Chaudhary Bansi Lal University

(A State University established under Haryana Act No. 25 of 2014)

SCHEME AND SYLLABI

for

TWO YEAR POSTGRADUATE PROGRAMME

M.Sc. MATHEMATICS

(1st and 2nd Semester)

As per NEP 2020

WITH EFFECT FROM THE SESSION 2025-26

Department of Mathematics
Chaudhary Bansi Lal University,
Prem Nagar-127031
Bhiwani
Haryana, India

Date of PGBOS&R: July 22, 2025

Vision and Mission of the University

Vision

To be known as a university having capacity to transform the society through continual innovations in education, research, creativity and entrepreneurship in the domain of higher education.

Mission

To create an environment in which new ideas, research and scholarship flourish and from which the leaders and innovators of tomorrow emerge.

To use local resources and environment as testing laboratory by the faculty and the students for generating new ideas and solutions of local problems.

To provide a challenging and rigorous curriculum which is global in outlook and simultaneously provides an understanding of the needs of society and industry.

To collaborate with leading academic and research institutes around the world to strengthen the education and research ecosystem.

To integrate ICT into teaching-learning processes and administrative systems for enhancing their effectiveness.

To create forums and to encourage students to participate in curricular and extra-curricular activities, to showcase and hone their talent and creativity.

To promote continuous engagement with stakeholders at all levels i.e. students, faculties, administration, alumni, industries, management of affiliated institutions, government regulatory bodies and community for their support, new ideas and feedback.

Vision and Mission of the Department

Vision

•To provide an environment where students can learn and become competent users of Mathematics and Mathematical applications in real life, industry and other disciplines.

- **To impart quality education combining academics with joy of discovery and inculcation of the spirit of research through innovative teaching and research methodologies.**

Mission

- **To provide quality education to the students to prepare them as a good academician to serve the society better.**
- **To achieve high standards of excellence in generating and propagating knowledge in Mathematics with research and academic excellence.**

Programme Learning Outcomes

PLO No.	Component	Outcomes
PLO 1.	Basic Knowledge and critical thinking	Capable of delivering basic disciplinary knowledge and able to understand critically the results.
PLO 2.	In- depth knowledge and problem solving abilities	Capable of describing advance knowledge gained during the programme and applying acquired knowledge to solve the problems.
PLO 3.	Creativity, analytical innovation and computation skills	Capable to identify, formulate, investigate and analyse the scientific problems innovatively to design through mathematical software and solutions to real life problems.
PLO 4.	Research aptitude and global competency	Ability to cultivate a research aptitude and use information to solve demanding research issues in the relevant and related fields globally.
PLO 5.	Holistic, multidisciplinary skill enhancement	Ability to learn through a multidisciplinary & holistic approach in various subjects, acquiring specialized talents and advanced methods consequently applying them to enhanced humanity.
PLO 6.	Ethical and professional responsibility	Encourage a moral, professional mind-set and the capacity to connect to societal issues.
PLO 7.	Leadership and team work abilities	The capacity to learn, collaborate with multidisciplinary teams and even take charge of a group.

Scheme and Syllabus of Two Year Post Graduate Programme (Semester I and Semester II) M.Sc. in Mathematics:2025-26

Courses			Credits Distribution			Total Credits	Total Workload	Marks				
	Nomenclature of Course	Course Code	L	T	P		Total Contact Hours	Theory		Practical		Total Marks
								Internal	External	Internal	External	
SEMESTER-I (23 Credits)												
CC-1 4 credits	Real Analysis-I	25PN-MTH101	4	0	0	4	4	30	70	-	-	100
CC-2 4 credits	Modern Algebra	25PN-MTH102	4	0	0	4	4	30	70	-	-	100
CC-3 4 credits	Ordinary Differential Equations	25PN-MTH103	4	0	0	4	4	30	70	-	-	100
CC-4 4 credits	Mechanics	25PN-MTH104	4	0	0	4	4	30	70	-	-	100
PC-1 3 credits	Programming in FORTRAN 90/95	25PN-MTH105	0	0	3	3	6	-	-	20	50	70
Any one of the following												
DEC-1 4 credits	Mathematical Statistics	25PN-MTH106	4	0	0	4	4	30	70	-	-	100
	Mathematical Modeling	25PN-MTH107	4	0	0	4	4	30	70	-	-	100
	Discrete Mathematics	25PN-MTH108	4	0	0	4	4	30	70	-	-	100
SEMESTER-II (25 Credits)												
CC-5 4 credits	Real Analysis-II	25PN-MTH201	4	0	0	4	4	30	70	-	-	100
CC-6 4 credits	Linear Algebra	25PN-MTH202	4	0	0	4	4	30	70	-	-	100
CC-7 4 credits	Partial Differential Equations and Fourier Analysis	25PN-MTH203	4	0	0	4	4	30	70	-	-	100
CC-8 4 credits	Complex Analysis	25PN-MTH204	4	0	0	4	4	30	70	-	-	100
PC-2 3 credits	Computational work using R-Programming	25PN-MTH205	0	0	3	3	6	-	-	20	50	70
Any one of the following												
DEC-2 4 credits	Operation Research Techniques	25PN-MTH206	4	0	0	4	4	30	70	-	-	100
	Mathematics for Finance and Insurance	25PN-MTH207	4	0	0	4	4	30	70	-	-	100
	Fuzzy Set Theory	25PN-MTH208	4	0	0	4	4	30	70	-	-	100
IKS/OEC 2 credits	Mathematics in India: From Vedic Period to Modern Times	25PN-MTH209	2	0	0	2	2	15	35	-	-	50

Semester-I

Name of the Course: Real Analysis-I	**Course Code : 25PN-MTH101**	**Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Understand the concepts of continuity, uniform continuity and their related theorems.
CLO2 Describe the concepts of limit, continuity and differentiability of real valued function of two variables.
CLO3 Explain maxima, minima and saddle pointes of two variables and Lagrange's method of multipliers.
CLO4 Understand Riemann integral and fundamental theorems of integral calculus.

Section – I

Continuity, Sequential continuity, Properties of continuous functions, Uniform continuity, Chain rule of differentiability. Mean value theorems: Rolle's Theorem and Lagrange's mean value theorem and their geometrical interpretations. Taylor's Theorem with various forms of remainders, Darboux intermediate value theorem for derivatives, Reduction formulae. Rectification, Intrinsic equations of curve.

Section – II

Limit and continuity of real valued functions of two variables. Partial differentiation. Total Differentials: Composite functions & Implicit functions. Change of variables. Homogenous functions & Euler's theorem on homogeneous functions. Taylor's theorem for functions of two variables.

Section - III

Differentiability of real valued functions of two variables. Schwarz and Young's theorem. Implicit function theorem. Maxima, Minima and saddle points of two variables. Lagrange's method of multipliers Jacobian.

Section – IV

Riemann integral, Integrability of continuous and monotonic functions, The Fundamental theorem of integral calculus. Mean value theorems of integral calculus.

References

1. Gabriel Klaumber: Mathematical Analysis, Mrcel Dekkar, Inc., New York, 1975.
2. R.R. Goldberg: Real Analysis, Oxford & I.B.H. Publishing Co., New Delhi, 1970.
3. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad.
4. S.C. Malik : Mathematical Analysis, Wiley Eastern Ltd., Allahabad.
5. Shanti Narayan: A Course in Mathemtical Analysis, S.Chand and company, New Delhi.
6. Murray, R. Spiegel: Theory and Problems of Advanced Calculus, Schaum Publishing co., New York.

Semester-I

Name of the Course: Modern Algebra	**Course Code: 25PN-MTH102**	**Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1 Demonstrate understanding of the idea of a group, subgroup, cyclic groups, normal groups and quotient groups.

CLO 2 Understand and apply the concepts of homomorphism, isomorphism, automorphisms and inner automorphisms of a group.

CLO 3 Understand rings, subrings, ring homorphisms and field of quotients,

CLO4 Demonstrate capacity for mathematical reasoning through analysing, proving and explaining concepts from advanced algebra.

Section – I

Definition of a group with example and simple properties of groups, Subgroups and Subgroup criteria, Generation of groups, cyclic groups, Cosets, Left and right cosets, Index of a sub-group coset decomposition, Largrage's theorem and its consequences, Normal subgroups, Quotient groups**.**

Section – II

Homoomorphisms, isomophisms, automorphisms and inner automorphisms of a group. Automorphisms of cyclic groups, Permutations groups. Even and odd permutations. Alternating groups, Cayley's theorem, Center of a group and derived group of a group..

Section - III

Introduction to rings, subrings, integral domains and fields, Characteristics of a ring. Ring homomorphisms, ideals (principle, prime and Maximal) and Quotient rings, Field of quotients of an integral domain.

Section – IV

Euclidean rings, Polynomial rings, Polynomials over the rational field, The Eisenstein's criterion, Polynomial rings over commutative rings, Unique factorization domain, R unique factorization domain implies so is R[X1 , X2,……Xn]

References:

1. Herstein I.N,1975. Topics in Algebra, Wiley Eastern Ltd., New Delhi.
2. Bhattacharya P.B., Jain S.K., Nagpal S.R., 2003, Basic Abstract Algebra (2nd edition), Cambridge University Press.
3. Sahai V., Bist V., 2013, Linear Algebra, Narosa Publishing House.
4. Luther I.S., Passi I.B.S., 1905, Algebra, Vol.-II, Narosa Publishing House.
5. Gallian J.A., 1999, Abstract Algebra, Narosa Publishing House.

Semester-I

Name of the Course: Ordinary Differential Equations	**Course Code: 25PN-MTH103**	**Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External) =100**	**Time of Examinations: 03 Hours**	

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Many fundamental laws of physics and chemistry can be formulated as differential equations.

CLO 2:. Learn to illustrate the concept of identification of differential equations, some analytical techniques to find solutions.

CLO 3 Demonstrate and understand the autonomous system and stability theory.

CLO 4: Use various methods to get qualitative information about the general behaviour of the solutions of various problems.

Section-I

Preliminaries: Initial value problem and equivalent integral equation. Lipschitz condition, Picard Fundamental existence and uniqueness theorem for dy/dt= f(t,y), Dependence of solutions on initial conditions and parameters, Solution of initial-value problems by Picard method.

