced Numerical Analysis	Astronomical Calculations in Siddhanta	Interpolation used in Indian ephemerides mirrors numerical approximation methods.
Finite Element Methods	Indian Engineering Calculations	Used in ancient Indian architectural calculations of joints and support.
Advanced Complex Analysis	Metaphysical Continuity Theories	Involves residue theorems and analytic continuation—mirrored in metaphysical ideas.
Advanced Abstract Algebra	Algebraic Innovations in India	Abstract algebra emerged from Indian number and symbol manipulation traditions.
Measure and Integration	Measurement in Vedic Land Division	Land division practices in Vedic India used measurement integration concepts.
Mechanics	Karma Theory and Motion	Karma theory involved modeling motion and impact similar to Newtonian mechanics.
Number Theory	Sulba Sutras and Modular Arithmetic	The Bakhshali manuscript shows early use of primes and modularity.
Fluid Dynamics	Panchabhuta and Hydrodynamics	Flow models reflect Panchabhuta (five elements) interactions.
Basic Mathematics for Social Sciences	Planning Strategies in Arthashastra	Public planning in ancient India optimized social and economic outcomes.
Numerical Methods	Interpolation Techniques in Siddhantas	Interpolation formulas used in Siddhantas similar to numerical methods.
Discrete Mathematics	Automata in Panini’s Sutras	Discrete modeling like automata is embedded in Sanskrit grammar frameworks.

General Information

VISION AND MISSION

University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

Department

Vision

To be an internationally recognized centre for research and teaching in mathematics. To encourage excellence, innovation, integrity and values for society in the department. To produce global leaders for academic and industry by imparting multidisciplinary and contemporary mathematical knowledge to the students.

Mission

- To contribute towards building calibre of the students by providing quality education and research in Mathematics through updated curriculum, effective teaching learning process.
- To impart innovative skills, team-work, ethical practices to the students so as to meet societal expectations.
- To build a strong base in Mathematics for various academic programs across the institute.

1. BACKGROUND

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon— integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and

Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About the Mathematics

Mathematics is a powerful tool for global understanding and communication that organizes our lives and prevents chaos. Mathematics helps us understand the world and provides an effective way of building mental discipline. Mathematics encourages logical reasoning, critical thinking, creative thinking, abstract or spatial thinking, problem-solving ability, and even effective communication skills. Mathematics is necessary to understand the other branches of knowledge. All depend on mathematics in one way or another. There is no science, art, or specialty except mathematics was the key to it. The discipline and mastery of any other science or art are very much related to the size of mathematics.

iii) About the Programme (Nature, extent and aims)

A master's degree is a postgraduate degree for students who want to become more skilled or specialized in a particular discipline. While bachelor's and other undergraduate degrees typically give a relatively broad overview of a particular area of study, master's degrees tend to be more focused and allow students to develop the depth of their knowledge in a particular subject, putting them on the right course to become leaders in their fields.

The M.Sc. Mathematics programme, aims to build strong foundations in core areas of higher mathematics in both the pure and applied areas. It is meant for students who would typically take up careers involving mathematical research or mathematical skills – in academia or in industry. The training imparted to the students helps them master the art of problem solving, developing logical reasoning and computational capabilities which are essential traits in all walks of life. Additionally, the knowledge of mathematical modeling and computational training which the students acquire during the programme makes them highly sought after. In keeping with the demands of industry and academia, the syllabus is updated regularly, with inputs taken from various stakeholders including students, alumni and parents at different stages of the preparation of the syllabus.

Eligibility:

Bachelor's degree or equivalent from any recognized Indian or foreign university with a minimum of 50% marks or equivalent grade in aggregate (Relaxation of 5% to the SC/ST/PWD/OBC (Non-creamy Layer) candidates).

iv) Qualification Descriptors (possible career pathways)

Upon successful completion of the course, the students receive a master degree in the Mathematics. M.Sc. Mathematics post-graduates of this department are expected to demonstrate knowledge of major portion of pure and applied mathematics and the ability to provide an overview of scholarly debates relating to Mathematics. Also it is expected that after the completion of this program they will be in a position to pursue their research in Mathematics. Along with mathematical skills, it is also expected that they will learn life skills of argumentation, communication and general social values which are necessary to live rich, productive and meaningful lives. The list below provides a synoptic overview of possible career paths provided by a postgraduate training in Mathematics:

1. Teaching
2. Research
3. Engineering
4. Computer programming (In different MNC's)
5. Statistician
6. Defense Research and Development Organization (DRDO) and Indian Space Research Organization (ISRO).
7. Can go for UPSC/Civil services exam.
8. Finance
9. Science and business

2. PROGRAMME OUTCOMES (POs)

Students enrolled in the Master's Programmes offered by the Departments under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities:

POs	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork	Ability to learn and work in a groups and capable of leading a team

	abilities	even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and Social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)
The graduates shall be able to realise the following specific outcomes by the end of program studies:
On successful completion of the M.Sc. Mathematics programme a student