Sturm Theory: Adjoint systems, Self-Adjoint Equations of the Second order, Abel's Formula, Sturm Separation and Comparison theorems, Lagrange's identity and Green's formula for second order differential equations,

Section-II

Linear systems, Matrix method for homogeneous first order system of linear differential equations, Fundamental set of solutions, Fundamental matrix of solutions, Wronskian of solutions, Basic theory of the homogeneous linear system, Abel-Liouville formula, Nonhomogeneous linear system. SLBVP, Properties of eigenvalues and eigen functions, Pruffer transformation,

Section-III

Nonlinear differential systems, Phase plane, Path, Critical points, Autonomous systems, Isolated critical points, Path approaching a critical point, Path entering a critical point, Types of critical points- Center, Saddle points, Spiral points, Node points, Stability of critical points, Asymptotically stable points, Unstable points, Critical points and paths of linear systems. Almost linear systems.

Section-IV

Nonlinear conservative dynamical system, Dependence on a parameter, Liapunov function and Liapunov's method to determine stability for nonlinear systems, Periodic solutions and Floquet theory for periodic systems, Limit cycles, Bendixson non-existence theorem, Poincare-Bendixson theorem(Statement only), Index of a critical point.

References:

1. Boyce W.E. and Diprima R.C., Elementary Differential Equations and Boundary Value Problems, John Wiley and Sons, Inc., New York, 2009, 9th edition.
2. Coddington E.A. and Levinson N., Theory of Ordinary Differential Equations, Tata McGraw Hill, 2017.
3. Deo S.G., Lakshmikantham V. and Raghavendra V., Textbook of Ordinary Differential Equations, Tata McGraw Hill, 2017.
4. Goldberg J. and Potter M.C., Differential Equations – A System Approach, Prentice Hall, 1998
5. Hartman P., Ordinary Differential Equations, John Wiley & Sons, 1987.
6. Ross S.L., Differential Equations, John Wiley and Sons Inc., New York, 1984.
7. Simmons G.F., Differential Equations, Tata McGraw Hill, New Delhi, 2003.
8. Somasundram D., Ordinary Differential Equations, A First Course, Narosa Pub. Co., 2016.
9. J. M. Gelfand and S. V. Fomin, Calculus of Variations, Prentice Hall, New Jersy, 1963.

Semester-I

Name of the Course: Mechanics	**Course Code: 25PN-MTH104**	**Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
After completing this course, student is expected to learn the following:
CLO1: Understand the notion of moment & product of inertia and its applications
CLO2: Use the Lagrangian and Hamiltonian functions to formulate the equation of motion for mechanical systems
CLO3: Understand Poisson Bracket along with principle of least action.
CLO4: Understand the concept of attraction and potential along with equipotential surfaces

Section – I

Moments and products of Inertia, Theorems of parallel and perpendicular axes, Angular momentum of a rigid body about a fixed point and about a fixed axes, Principal axes, Kinetic energy of a rigid body rotating about a fixed point, Momental ellipsoid- Equimomental systems, Coplanar distributions. Euler's dynamical equations for the motion of a rigid body about a fixed point, Further properties of Rigid body motion under no forces.

Section – II

Generalized co-ordinates. Holonomic and Non-holonomic systems. Scleronomic and Rheonomic systems. Lagrange's equations for a simple holonomic dynamical system, Lagrange's equations for conservative and impulsive forces. Kinetic energy as a quadratic functions of velocities. Generalized potential, Energy equation for conservative fields. Hamilton's canonical variables. Donkin's theorem. Hamilton canonical equations. Cyclic coordinates. Routh's procedure.

Section – III

Poisson Bracket. Poisson's Identity. Jacobi-Poisson Theorem. Hamilton's Principle. Principle of Least action. Poincare Cartan Integral invariant. Whittaker's equations. Jacobi's equations. Hamilton-Jacobi equation. Jacobi theorem. Method of Separation of variables. Lagrange Brackets, Canonical Transformations, Condition of canonical character of a transformation in terms of Lagrange and Poisson brackets. Invariance of Lagrange and Poisson brackets under canonical transformations.

Section – IV

Gravitation: Attraction and potential of rod, disc, spherical shells and sphere. Laplace and Poisson equations. Work done by self-attracting systems. Distributions for a given potential. Equipotential surfaces. Surface and solid harmonics. Surface density in terms of surface harmonics.

References:
1. F. Chorlton, A Text Book of Dynamics, CBS Publishers & Dist., New Delhi. 2004.
2. F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow. 1975.
3. F. B. Hildebrand, Method of Applied Mathematics, Dover Publications,2012.

Semester-I

Name of the Course: Programming in FORTRAN 90/95	**Course Code: 25PN-MTH105**	**Credits:3**
Maximum Marks **Practical: 20(Internal)+50(External)=70**	**Time of Examinations: 3 Hours**	

Course Learning Outcomes (CLO):

CLO1: Students would be able to understand Fortran programming

CLO2: Be familiar with the concepts of loops, arrays, and functions.

CLO3: Students would be able to create algorithm and program to solve a real world problem.

Practical/ Computational Work

Practical: 20(Internal)+50(External)=70

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 25 Marks

ii) Viva-voce and practical record: 25 Marks

Introduction to Programming: Problem solving using Algorithms and Flowcharts.

Introduction to FORTRAN 90: Character Set, Constants and Variables, Data Types, Subscripted Variables and Simple Fortran Functions, Fortran Operators: types and precedence, Format Free Read Command, Format Free Print Command, Formatted Input and Output, Format Statement, Data object declaration, type declaration statement, Implicit Statement.

Conditional and control commands: IF- THEN - ENDIF Construct, IF - THEN - ELSE - ENDIF Construct, Logical IF Commands, Arithmetic IF Commands, CASE Construct; Transfer Commands, Loops in Fortran: Do Construct, Nested DO-Loops; CONTINUE Statement, Implied Do, Intent, Save, Exit, Stop, Data, Equivalence, Common, Parameter and Cycle Statement.

Arrays: Introduction, Array Storage: 1-D, 2-D and 3-D Arrays, Dimension Statement, Dynamic Allocation of Arrays. Functions and Subroutine: Statement Function, Library Functions, Function Subprograms, Dummy arguments, Actual arguments, Calling Functions and Subroutine.

File Manipulation: The OPEN & CLOSE statements, File INPUT/OUTPUT, READ & WRITE statements for sequential and Direct Access File, Formatted and Unformatted READ/WRITE statements. Pointers in Fortran.

List of Practicals

Following is the list of programmes to be performed on Fortran 95:

1. Solving mean, median, standard deviation, variance, correlation
2. Demonstrate basic structure of FORTRAN Program.
3. Demonstrates the use of arrays for data analysis-max, min, and average
4. Program to demonstrate use of formatted output.
5. Demonstrates the use of arrays with Fortran 90 specifications.
6. To find largest (or smallest) of three numbers. Computation of LCM and GCD.
7. To find the transpose of a matrix, addition and multiplication of two matrices.
8. Find the roots of quadratic equation, Area, volume of given figure.
9. Use of control statements, eg, IF, DO loop statement etc.
10. Calculate the SIN and COS of an angle given in degrees.
11. Example of a BUBBLE SORT.
12. Example of a SELECTION SORT using Fortran 90/95.

References:

1. Metcalf M., Reid J., Cohen M., 1999, FORTRAN 90/95 Explained, Oxford University Press, 2nd Revised edition.
2. Rajaraman V., 2009, Computer Programming in FORTRAN 90 and 95, PHI Learning. New Delhi.
3. Anders G.E., Fisk C.S.R., 1995, Spreadsheet Accounting Tutorial and Applications, McGraw-Hill.
4. Shelly G.B., Cashman T.J., Quasney J.S., 2000, Microsoft Excel 2000: Comprehensive Concepts and Techniques, Cashman Series.
5. Lambert J., Cox J., 2010, Microsoft Office Professional 2010 step by step, Microsoft Press U.S.
6. Nyhoff L., Leestma S., 1999, Introduction to Fortran 90., Prentice Hall.

Semester-I

Name of the Course: Mathematical Statistics	**Course Code: 25PN-MTH106**	**Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students will learn about the concept of probability, statistical distributions.
CLO2: Students will be able to illustrate the concept of testing of hypothesis.
CLO3: Students gets to learn the application of mathematics and its relation to the real world.

Section – I

Probability: Classical, Statistical and axiomatic approach, Addition theorem, Boole's inequality, Conditional probability and multiplication theorem, Independent events, Bayes' theorem and its applications.
Random variable, discrete and continuous random variables, probability mass and density functions, distribution function.

Section – II

Joint, marginal and conditional distributions. Mathematical Expectation and its properties. Variance, Covariance, Moment generating function. Discrete distributions: Binomial, Poisson and geometric distributions with their properties.

Section – III

Continuous distributions: Uniform, Normal, Gamma and Exponential distributions and their properties. Chebychev's inequality, Central Limit Theorem. Weak Law of Large Numbers.

Section – IV

Point and interval estimation, Unbiasedness, Sufficiency, Consistency and Efficiency. Testing of Hypothesis, Null and alternative hypotheses, Simple and composite hypotheses, types of errors, Level of significance, Power of the Test, Critical Region. One tailed and two tailed tests, t-test, Chi-square test and F-test.

References:

1. 1. A.M. Mood, Graybill F.A. and Boes D.C., Introduction to the theory of Statistics, McGraw Hill Book Company, 2001.
2. J.E. Freund, Mathematical Statistics, Prentice Hall of India, 2014.
3. M. Speigel, Probability and Statistics, Schaum Outline Series.
4. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand Pub., New Delhi,2014.
5. H.C. Taneja, Statistical Methods for Engineering & Sciences, I. K.International,2009.
6. Gun A.M, Gupta M.K, Dasgupta , Fundamental of Statistics Vol. 1 & 2, World Press,2016

Semester-I

Name of the Course: Mathematical Modeling	**Course Code: 25PN-MTH107**	**Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Be familiar the concept of mathematical modeling.

CLO2: Derive solutions of various problems using different techniques to describe and explore real world data and phenomena.

CLO3: Learn about application of mathematics using ODE in various fields.

CLO4: Solving real life problems using mathematical modelling.

Section – I

Mathematical modeling: need, techniques, classification and illustrations; Mathematical modeling through ordinary differential equations of first order. Linear growth and Decay models. Non-Linear and Decay models.

Section – II

Epidemic spreading and compartment Population Dynamics, Epidemics models; mathematical mode1ing through systems of ordinary differential equations; mathematical mode1ing in economic, medicine, arm-race, battle.

Section – III

Mathematical modeling through ordinary differential equations of second order Planetary motion, Circular motion and motion of Satellites. Higher order (linear) models. Mathematical modeling through difference equations: Need, basic theory; mathematical modeling in probability theory, economics, finance, population dynamics and genetics.

Section – IV

Mathematical modeling through partial differential equations: simple models, mass-balance equations, variational principles, probability generating function, traffic flow problems, initial & boundary conditions.

References:

1. J.N. Kapur: Mathematical Modeling, Wiley Eastern Ltd., 1990
2. B. Albright;Mathematical Modeling with Excel, Jones & Bartlett,2010

Semester-I

Name of the Course: Discrete Mathematics	**Course Code: 25PN-MTH108**	**Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:
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Course Learning Outcomes (CLO):

CLO1: Understand and apply discrete numeric functions, generating functions, and solve recurrence relations using both algebraic and generating function methods.

CLO2: Analyze algebraic structures such as groups, rings, and lattices, and demonstrate understanding of their fundamental properties.

CLO3: Apply Boolean algebra to simplify logic expressions and design efficient digital circuits using Karnaugh maps and switching theory.

CLO4: Develop problem-solving skills in number theory, including divisibility, modular arithmetic, and congruences.

Section – I

Discrete numeric functions, Generating functions, recurrence relations with constant coefficients. Homogeneous solution, particular relations, total rotation, Solution of recurrence relation by the method of generating functions.

Section-II

Semigroups, Lattices and their properties, lattice as algebraic system, Bounded, Complement and distributive lattices.

Section-III

Boolean algebra, definition and examples, properties, duality, distributive and complemented Calculus. Design and implementation of digital networks, switching circuits, Karnaugh map.

Section-IV

The division algorithm, different bases, the equation ax + by = n, the bracket function and binomial coefficients, the ¢-function, the order of an integer modulo m, periodic decimals.

Books Recommended:

1. J.P. Tremblay & R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co., 1997.
2. J.L. Gersting, Mathematical Structures for Computer Science, (3rd edition), Computer Science Press, New York.
3. Seymour Lipschutz, Finite Mathematics (International edition 1983), McGraw-Hill Book Company, New York.
4. C.L. Liu, Elements of Discrete Mathematics, McGraw-Hilll Book Co.
5. Babu Ram, Discrete Mathematics, Vinayak Publishers and Distributors, Delhi, 2004.
6. Thomas Koshy, Elementary Number Theory with Applications, Academic Press is an imprint of Elsevier, London, 2007.
7. Neal H. McCoy, The Theory of Numbers, The Macmillan Company, New York Collier-Macmillan Limited, London, 1966.

Chaudhary Bansi Lal University

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SCHEME AND SYLLABI

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TWO YEAR POSTGRADUATE PROGRAMME

M.Sc. MATHEMATICS

As per NEP 2020

WITH EFFECT FROM THE SESSION 2025-26

Department of Mathematics
Chaudhary Bansi Lal University,
Prem Nagar-127031
Bhiwani
Haryana, India

Date of PGBOS&R: July 22, 2025

Vision and Mission of the University

Vision

To be known as a university having capacity to transform the society through continual innovations in education, research, creativity and entrepreneurship in the domain of higher education.

Mission

To create an environment in which new ideas, research and scholarship flourish and from which the leaders and innovators of tomorrow emerge.

To use local resources and environment as testing laboratory by the faculty and the students for generating new ideas and solutions of local problems.

To provide a challenging and rigorous curriculum which is global in outlook and simultaneously provides an understanding of the needs of society and industry.

To collaborate with leading academic and research institutes around the world to strengthen the education and research ecosystem.

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To create forums and to encourage students to participate in curricular and extra-curricular activities, to showcase and hone their talent and creativity.

To promote continuous engagement with stakeholders at all levels i.e. students, faculties, administration, alumni, industries, management of affiliated institutions, government regulatory bodies and community for their support, new ideas and feedback.

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Vision

•To provide an environment where students can learn and become competent users of Mathematics and Mathematical applications in real life, industry and other disciplines.

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Mission

- To provide quality education to the students to prepare them as a good academician to serve the society better.
- To achieve high standards of excellence in generating and propagating knowledge in Mathematics with research and academic excellence.

Programme Learning Outcomes

PLO No.	Component	Outcomes
PLO 1.	Basic Knowledge and critical thinking	Capable of delivering basic disciplinary knowledge and able to understand critically the results.
PLO 2.	In- depth knowledge and problem-solving abilities	Capable of describing advance knowledge gained during the programme and applying acquired knowledge to solve the problems.
PLO 3.	Creativity, analytical innovation and computation skills	Capable to identify, formulate, investigate and analyse the scientific problems innovatively to design through mathematical software and solutions to real life problems.
PLO 4.	Research aptitude and global competency	Ability to cultivate a research aptitude and use information to solve demanding research issues in the relevant and related fields globally.
PLO 5.	Holistic, multidisciplinary skill enhancement	Ability to learn through a multidisciplinary & holistic approach in various subjects, acquiring specialized talents and advanced methods consequently applying them to enhanced humanity.
PLO 6.	Ethical and professional responsibility	Encourage a moral, professional mind-set and the capacity to connect to societal issues.
PLO 7.	Employment-ready and entrepreneurial skills	Ability to adapt to the future of work by responding to rapid technological developments and innovations that continuously reshape employers' skill demands and work processes.

Scheme and Syllabus of Two Year Post Graduate Programme (Semester I & II) M.Sc. in Mathematics:2025-26

First Year (Semester I and II) of 2 years PG programme (NHEQF level6)

Courses	Nomenclature of Course	Course Code	Credits Distribution			Total Credits	Total Workload	Marks				
			L	T	P		Total Contact Hours	Theory		Practical		Total Marks
								Internal	External	Internal	External	
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CC-1 4 credits	Real Analysis-I	25PN-MTH101	4	0	0	4	4	30	70	-	-	100
CC-2 4 credits	Modern Algebra	25PN-MTH102	4	0	0	4	4	30	70	-	-	100
CC-3 4 credits	Ordinary Differential Equations	25PN-MTH103	4	0	0	4	4	30	70	-	-	100
CC-4 4 credits	Mechanics	25PN-MTH104	4	0	0	4	4	30	70	-	-	100
PC-1 3 credits	Programming in FORTRAN 90/95	25PN-MTH105	1	0	2	3	1+4	-	-	20	50	70
Any one of the followings												
DEC-1 4 credits	Mathematical Statistics	25PN-MTH106	4	0	0	4	4	30	70	-	-	100
	Mathematical Modeling	25PN-MTH107	4	0	0	4	4	30	70	-	-	100
	Discrete Mathematics	25PN-MTH108	4	0	0	4	4	30	70	-	-	100
SEMESTER-II (25 Credits)												
CC-5 4 credits	Real Analysis-II	25PN-MTH201	4	0	0	4	4	30	70	-	-	100
CC-6 4 credits	Linear Algebra	25PN-MTH202	4	0	0	4	4	30	70	-	-	100
CC-7 4 credits	Partial Differential Equations and Fourier Analysis	25PN-MTH203	4	0	0	4	4	30	70	-	-	100
CC-8 4 credits	Complex Analysis	25PN-MTH204	4	0	0	4	4	30	70	-	-	100
PC-2 3 credits	Computational work using R-Programming	25PN-MTH205	1	0	2	3	1+4	-	-	20	50	70
Any one of the followings												
DEC-2 4 credits	Operation Research Techniques	25PN-MTH206	4	0	0	4	4	30	70	-	-	100
	Mathematics for Finance and Insurance	25PN-MTH207	4	0	0	4	4	30	70	-	-	100
	Fuzzy Set Theory	25PN-MTH208	4	0	0	4	4	30	70	-	-	100
	MOOC'S Course		4	0	0	4	4	30	70	-	-	100
Any one of the followings												
IKS/VAC 2 credits	Indian Mathematics and Astronomy in IKS	25PN-MTH-IKS-201	2	0	0	2	2	15	35	-	-	50
	Vedic Mathematics and its Applications	25PN-MTH-VAC-201	2	0	0	2	2	15	35	-	-	50

Semester-II

Name of the Course: Real Analysis-II	**Course Code: 25PN-MTH201**	**Course:CC** **Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO): **CLO1:** Students would be able to explain the fundamental concepts of Reimann-Stieltjes integral. **CLO2:** Analyze the geometric interpretation of metric space, construct and interpret various proper and improper integrals and operate with real numbers, real functions. **CLO3:** By use of characteristics of study of metric spaces in the related fields such as geometry and complex analysis etc. **CLO4:** Understand continuity, uniform continuity and compactness of metric spaces and properties.	
Section – I Contribution of Indian mathematicians in real analysis, Riemann-Stieltjes integral, Existence and properties, Integration and differentiation, condition of integrability, Integration of vector-valued functions, Fundamental theorem of Calculus, Relation between Riemann Integral and Riemann-Stieltjes integral, Rectifiable curves.	15 hrs
Section-II Sequence and series of functions, Point wise and uniform convergence, Comparison tests, Cauchy criterion for uniform convergence, Weirstrass M-test, Abel's and Dirichlet's tests for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiation, Weierstrass approximation theorem. Improper integrals and their convergence, Frullani's integral, Integral as a function of a parameter. Continuity, Differentiability and integrability of an integral of a function of a parameter. Power series, uniform convergence and uniqueness theorem, Abel theorem, Tauber theorem.	15 hrs
Section-III Definition and examples of metric spaces, neighbourhoods, limit points, interior points, open and closed sets, closure and interior, boundary points, subspace of a metric space, equivalent metrics, Cauchy sequences, completeness, Cantor's intersection theorem, Baire's category theorem, contraction Principle	15 hrs
Section-IV Continuous functions, uniform continuity, compactness for metric spaces, sequential compactness, Bolzano-Weierstrass property, total boundedness, finite intersection property, continuity in relation with compactness, connectedness, components, continuity in relation with connectedness.	15 hrs

Books Recommended:

1. Jain P.K., Ahmad K., 2004, Metric Spaces, 2nd Ed., Narosa Publishing House, New Delhi
2. Ram B., 2004, Metric Spaces, Vinayaka Publication
3. Apostol T.M., 1985, Mathematical Analysis, Narosa Publishing House, New Delhi.
4. Goldberg R.R.,1970, Real analysis, Oxford & IBH publishing Co., New Delhi.
5. Somasundaram D., Choudhary B., 1997, A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi.
6. Narayan S., Mittal P.K.,2013, A Course of Mathematical Analysis, S. Chand & Co., New Delhi
7. Copson E.T., 1968, Metric Spaces, Cambridge University Press.
8. Simmons G.F., 1963, Introduction to Topology and Modern Analysis, McGraw Hill.