Number	**Programme Specific Outcomes**
PSO-1	Will have a strong foundation in both pure and applied mathematics.
PSO-2	Will be able to apply mathematical skills for solving problems and for preparing various competitive exams.
PSO-3	Will be able to communicate mathematical knowledge effectively, in writing as well as orally.
PSO-4	Will identify applications of mathematics in other disciplines, leading to enhancement of career prospects in different fields and research areas.
PSO-5	Will have basic knowledge of programming and computational techniques as required for employment.
PSO-6	Should have the knowledge of the fundamental axioms in mathematics and capability of developing ideas based on them and inculcate mathematical reasoning.
PSO-7	Will be able to locate and analyse the different mathematical texts with appropriate theoretical framework.
PSO-8	Have the knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in science, social science, engineering and technology.
PSO-9	Should be able to develop analytical skills, critical thinking, creativity, communication and presentation skills through assignments, seminar, project work.
PSO-10	Should be able to apply their skills and knowledge that translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.

4. GRADUATE ATTRIBUTES

No.	Graduate Attributes
PGA-1	Disciplinary Knowledge
PGA-2	Creative and Critical Thinking
PGA-3	Reflective Thinking
PGA-4	Problem Solving
PGA-5	Analytical Reasoning
PGA-6	Communication Skills
PGA-7	Research Skills
PGA-8	Life Skills
PGA-9	Life-long Learning
PGA-10	Global Competency

5. STRUCTURE OF MASTER'S PROGRAMME

Types of Courses	Nature	Total Credits	%
Core Courses (CC)	Compulsory		
Elective Courses (EC)	Discipline Specific Courses		
	Multidisciplinary Courses		

Note: The Scheme and Syllabus of the course are subject to change according to the UGC guidelines, NEP-2020 and University ordinance.

Evaluation Scheme: **The evaluation scheme for each course/component shall be as per the relevant clause of the university ordinances.**

Course Type

Core Courses (CC)
Discipline Specific Electives (DSE)
Multidisciplinary Courses (MDC)

6. LEARNING OUTCOME INDEX

6.1A Mapping of Courses with PSOs (first year)

Semester	**PSOs ⇨**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PSO 7**	**PSO 8**	**PSO 9**	**PSO 10**
	Course No. ⇩										
I	**1**	√	√	√	√	x	√	√	√	√	√
	2	√	√	√	√	√	√	√	√	√	√
	3	√	√	√	√	√	√	√	√	√	√
	4	√	√	√	√	√	x	√	√	√	√
	5	√	√	√	√	√	√	x	√	√	√
	6	√	√	√	√	√	√	√	√	√	√
	7	√	√	√	√	x	√	√	√	√	√
	8	√	√	√	√	x	√	√	√	√	√
	9	√	√	√	√	√	√	√	√	√	√
II	**10**	√	√	√	√	√	√	√	√	√	√
	11	√	√	√	√	√	√	√	√	√	√
	12	√	√	√	√	√	√	√	√	√	√
	13	√	√	√	√	√	√	√	√	√	√
	14	√	√	√	√	√	√	√	x	x	√
	15	√	√	√	√	√	√	√	x	x	√
	16	√	√	√	√	√	√	√	√	√	√
	17	√	√	√	√	√	√	√	√	√	√
	18	√	√	√	√	√	√	√	√	x	√
	19	√	√	√	√	√	√	√	√	√	√
	20	√	√	√	√	√	√	√	√	√	√
	21	√	√	√	√	√	√	√	√	√	√

6.1B Mapping of Courses with PSOs (second year)

Semester	PSOs ⇨	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
	Course No. ⇩										
III	22	√	√	√	√	x	√	√	√	√	√
	23	√	√	√	√	√	√	√	x	√	√
	24	√	√	√	√	√	√	√	√	√	√
	25	√	√	√	√	√	√	√	√	√	√
	26	√	√	√	√	√	√	√	√	√	√
	27	√	√	√	√	x	√	√	√	√	√
	28	√	√	√	√	√	√	√	√	√	√
	29	√	√	√	√	√	x	√	√	√	√
	30	√	√	√	√	√	√	√	√	√	√
IV	31	√	√	√	√	√	√	√	√	√	√
	32	√	√	√	√	x	√	√	√	√	√
	33	√	√	√	√	√	√	√	√	√	√
	34	√	√	√	√	x	√	√	√	√	√
	35	√	√	√	√	√	√	√	√	√	x
	36	√	√	√	√	√	√	√	√	√	√
	37	√	√	√	√	√	√	√	√	√	√
	38	√	√	√	√	√	√	√	√	√	√
	39	√	√	√	√	√	√	√	√	√	√
	40	√	√	√	√	x	√	√	√	√	√
	41	√	√	√	√	√	√	√	√	√	√
	42	√	√	√	√	√	√	√	√	√	√
	43	√	√	√	√	√	√	√	√	√	√
	44	√	√	√	√	√	√	√	√	√	√
	45	√	√	√	√	√	√	√	√	√	√