Mapping of PLOs with Course Contents of 25PN-MTH201

PLO No.	PLO Description	Mapped Course Content / CLO	Overall Mapping level
PLO 1	Basic Knowledge and Critical Thinking	CLO1: Riemann-Stieltjes integral, existence, properties, integration and differentiation; Section I: Fundamental concepts, rectifiable curves.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	CLO2: Sequence and series of functions, improper integrals, uniform convergence, power series; Section II: Convergence tests, Weierstrass approximation, Frullani's integral.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	CLO3: Metric spaces, neighbourhoods, limit points, open/closed sets, completeness, Baire's theorem; Section III: Metric space theory and applications .	S
PLO 4	Research Aptitude and Global Competency	CLO4: Continuity, uniform continuity, compactness, connectedness; Section IV: Advanced metric space properties and their implications .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	CLO1, CLO2, CLO3, CLO4: Integration of analysis concepts with geometry, complex analysis, and applied mathematics .	M
PLO 6	Ethical and Professional Responsibility	CLO4: Rigorous mathematical reasoning, logical consistency, ethical approach to proofs .	M
PLO 7	Employment ready and entrepreneurial skills	CLOs:Problem-solving, analytical skills applicable in research and technical fields.	M

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak.

Semester-II

Name of the Course: Linear Algebra	**Course Code: 25PN-MTH202**	**Course:CC Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1 Get familiar with vector spaces, subspaces and existence theorem for basis of a finitely generated vector space.

CLO 2 Describe the concepts of homomorphism, isomorphism and dual spaces.

CLO 3 Learn singular and non-singular linear transformations, eigen values and eigen vectors of linear transformations.

CLO 4 Understand the Gram Schmidt orthogonalization process, inner product spaces, orthogonal vectors, and orthogonal sets.

Section-I Contribution of Indian mathematicians in linear algebra, Vector spaces, Subspaces, Sum and direct sum of subspaces, Linear span, Linearly Independent and dependent subsets of a vector space, Finitely generated vector space, Existence theorem for basis of a finitely generated vector space, Finite dimensional vector spaces.	15 hrs
Section-II Invariance of the number of elements of bases sets, Dimensions, Quotient space and its dimension, Homomorphism and isomorphism of vector spaces, Linear transformations and linear forms on vector spaces, Vector space of all the linear transformations.	15 hrs
Section -III Dual spaces, Bidual spaces, Annihilator of subspaces of finite dimensional vector spaces, Null space, Range space of a linear transformation, Rank and Nullity theorem.	15 hrs
Section-IV Algebra of linear transformation, Minimal polynomial of a linear transformation, Singular and non-singular linear transformations, Matrix of a linear transformation, Change of basis, Eigen values and eigen vectors of linear transformations.	15 hrs

References:

1. I.N. Herstein,: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975
2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra (2nd edition).
3. Vivek Sahai and Vikas Bist, Linear Algebra, Narosa Publishing House.
4. I.S. Luther and I.B.S. Passi, Algebra, Vol.-II, Narosa Publishing House.
5. Kenneth M Hoffman, Ray Kunze, Linear Algebra, 2nd Edition, PRENTICE-HALL, INC., Englewood Cliffs, New Jersey, 1971.

Mapping of PLOs with Course Contents of 25PN-MTH202

PLO No.	PLO Description	Mapped Course Content / CLO	Overall Mapping level
PLO 1	Basic Knowledge and Critical Thinking	CLO1: Vector spaces, subspaces, basis, finite-dimensional spaces; Section I: Vector spaces, linear independence, basis, dimension.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	CLO2: Homomorphism, isomorphism, linear transformations; Section II: Homomorphism, isomorphism, quotient spaces, dimension.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	CLO3: Singular/non-singular transformations, eigenvalues, eigenvectors; Section IV: Linear transformations, eigenvalues, eigenvectors, matrix representation.	MS
PLO 4	Research Aptitude and Global Competency	CLO4: Inner product spaces, orthogonalization; Section IV: Gram-Schmidt process, inner product spaces.	M
PLO 5	Holistic, Multidisciplinary Skill Enhancement	CLO1, CLO2, CLO3, CLO4: Integration of linear algebra concepts with geometry, physics, and engineering.	M
PLO 6	Ethical and Professional Responsibility	CLO4: Logical consistency, rigorous reasoning in mathematical proofs .	M
PLO 7	Employment ready and entrepreneurial skills	CLOs:Problem-solving, analytical skills applicable in industry, research, and technical fields.	M

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak.

Semester-II

Name of the Course: **Partial Differential Equations and Fourier Analysis**	**Course Code: 25PN-MTH203**	**Course:CC** **Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 3 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Solve Lagrange's linear equations using Charpit's general method and Jacobi's method.

CLO2 Classify partial differential equations and transform them into canonical forms. And Solution of partial differential equations of second order by Monge's method.

CLO3 Understand the characteristic equations and characteristic curves of second order partial differential equations and solution of Lapace equation, Wave equation and diffusion equation.

CLO4: Understand to expend the function as Fourier series and evaluation of Fourier transformation.

Section – I Contribution of Indian mathematicians in PDE & Fourier Analysis, Linear partial differential equations of second and higher orders. Linear and non-linear homogeneous and non-homogeneous equations with constant coefficients, Partial differential equation with variable co-efficients reducible to equations with constant coefficients, Complimentary functions and particular Integrals, Equations reducible to linear equations with constant coefficients.	15 hrs
Section - II Classification of linear partial differential equations of second order, Hyperbolic, Parabolic and Elliptic types, Reduction of second order linear partial differential equations to Canonical (Normal) forms and their solutions, Solution of linear hyperbolic equations, Monge's method for partial differential equations of second order.	15 hrs
Section – III Cauchy's problem for second order partial differential equations, Characteristic equations and characteristic curves of second order partial differential equations, Method of separation of variables: Laplace's equation, Wave equation (one and two dimensions), Diffusion (Heat) equation (one and two dimension) in Cartesian Co-ordinate system.	15 hrs
Section – IV Fourier Analysis: Fourier Series- arbitrary period, even and odd function, half-range expansion, Forced oscillations, Fourier integral, Fourier sine integral, Fourier cosine integral, Fourier transforms, solution of PDE using Fourier transforms, Convolution Theorem, Inverse function theorem.	15 hrs

References:

1. D.A. Murray: Introductory Course on Differential Equations, Orient Longman, (India), 1967
2. Erwin Kreyszing : Advanced Engineering Mathematics, John Wiley & Sons, Inc., New York, 1999
3. A.R. Forsyth : A Treatise on Differential Equations, Macmillan and Co. Ltd.
4. Ian N.Sneddon : Elements of Partial Differential Equations, McGraw Hill Book Company, 1988
5. Frank Ayres : Theory and Problems of Differential Equations, McGraw Hill Book Company, 1972
6. J.N. Sharma & Kehar Singh : Partial Differential Equations

Mapping of PLOs with Course Contents of 25PN-MTH 203

PLO No.	PLO Description	Mapped Course Content / CLO	Overall Mapping level
PLO 1	Basic Knowledge and Critical Thinking	CLO1: Solving Lagrange's linear equations; Section I: Linear PDEs, complementary functions, particular integrals.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	CLO2: Classification and canonical forms of PDEs; Section II: Classification, reduction to canonical forms, Monge's method.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	CLO3: Characteristic equations, separation of variables, Laplace, wave, and diffusion equations; Section III: Cauchy's problem, characteristic curves, solution methods.	S
PLO 4	Research Aptitude and Global Competency	CLO4: Fourier series, Fourier transforms, solution of PDEs using Fourier methods; Section IV: Fourier analysis, convolution theorem, inverse function theorem.	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	CLO1, CLO2, CLO3, CLO4: Integration of PDE and Fourier analysis with physics, engineering, and applied sciences.	M
PLO 6	Ethical and Professional Responsibility	CLO4: Rigorous mathematical reasoning, ethical approach to modeling and problem-solving.	M
PLO 7	Employment ready and entrepreneurial skills	Problem-solving, analytical skills applicable in industry and research.	M

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak.

Semester-II

Name of the Course: Complex Analysis	**Course Code: 25PN-MTH204**	**Course:CC Credits:4**
Maximum Marks Theory: 30(Internal)+70(External)=100	**Time of Examinations: 03 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Be familiar with function of complex variables and represent the sum function of a power series as an analytic function with radius of convergence.
CLO 2: Understand complex integration, integral formulas and Liouville theorem.
CLO 3: Demonstrate the ideas of singularities and understanding the argument principle along with fundamental theorem of algebra.
CLO 4: Understand concept of residues, evaluate contour integrals and solve polynomial equations.

Section-I Contribution of Indian mathematicians in complex analysis, Function of a complex variable, Continuity, Differentiability, Analytic functions and their properties, Cauchy-Riemann equations in cartesian and polar coordinates, Power series, Radius of convergence, Differentiability of sum function of a power series, Branches of many valued functions with special reference to argz, logz and z^a.	15 hrs
Section-II Path in a region, Contour, Complex integration, Cauchy theorem, Cauchy integral formula, Extension of Cauchy integral formula for multiple connected domain, Poisson integral formula, Higher order derivatives, Complex integral as a function of its upper limit, Morera theorem, Cauchy inequality, Liouville theorem, Taylor theorem.	15 hrs
Section-III Zeros of an analytic function, Laurent series, Isolated singularities, Cassorati-Weierstrass theorem, Limit point of zeros and poles. Maximum modulus principle, Schwarz lemma, Meromorphic functions, Argument principle, Rouche theorem, Fundamental theorem of algebra, Inverse function theorem.	15 hrs
Section-IV Calculus of residues, Cauchy residue theorem, Evaluation of integrals of the types $\int_0^{2\pi} f(\cos t, \sin t)dt$, $\int_{-\infty}^{\infty} f(x)dx$, $\int_0^{\infty} f(x) \sin mx\, dx$ and $\int_0^{\infty} f(x) \cos mx\, dx$, Conformal mappings. Space of analytic functions and their completeness, Hurwitz theorem, Montel theorem, Riemann mapping theorem.	15 hrs

References:

1. H.A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
2. J.B. Conway, Functions of One Complex Variable, Springer-Verlag, International student-Edition, Narosa Publishing House, 2002.
3. Liang-Shin Hann & Bernand Epstein, Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
4. E.T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London, 1972.
5. E.C. Titchmarsh, The Theory of Functions, Oxford University Press, London, 1939.
6. Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company, 2009.
7. H.S. Kasana, Complex Variable Theory and Applications, PHI Learning Private Ltd, 2011.
8. Dennis G. Zill and Patrik D. Shanahan, A First Course in Complex Analysis with Applications, John Bartlett Publication, 2nd Edition, 2010.

Mapping of PLOs with Course Contents of 25PN-MTH 204

PLO No.	PLO Description	Mapped Course Content / CLO	Overall Mapping level
PLO 1	Basic Knowledge and Critical Thinking	CLO1: Functions of complex variables, power series, analytic functions, Cauchy-Riemann equations; Section I: Continuity, differentiability, branches of many-valued functions.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	CLO2: Complex integration, Cauchy theorem, integral formulas, Liouville theorem; Section II: Path, contour, complex integration, Morera theorem, Taylor theorem.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	CLO3: Singularities, Laurent series, argument principle, fundamental theorem of algebra; Section III: Zeros, poles, maximum modulus principle, Rouche theorem.	S
PLO 4	Research Aptitude and Global Competency	CLO4: Residues, contour integrals, conformal mappings, Riemann mapping theorem; Section IV: Residue calculus, evaluation of integrals, advanced mapping theorems.	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	CLO1, CLO2, CLO3, CLO4: Integration of complex analysis with physics, engineering, and applied sciences.	M
PLO 6	Ethical and Professional Responsibility	CLO4: Logical consistency, ethical reasoning in proofs and modeling.	M
PLO 7	Employment ready and entrepreneurial skills	Section IV: Use of mathematical software, problem-solving for real-world applications.	SM

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak.

Semester-II

Name of the Course: **Computational work using R-Programming**	**Course Code:** **25PN-MTH205**	**Course:CC** **Credits:1L+2P=3**
Maximum Marks **Practical: 20(Internal)+50(External)=70**	**Time of Examinations: 3 Hours**	

Course Learning Outcomes (CLO):

CLO1: Students would be able to carry out mathematical formulations of the given real problems as LPPs, solve LPP's using Graphical /Simplex methods for the given problem using R language.

CLO2: Solve different types of transportation problems, assignment problems, crew assignment problems, travelling salesman problems, game problems for the given data using R..

Practical/ Computational Work

Practical: 20(Internal)+50(External)=70

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 25 Marks

ii) Viva-voce and practical record: 25 Marks

R Sessions and Functions, Basic Math, Variables, Data Types, Vectors, Conclusion, Advanced Data Structures, Data Frames, Lists, Matrices, Arrays, Classes, R Programming Structures, Control Statements, Loops, Operators, No Pointers in R, Recursion, Doing Math and Simulation in R, Graphics: Creating Graphs, The Workhorse of R Base Graphics, the plot() Function Customizing Graphs, Saving Graphs to Files.

List of Practicals

Following is the list of programmes to be performed on R-Programming:

1. To show basic syntax of R language
2. To demonstrate Normal Distribution,
3. To demonstrate Binomial Distribution
4. To find Correlation and Covariance
5. To demonstrate T-Tests and ANOVA Test
6. To demonstrate Sorting in R
7. To demonstrate Linear Algebra Operation on Vectors and Matrices
8. To plot functions in R
9. To solve simplex problem
10. To solve assignment problem
11. To solve transportation problem

References:

1. Teetor P., 2011, R Cookbook, Oreilly.
2. Kabacoff R., 2015, R in Action: Data Analysis and Graphics in R, Manning publications.
3. Matloff N., 2011, The Art of R Programming, Cengage Learning.
4. Lander J.P., 2018, R for Everyone: Advanced Analytics and Graphics, Pearson Publications.
5. Venables W. N.,Ripley B. D., 2002, Modern Applied Statistics with S (Statistics and Computing), 4th ed., Springer.

Mapping of PLOs with Course Contents of 25PN-MTH 205

PLO No.	PLO Description	Mapped Course Content / CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	CLO1: Mathematical formulation of LPPs, graphical/simplex methods using R; Practical: Basic syntax, variables, data types, vectors.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	CLO2: Solving transportation, assignment, crew assignment, TSP, and game problems using R; Practical: Solving LPPs, sorting, linear algebra operations.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	CLO2: Applying R for various optimization problems; Practical: Graphics, simulation, advanced data structures, recursion.	S
PLO 4	Research Aptitude and Global Competency	CLO2: Using R for statistical and mathematical analysis; Practical: Normal and binomial distributions, correlation, covariance, T-tests, ANOVA.	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	CLO1, CLO2: Integration of R programming with statistics, operations research, and data analysis.	M
PLO 6	Ethical and Professional Responsibility	CLO2: Ethical use of data, logical consistency in programming and analysis.	M
PLO 7	Employment ready and entrepreneurial skills	. Using R for data analysis, visualization, and problem-solving	M

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak.

Semester-II

Name of the Course: Operation Research Techniques	**Course Code: 25PN-MTH206**	**Course:DEC Credits:4**
Maximum Marks Theory: 30(Internal)+70(External)=100	**Time of Examinations: 03 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO 1: Students will be able to illustrate the concept of optimization techniques and LPP.
CLO 2:Students will be familiar with transportation problems and assignments problems.
CLO3 : Student will be able to understand the application of queuing models in practical problems.
CLO 4: Student will be able to learn the application of Economic order quantity model in different field.

Section-I **Operations Research:** Origin, definition and its scope, Linear Programming: Formulation and Solution of linear programming problems by Graphical and Simplex methods, Big - M and Two-phase methods, Degeneracy, Duality in linear programming.	15 hrs
Section-II **Transportation Problems:** Basic Feasible Solutions, Optimum solution by stepping stoneand modified distribution methods, unbalanced and degenerate problems, trans-shipment problem. Assignment problems: Solution by Hungarian method, unbalanced problem, case of maximization, travelling salesman and crew assignment problems.	15 hrs
Section-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).	15 hrs
Section-IV **Inventory control models:** Economic order quantity (EOQ) model with uniform demand and with different rates of demands in different cycles, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.	15 hrs

References:

1. F. Hillier and G.J. Lieberman, Introduction to Operation Research, Holden Day,1990.
2. H. A. Taha, Operation Research-An Introduction, Printice Hall of India, 2017.
3. J.K. Sharma, Mathematical Model in OperationS Research, Tata McGraw Hill,1989.
4. Kanti Swaroop, P.K. Gupta, Man Mohan, Operations Research, Sultan Chand and Sons, 2010.
5. N.S. Kambo, Mathematical Programming Techniques, McGraw Hill, 2008.
6. P. K. Gupta, and D.S. Hira, Operations Research, S. Chand & Co., 1976.
7. S. D. Sharma, Operation Research, Kedar Nath Ram Nath Publications, 2009.

Mapping of PLOs with Course Contents of 25PN-MTH 206

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Linear Programming, formulation, graphical and simplex methods, duality.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Transportation, assignment, trans-shipment, travelling salesman, crew assignment problems.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Queuing models (M/M/1, M/M/C, etc.), Section IV: Inventory control models, EOQ, shortages, price breaks.	S
PLO 4	Research Aptitude and Global Competency	Section III & IV: Practical applications of queuing and inventory models, optimization in real-world scenarios.	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of OR techniques in economics, management, engineering, and practical problems .	M
PLO 6	Ethical and Professional Responsibility	Ethical decision-making in optimization, resource allocation, and modeling .	M
PLO 7	Employment ready and entrepreneurial skills	Section II & IV: Solving real-world optimization problems	M

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak.

Semester-II

Name of the Course: **Mathematics for Finance and Insurance**	**Course Code:** **25PN-MTH207**	**Course:DEC** **Credits:4**
Maximum Marks **Theory: 30(Internal)+70(External)=100**	**Time of Examinations: 03 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Demonstrate knowledge of the terminology related to nature, scope, goals, risks and decisions of financial management.

CLO2: Predict various types of returns and risks in investments and take necessary protective measures for minimizing the risk.

CLO3: Develop ability to understand, analyze and solve problems in bonds, finance and insurance.

CLO4: Build skills for computation of premium of life insurance and claims for general insurance using probability distributions.

Section-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.	15 hrs
Section-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.	15 hrs
Section-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.	15 hrs
Section-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.	15 hrs

References:

1. Ross, S. M. An Introduction to Mathematical Finance. Cambridge University Press, 2019.
2. 2. Elliott, R. J. and Kopp, P. E. Mathematics of Financial Markets. Sprigner Verlag, New York Inc, 2018.
3. 3. Damodaran, A. Corporate Finance - Theory and Practice. John Wiley & Sons, Inc, 2012.
4. 4. Hull, J. C. Options, Futures, and Other Derivatives. Prentice-Hall of India Private Ltd, 2010.
5. 5. Daykin, C. D., Pentikainen, T. and Pesonen, M. Practical Risk Theory for Actuaries. Chapman & Hall, 2008.
6. 6. Dorfman, M. S. Introduction to Risk Management and Insurance. Prentice Hall, Englwood Cliffs, New Jersey, 1999.
7. 7. Neftci, S. N. An Introduction to the Mathematics of Financial Derivatives. Academic Press, Inc, 1991.

Mapping of PLOs with Course Contents of 25PN-MTH207

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Financial management overview, time value of money, annuities.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Returns, risks, Markowitz model, Sharpe model, IRR calculation.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Bond valuation, duration, convexity, insurance fundamentals.	S
PLO 4	Research Aptitude and Global Competency	Section IV: Life and general insurance, premium and claim calculations, probability distributions.	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of finance, insurance, and probability concepts in real-world applications	M
PLO 6	Ethical and Professional Responsibility	Ethical decision-making in financial and insurance contexts.	M
PLO 7	Employment ready and entrepreneurial skills	Practical computations for finance/insurance.	M

S: Strong; MS: Moderate to Strong; M: Moderate, W: Weak.

Semester-II

Name of the Course: Fuzzy Set Theory	**Course Code: 25PN-MTH208**	**Course :DEC Credits:4**
Maximum Marks Theory: 30(Internal)+70(External)=100	**Time of Examinations: 03 Hours**	

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Learn fuzzy sets using linguistic words and represent these sets by membership functions.

CLO 2: Define mapping of fuzzy sets by a function and fuzzy-set-related notions; such as α-level sets, convexity, normality, support, etc.

CLO 3: Know the concepts of fuzzy graph, fuzzy relation, fuzzy morphism and fuzzy numbers.

CLO 4: Become familiar with the extension principle, its compatibility with the α-level sets and its usefulness in performing fuzzy number arithmetic operations

Section-I	15 hrs
Definition of Fuzzy Set, Expanding 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.	
Section-II	15 hrs
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, Composition of Fuzzy Relation, α- cut of Fuzzy Relation, Projection and Cylindrical Extension, Extension by Relation, Extension Principle, Extension by Fuzzy Relation, Fuzzy distance between Fuzzy Sets.	
Section-III	15 hrs
Graph and Fuzzy Graph, Fuzzy Graph and Fuzzy Relation, α- cut of Fuzzy Graph, Fuzzy Network, Reflexive Relation, Symmetric Relation, Transitive Relation, Transitive Closure, Fuzzy Equivalence Relation, Fuzzy Compatibility Relation, Fuzzy Pre-order Relation, Fuzzy Order Relation, Fuzzy Ordinal Relation, Dissimilitude Relation, Fuzzy Morphism, Examples of Fuzzy Morphism.	
Section-IV	15 hrs
Interval, Fuzzy Number, Operation of Interval, Operation of α- cut Interval, Examples of Fuzzy Number Operation, 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.	

References:

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
2. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
3. John Yen, Reza Langari, Fuzzy Logic-Intelligence, Control and Information, Pearson Education,1999.

Mapping of PLOs with Course Contents of 25PN-MTH 208

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Definition, operations, and standard concepts of fuzzy sets.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Fuzzy relations, operations, extension principle, α-level sets.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Fuzzy graphs, fuzzy morphisms, connectivity, relations.	S
PLO 4	Research Aptitude and Global Competency	Section IV: Fuzzy numbers, interval operations, approximation, applications.	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of fuzzy logic with engineering, computer science, and decision-making.	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical modeling in fuzzy logic applications.	M
PLO 7	Employment ready and entrepreneurial skills	Practical applications of fuzzy logic in industry	MS

S: Strong; MS: Moderate to Strong; M: Moderate; W: Weak

Semester-II

Name of the Course **Indian Mathematics & Astronomy in IKS**	Course Code: **25PN-MTH-IKS 201**	Course: IKS Credits:2
Maximum Marks **Theory: 15(Internal)+35(External)=50**	Time of Examinations: 2 Hours	

Note:
Examiner will set five questions, and the candidates will be required to attempt three questions in all. Question number one will be compulsory containing seven short answer type questions (7x1) from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section (2x14).

Course Learning Outcomes (CLO):

CLO1: To introduce fundamentals of Ancient Indian Educations to understand the pattern and purpose of studying vedas, vedangas, upangas, upveda, purana & Itihasa.

CLO2: To provide information about great Mathematicians and astronomers who given significant contribution in Indian Mathematics and Astronomy.

Section – I Introduction to Indian Knowledge System(IKS) : Caturdaéa Vidyästhänan, 64 Kalas, Shilpa Sästra, Four Vedas, Vedäniga, Indian Philosophical Systems, Vedic Schools of Philosophy (Sämkhya and Yoga, Nyaya and Vaisésika, Pürva-Mimämsä and Vedänta), Non-Vedic schools of Philosophical Systems (Cärväka, Buddhist, Jain), Puranas (Maha-puranas, Upa-Puranas and Sthala-Puranas), Itihasa (Ramayana, Mahabharata), Niti Sastras, Subhasitas	15 hrs
Section-II Indian Mathematics & Astronomy: Indian Mathematics, Great Mathematicians and their contributions, Arithmetic Operations, Geometry (Sulba Sutras, Aryabhatiya-bhasya), value of π, Trigonometry, Algebra, Chandah Sastra of Pingala, Indian Astronomy, celestial coordinate system, Elements of the Indian Calendar, Aryabhatiya and the Siddhantic Tradition, Pancanga — The Indian Calendar, System Astronomical Instruments (Yantras) Jantar Mantar of Raja Jai Singh Sawai.	15 hrs

Refrences:

1. Mahadevan ,B Textbook on IKS, IIM, Bengaluru
2. Bora ,M.C. ,Bhartiya Knowledge Systems, Khanna Publishing House, 2024
3. Mahadevan B. etal ,Introduction to Indian Knowledge System; Concepts and Applications, PHI, 2023
4. Rao, S.B.,Indian Mathematics and Astronomy: Some Landmarks, Bhartiya Vidhya Bhavan, 2012

Mapping of PLOs with Course Contents of 25PN-MTH-IKS 201

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Introduction to IKS, Vedic and non-Vedic systems, Puranas, Itihasa.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Indian mathematics, astronomy, contributions of mathematicians, calendar, instruments.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section II: Indian mathematical and astronomical innovations, problem-solving approaches.	M
PLO 4	Research Aptitude and Global Competency	Section II: Historical and research-oriented contributions in Indian mathematics and astronomy.	M
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of Indian knowledge systems with mathematics, astronomy, philosophy, and culture.	M
PLO 6	Ethical and Professional Responsibility	Ethical values, cultural context, and responsible study of ancient knowledge.	M
PLO 7	Employment ready and entrepreneurial skills	Collaborative learning, group discussions on IKS and its applications. Appreciation of Traditional Knowledge in Modern Context.	M

S: Strong; MS: Moderate to Strong; M: Moderate, W:Weak

Name of the Course: Vedic Mathematics and its applications	Course Code: 25PN-MTH-VAC 201	Course : VAC Credits:2
Maximum Marks Theory: 15(Internal)+35(External)=50	Time of Examinations: 2 Hours	

Note:
Examiner will set five questions, and the candidates will be required to attempt three questions in all. Question number one will be compulsory containing seven short answer type questions (7x1) from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section (2x14).

Course Learning Outcomes (CLO):

CLO1: Student will be able to Describe the multiplication of polynomials by Vedic sutras.
CLO2: Student will be able to Understand and Apply meaning of 6 to 11 Vedic sutras
CLO3: Student will be able to Examine division of polynomials, Quotient & Remainder
CLO4: Student will be able to Evaluate complex sums with Division algorithm and also be able to Construct problems, develop algorithms and implement for various applications.

SECTION-I Multiplication of polynomials by Urdhwatiryagbhyam, Nikhilam methods. Verification by Gunit Samuchchayah. Awareness of I to 16 Vedic sutras (as per Shankaracharya Bharthikrishan Teerthji Swamiji's book) Division of polynomials, Quotient & Remainder. Division algorithm. Applications of division methods.	15 hrs
SECTION-II Factorization of polynomials up to degree 3 using Aanurupyen Lopan-Sthapanabhyam Aadyam Aadyen Antyam Antyen methods. Verification by Beejank. Simultaneous equations of 3 variables. Meru Prastar - Expansion of (a+b)". Determinants of 3rd order. Partial Fractions.	15 hrs

Refrences:

1. C. N. Srinivasiengar (1967). History of Mathematics in India. The World Press Pvt. Ltd., Calcutta.
2. Swami Shri Bharti Krishan Tirthji Maharaj (1981). Vedic Mathematics, (Dr.V.S. Agrawala, Editor), Motilal Banarsidas Indological Publishers and Booksellers. New Delhi.
3. G.G. Emch, R. Sridharan and M.D. Srinivas (2005). Contribution to the History of Indian Mathematics. Hindustan Book Agency.
4. Rajesh Kumar Thakur (2013). The Essentials of Vedic Mathematics, Rupa Publications India.
5. Vedic Ganita: Vihangama Drishti-1, Siksha Sanskriti Uthana Nyasa, New Delhi
6. Vedic Ganita Praneta, Siksha Sanskriti Uthana Nyasa, New Delhi
7. V.G. Unkalkar (2016). Excel with Vedic Mathematics, Vandana Publishers, Banglore

Mapping of PLOs with Course Contents of 25PN-MTH-VAC 201

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Multiplication, division, and verification of polynomials using Vedic sutras.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Factorization, simultaneous equations, determinants, partial fractions	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section II: Meru Prastar, problem construction, algorithm development	M
PLO 4	Research Aptitude and Global Competency	Section I & II: Application of Vedic methods in modern mathematics and research-oriented problem-solving	M
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of Vedic mathematics with modern math and real-world applications	M
PLO 6	Ethical and Professional Responsibility	Ethical use of Vedic mathematics, logical consistency in problem-solving .	M
PLO 7	Employment ready and entrepreneurial skills	Algorithm development, computational techniques.	M

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak.

Chaudhary Bansi Lal University

(A State University established under Haryana Act No. 25 of 2014)

SCHEME AND SYLLABI

for

TWO YEAR POSTGRADUATE PROGRAMME

M.Sc. MATHEMATICS

As per NEP 2020

WITH EFFECT FROM THE SESSION 2025-26

Department of Mathematics
Chaudhary Bansi Lal University,
Prem Nagar-127031
Bhiwani
Haryana, India

Date of PGBOS&R: July 22, 2025

Option-I

Second Year (Semester III and IV) of 2- year PG Program (NHEQF level 6.5) (For UTD and affiliated colleges)

SEMESTR III

Courses	Nomenclature of Course	Course Code	Credits Distribution				Total Workload	Marks				
			L	T	P	Total Credits	Total Contact Hours	Theory		Practical		Total Marks
								Internal	External	Internal	External	
SEMESTER-III (25 Credits)								**Total Marks: 620**				
CC-9 4 CREDITS	Abstract Algebra	25PN-MTH301	4			4	4	30	70			100
CC-10 4 CREDITS	Topology	25PN-MTH302	4			4	4	30	70			100
CC-11 4 CREDITS	Measure Theory and Integration	25PN-MTH303	4			4	4	30	70			100
PC-3 3 CREDITS	Data Science Using Python	25PN-MTH304	1		2	3	1+4			20	50	70
Any one of the followings												
DEC-3 4 CREDITS	Mechanics of Solids-I	25PN-MTH305	4			4	4	30	70			100
	Graph Theory	25PN-MTH306	4			4	4	30	70			100
	Advanced Numerical Analysis	25PN-MTH307	4			4	4	30	70			100
Any one of the followings												
DEC-4 4 CREDITS	Fluid Dynamics	25PN-MTH308	4			4	4	30	70			100
	Statistical Inference	25PN-MTH309	4			4	4	30	70			100
	Analytical Number Theory	25PN-MTH310	4			4	4	30	70			100
EEC 2 CREDITS	Introduction to LaTex	25PN-MTH-EEC-30 1			2	2	4			15	35	50

Semester-III

Name of the Course	Abstract Algebra		Course Code: 25PN-MTH301	Course :CC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100		Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Apply Sylow theorems to analyze p-groups and small finite groups.
CLO 2: Analyse series in groups (normal, solvable, derived, central, composition) and study solvable and nilpotent groups with related theorems.
CLO 3: Explain and use basic module concepts including cyclic, simple, semisimple and free modules, and modules over a PID.
CLO 4: Describe and apply Noetherian and Artinian conditions for modules and rings, and related results such as Hilbert basis and Wedderburn–Artin theorems.

Section-I Sylow theorems: p-groups, Sylow subgroups, Applications of Sylow theorems, Description of group of order p^2 and pq, Survey of groups upto order 15.	**15hrs**
Section-II Normal and subnormal series, Solvable series, Derived series, Solvable groups, Solvability of S_n-the symmetric group of degree $n \geq 2$, Central series, Nilpotent groups and their properties, Equivalent conditions for a finite group to be nilpotent, Composition series, Zassenhaus lemma, Jordan-Holder theorem.	**15hrs**
Section-III Modules, Cyclic modules, Simple and semi-simple modules, Schurs' lemma, Free modules, Modules over principal ideal domain and its applications to finitely generated abelian groups.	**15hrs**
Section-IV Noetherian and Artinian modules, Modules of finite length, Noetherian and Artinian rings, Hilbert basis theorem. $Hom_R(R,R)$, Nil and Nilpotent ideals, Opposite rings, Wedderburn – Artin theorem.	**15hrs**

References:

1. I.S. Luther and I.B.S.Passi, Algebra, Vol. I-Groups, Vol. III-Modules, Narosa Publishing House (Vol. I – 2013, Vol. III –2013).
2. Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, First Indian Edition, 2010.
3. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
4. D.S. Malik, J.N. Mordenson, and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, International Edition, 1997.
5. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.
6. C. Musili, Introduction to Rings and Modules, Narosa Publication House, 1994.
7. N. Jacobson, Basic Algebra, Vol. I & II, W.H Freeman, 1980 (also published by Hindustan Publishing Company).
8. M. Artin, Algebra, Prentice-Hall of India, 1991.
9. Ian D. Macdonald, The Theory of Groups, Clarendon Press, 1968.

Mapping of PLOs with Course Contents of 25PN-MTH- 301

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO I	Basic Knowledge and Critical Thinking	Section I: Sylow theorems, p-groups, applications to group analysis.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Normal, solvable, nilpotent, and composition series; group structure theorems.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Modules, cyclic, simple, semisimple, free modules, applications to abelian groups.	S
PLO 4	Research Aptitude and Global Competency	Section IV: Noetherian/Artinian modules and rings, Hilbert basis, Wedderburn–Artin theorem .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of abstract algebra with advanced mathematics and research topics.	M
PLO 6	Ethical and Professional Responsibility	Rigorous logical reasoning, ethical approach to mathematical proofs.	M
PLO 7	Employment ready and entrepreneurial skills	Development of problem-solving and analytical skills with algebraic structures.	S

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-III

Name of the Course	Topology	Course Code: 25PN-MTH302	Course: CC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Use closure, interior, boundary, and neighbourhood systems to define and analyze topological spaces.

CLO 2: Study continuity, connectedness, and topological properties using bases and subbases.

CLO 3: Characterize separation and countability axioms and apply key theorems like Lindelöf.

CLO 4: Analyze compactness, local compactness, and one-point compactification.

Section-I Definition and examples of topological spaces, Comparison of topologies on a set, Intersection and union of topologies on a set, Limit point of a set, Derived set, Closed set, Closure of a set, Kuratowski closure axioms, Closure operator, Dense sets, Interior point and Interior of a set, Interior axioms, Exterior of a set, Exterior axioms, Boundary of a set, Interior, exterior and boundary operators, Neighborhoods, Alternative methods of defining a topology in terms of neighborhood system and Kuratowski closure operator.	15hrs
Section-II Relative (Induced) topology, Base and subbase for a topology, Base for neighbourhood system. Continuous functions, Composition of continuous functions, Pasting lemma, Open and closed functions, Homeomorphisms, Topological properties. Connectedness and its characterization, Connected subsets and their properties, Continuity and connectedness, Components, Locally connected spaces.	**15hrs**
Section-III Separation axioms: T0, T1, T2-spaces, their characterization and basic properties, T2-spaces and sequences. First countable, Second countable and Separable spaces, Hereditary and topological property, Countability of a collection of disjoint open sets in separable and second countable spaces, Lindel"of theorem.	**15hrs**
Section-IV Compact spaces and subsets, Compactness in terms of finite intersection property, Continuity and compact sets, Basic properties of compactness, Closedness of compact subset of a Hausdorff space and of a continuous map from a compact space into a Hausdorff and its consequence. Sequentially and Countably compact spaces, Locally compact spaces and One point compactification.	15hrs

References:

1. Patty C.W., 2009, Foundation of Topology, Jones & Bertlett.
2. Croom F.H., 2009. Principles of Topology, Cengage Learning.
3. Simmons G.F., 1963, Introduction to Topology and Modern Analysis, McGraw- Hill
4. Book Company.
5. Kelly J.L., 2000, General Topology, Springer Verlag, New York.
6. Munkres J.R., 2002, Toplogy, Pearson Education Asia.
7. Rao K.C., 2009,Topology, Narosa Publishing House Delhi.
8. Joshi K.D., 2006, Introduction to General Topology, Wiley Eastern Ltd.

Mapping of PLOs with Course Contents of 25PN-MTH-302

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Definition, closure, interior, boundary, neighbourhood systems, Kuratowski axioms.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Relative topology, continuity, connectedness, homeomorphisms, topological properties.	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Separation and countability axioms, Lindelöf theorem, characterization of spaces .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Compactness, local compactness, one-point compactification, advanced topological theorems .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of topology with geometry, analysis, and advanced mathematics .	M
PLO 6	Ethical and Professional Responsibility	Rigorous logical reasoning, ethical approach to mathematical proofs .	M
PLO 7	Employment ready and entrepreneurial skills	Analytical and logical reasoning skills are developed, which are valuable for employment, but entrepreneurial skills are not a focus.	M

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-III

Name of the Course	Measure and Integration Theory	Course Code: 25PN-MTH303	Course: CC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Understand Lebesgue measure, measurable sets, and non-measurable sets.
CLO 2: Analyze measurable functions and convergence theorems.
CLO 3: Compute Lebesgue integrals and apply convergence theorems.
CLO 4: Use Vitali covering, differentiate monotonic functions, and relate absolute continuity to the fundamental theorem of calculus.

Section-I Set functions, Intuitive idea of measure, Elementary properties of measure, Measurable sets and their fundamental properties. Lebesgue measure of aset of real numbers, Algebra of measurable sets, Borel set, Equivalent formulation of measurable set sin terms of open, Closed, F_σ and G_δ sets, Non measurable sets.	**15hrs**
Section-II Measurable functions and their equivalent formulations. Properties of measurable functions. Approximation of a measurable function by a sequence of simple functions, Measurable functions as nearly continuous functions, Egoroff theorem, Lusin theorem, Convergence in measure and F. Riesz theorem. Almostun iform convergence.	**15hrs**
Section-III Short comings of Riemann Integral, Lebesgue Integral of a bounded function over a set of finite measure and its properties. Lebesgue integral as a generalization of Riemann integral, Bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions, Integral of non-negative functions, Fatou Lemma, Monotone convergence theorem, General Lebesgue Integral, Lebesgue convergence theorem.	15hrs
Section-IV Vitali covering lemma, Differentiation of monotonic functions, Function of bounded variation and its representation as difference of monotonic functions, Differentiation of indefinite integral, Fundamental theorem of calculus, Absolutely continuous functions and their properties.	**15hrs**

References:

1. Walter Rudin, Principles of Mathematical Analysis (3rd edition) McGraw-Hill, Kogakusha, , International Student Edition, 1976.
2. H.L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th Edition, New York, 1993.
3. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International (P) Limited Published, New Delhi, 1986.
4. G.De Barra, Measure Theory and Integration, Wiley Eastern Ltd., 1981.
5. R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd, 1976.
6. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.

Mapping of PLOs with Course Contents of 25PN-MTH-303

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Lebesgue measure, measurable sets, Borel sets, non-measurable sets .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Measurable functions, convergence theorems, Egoroff and Lusin theorems .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Lebesgue integrals, convergence theorems, properties, relation to Riemann integral.	S
PLO 4	Research Aptitude and Global Competency	Section IV: Vitali covering, differentiation, fundamental theorem of calculus, absolute continuity.	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of measure theory with analysis, probability, and applied mathematics .	M
PLO 6	Ethical and Professional Responsibility	Rigorous logical reasoning, ethical approach to mathematical proofs .	M
PLO 7	Employment ready and entrepreneurial skills	Analytical and logical reasoning skills are developed, which are valuable for employment, but entrepreneurial skills are not a focus.	M

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak

Semester-III

Name of the Course	Data Science using Python	Course Code: 25PN-MTH304	Course: PC Credits:3(1+2)
Maximum Marks	Practical: 20(Internal)+50(External)=70	Time of Examinations	3 Hours

Course Learning Outcomes (CLO):

CLO1: Data Structures: Manipulating lists, tuples, dictionaries, and sets, and understanding their applications in data science.

CLO2: File Handling: Reading and writing data from various file formats (e.g., CSV, JSON, text files).

CLO3: Programming Fundamentals: Applying conditional statements, loops, and functions to solve data-related problems.

CLO4: Object-Oriented Programming (OOP): Implementing concepts like data hiding and abstraction in Python.

Practical/ Computational Work

Practical: 20(Internal)+50(External)=70

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 25 Marks ii) Viva-voce and practical record: 25Marks

Introduction: History of Python, Need of Python Programming, Applications Basics of Python Programming Using the REPL(Shell), Running Python Scripts, Variables, Assignment, Keywords, Input-Output, Indentation. Types, Operators and Expressions: Types – Integers, Strings, Booleans; Operators- Arithmetic Operators, Comparison (Relational) Operators, Assignment Operators, Logical Operators, Bitwise Operators, Membership Operators, Identity Operators, Expressions and order of evaluations Control Flow- if, if-elif-else, for, while break, continue, pass

Data Structures Lists: Operations, Slicing, Methods; Tuples, Sets, Dictionaries, Sequences. Comprehensions Functions: Defining Functions, Calling Functions, Passing Arguments, Keyword Arguments, Default Arguments, Variable-length arguments, Anonymous Functions, Fruitful Functions (Function Returning Values), Scope of the Variables in a Function- Global and Local Variables. Modules: Creating modules, import statement, from. Import statement, name spacing, Python packages, Introduction to PIP, Installing Packages via PIP, Using Python Packages

Object-Oriented Programming OOP in Python: Classes, 'self-variable', Methods, Constructor Method, Inheritance, Overriding Methods, Data hiding, Error, and Exceptions: Difference between an error and Exception, Handling Exception, try except for block, Raising Exceptions, User Defined Exceptions.

List of Practicals

Following is the list of programmes to be performed on Python:

1. Write a Python program to sum all the items in a list.
2. Write a Python program to multiply all the items in a list.
3. Write a Python program to get the largest number from a list.
4. Write a Python program to get the smallest number from a list.
5. Write a Python program to remove duplicates from a list.
6. Write a Python program to check a list is empty or not.
7. Write a Python program to clone or copy a list.
8. Write a Python program to find the list of words that are longer than n from a given list of words.
9. Write a Python function that takes two lists and returns True if they have at least one common member.
10. Write a Python program to print the numbers of a specified list after removing even numbers from it.
11. Write a Python program to shuffle and print a specified list.
12. Write a Python program to generate and print a list of first and last 5 elements where the values are square of numbers between 1 and 30 (both included).
13. Write a Python program to generate and print a list except for the first 5 elements, where the values are square of numbers between 1 and 30 (both included).
14. Write a Python program to generate all permutations of a list in Python.
15. Write a Python program to get the difference between the two lists.

References:

1. Python Programming: A Modern Approach, Vamsi Kurama, Pearson
2. Learning Python, Mark Lutz, Orielly

3. Think Python, Allen Downey, Green Tea Press
4. Core Python Programming, W.Chun, Pearson.
5. Introduction to Python, Kenneth A. Lambert, Cengage

Mapping of PLOs with Course Contents of 25PN-MTH-304

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	CLO1: Data structures (lists, tuples, dictionaries, sets), practical exercises on basic operations.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	CLO2: File handling, reading/writing CSV, JSON, text files; CLO3: Conditional statements, loops, functions .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	CLO3: Programming fundamentals, CLO4: Object-oriented programming, data hiding, abstraction .	S
PLO 4	Research Aptitude and Global Competency	CLO2, CLO3: Application of Python in data science, file formats, and real-world data problems .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of Python programming with data science, statistics, and analytics .	M
PLO 6	Ethical and Professional Responsibility	Ethical handling of data, logical consistency in programming .	M
PLO 7	Employment ready and entrepreneurial skills	Practical Python skills directly applicable in employment and entrepreneurship.	S

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-III

Name of the Course	Mechanics of Solids-I	Course Code: 25PN-MTH305	Course :CC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Get familiar with Cartesian tensors, as generalization of vectors, and their properties which are used in the analysis of stress and strain to describe the phenomenon of solid mechanics.

CLO 2 Analyse the basic properties of stress and strain components, their transformations, extreme values, invariants and Saint-Venant principle of elasticity.

CLO 3 Demonstrate generalized Hooke's law for three dimensional elastic solid which provides the linear relationship between stress components and strain components.

CLO 4 Use different types of elastic symmetries to derive the stress-strain relationship for isotropic elastic materials for applications to architecture and engineering.

Section-I Cartesian tensors: Cartesian tensors of different order, Properties of tensors, Symmetric and skew-symmetric tensors, Isotropic tensors of different orders and relation between them, Tensor invariants. Eigen-values and eigen vectors of a second order tensor, Scalar, vector, tensor functions, Comma notation, Gradiant, Divergence and Curl of a tensor field.	15hrs
Section-II Analysis of Stress: Stress vector, stress components. Cauchy equations of equilibrium. Stress tensor. Symmetry of stress tensor. Stress quadric of Cauchy. Principal stress and invariants. Maximum normal and shear stresses. Mohr's diagram. Examples of stress.	**15hrs**
Section-III Analysis of Strain: Affine transformations. Infinitesimal affine deformation. Geometrical interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariants. General infinitesimal deformation. Saint-Venant's equations of Compatibility. Finite deformations. Examples of uniform dilatation, simple extension and shearing strain.	**15hrs**
Section-IV Equations of Elasticity: Hooke's law and its generalization. Hooke's law in media with one plane of symmetry, orthotropic and transversely isotropic media, Homogeneous isotropic media. Elastic moduli for isotropic media. Equilibrium and dynamic equations for an isotropic elastic solid. Beltrami-Michell compatibility equations, Strain energy function and its connection with Hooke's law. Clapeyron's theorem. Saint-Venant's Principle(statement only).	15hrs

References:

1. A. E. H. Love, A Treatise on a Mathematical Theory of Elasticity, Dover Pub., New York.
2. A. S. Saada, Elasticity- Theory and applications, Pergamon Press,New York.
3. D.S. Chandersekhariah and L. Debnath, Continum Mechanics, Academic Press, 1994.
4. H. Jeffreys, Cartesian tensors.
5. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw HillPublishing Company Ltd., New Delhi, 1977.
6. Shanti Narayan, Text Book of Tensors, S. Chand & Co.
7. Teodar M. Atanackovic and Ardeshiv Guran, Theory of Elasticity for Scientists and Engineers Birkhausev, Boston, 2000.
8. Y.C. Fung, Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965.
9. R.B. Hetnarski, J. Ignaczak; the Mathematical Theory of Elasticity, CRC Press, 2nd Edition.
10. A.K. Mal & S.J. Singh, Deformation of Elastic Solids, Prentice Hall, New Jersey, 1991.

Mapping of PLOs with Course Contents of 25PN-MTH-305

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Cartesian tensors, tensor properties, invariants, gradient, divergence, curl.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Stress analysis, Cauchy equations, principal stress, Mohr's diagram .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Strain analysis, Saint-Venant's equations, finite deformations .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Elasticity equations, Hooke's law, elastic symmetries, applications in engineering.	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of tensor analysis, stress-strain relations with engineering and architecture .	M
PLO 6	Ethical and Professional Responsibility	Ethical approach to modeling, logical consistency in mechanical analysis .	M
PLO 7	Employment ready and entrepreneurial skills	Practical stress-strain analysis for design applications.	S

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-III

Name of the Course	Graph Theory	Course Code: 25PN-MTH306	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Identify and describe types of graphs and basic graph properties.
CLO2: Solve problems using concepts of connectivity, Euler and Hamiltonian paths.
CLO3: Apply spanning tree algorithms to real-life networks.
CLO4: Use coloring and planarity in graph-based applications like scheduling and layout designs.

Section I Definition and representation of graphs, Types of graphs: simple, multigraph, pseudograph, complete, regular, bipartite, Degree of vertices, Handshaking Lemma, Subgraphs, complement, isomorphism of graphs.	**15hrs**
Section-II Walks, trails, paths, and circuits, Connected components, Eulerian and Hamiltonian graphs, Euler's theorem (with proof and examples), Hamiltonian paths and cycles (Dirac's and Ore's theorems – statements only), Applications: route planning, social network graphs.	**15hrs**
Section-III Definition and types of trees: rooted, binary, m-ary, Properties of trees, tree traversal algorithms (preorder, inorder, postorder), Spanning trees and their applications, Kruskal's and Prim's Algorithms (step-by-step process, with examples).	15hrs
Section-IV Vertex coloring, chromatic number, applications in timetabling and scheduling, Independent sets and cliques, Planar graphs: definitions, Euler's formula, regions, and faces, Kuratowski's theorem (statement only), dual graphs.	15hrs

Books Recommended:

1. J.A. Bondy and U.S.R. Murty, Graph Theory with Applications, The Macmillan Press Ltd (UK) and Elsevier Science Publishing Co., Inc. (USA), 1976.
2. Douglas B. West, Introduction to Graph Theory, 2nd Edition, Pearson, 2000.
3. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 8th Edition, McGraw Hill, 2018.
4. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall of India Pvt. Ltd., 2004.

Mapping of PLOs with Course Contents of 25PN-MTH-306

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Definition, types, representation, basic properties of graphs.	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Connectivity, Eulerian/Hamiltonian paths, applications in networks .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Trees, traversal algorithms, spanning trees, Kruskal's and Prim's algorithms .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Coloring, planarity, applications in scheduling, layout designs .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of graph theory with computer science, engineering, and real-world applications .	M
PLO 6	Ethical and Professional Responsibility	Ethical reasoning in modeling, logical consistency in proofs .	M
PLO 7	Employment ready and entrepreneurial skills	Section III & IV: Spanning tree algorithms, coloring, planarity for real-world applications.	M

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak

Semester-III

Name of the Course	Advanced Numerical Analysis	Course Code: 25PN-MTH307	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Learn numerical technique to find the numerical solutions of system of linear and nonlinear equations and some curve fitting problems

CLO2: Solve bivariate interpolation problems, difference equations and eigen value problems.

CLO3: Understand finite difference methods for numerical solutions of partial differential equations especially heat, wave, Laplace and Poisson equations.

CLO4: Familiarize the students with advantages and limitations of numerical techniques.

Section – 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.	15hrs
Section – 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	**15hrs**
Section - 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.	15hrs
Section – 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.	15hrs

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.

Mapping of PLOs with Course Contents of 25PN-MTH-307

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Iterative methods, Chebyshev, Newton-Raphson, SOR, interpolation, curve fitting .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Finite difference operators, difference equations, eigenvalue problems .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III & IV: Finite difference methods for PDEs, explicit/implicit schemes, ADI methods .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Advantages and limitations of numerical techniques, advanced PDE solutions .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of numerical methods with physics, engineering, and applied sciences .	M
PLO 6	Ethical and Professional Responsibility	Ethical reasoning in modeling, logical consistency in numerical solutions .	M
PLO 7	Employment ready and entrepreneurial skills	All sections: Practical numerical techniques for real-world problems	S

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-III

Name of the Course	Fluid Dynamics	Course Code: 25PN-MTH308	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Derive and solve equation of continuity, equations of motion, vorticity equation, equation of moving boundary surface, pressure equation and equation of impulsive action for a moving inviscid fluid.
CLO2: Calculate velocity fields and forces on bodies for simple steady and unsteady flow including those derived from potentials.
CLO3: Understand the concepts of velocity potential, stream function and complex potential, and their use in solving two-dimensional flow problems applying complex-variable techniques.
CLO4: Represent mathematically the potentials of source, sink and doublets in two-dimensions as well as three-dimensions, and study their images in impermeable surfaces.

Section – I Kinematics - Eulerian and Lagrangian methods. Stream lines, path lines and streak lines. Velocity potential. Irrotational and rotational motions. Vortex lines. Equation of continuity. Boundary surfaces. Translation, Deformation and Rotation of Fluid Element; Reynold's Transport Theorem.	15hrs
Section – II Acceleration at a point of a fluid. Components of acceleration in cylindrical and spherical polar co-ordiantes, Pressure at a point of a moving fluid. Euler's and Lagrange's equations of motion. Bernoulli's equation. Impulsive motion. Stream function. Circulation, Kelvin Circulation Theorem.	15hrs
Section – III Acyclic and cyclic irrotation motions. Kinetic energy of irrotational flow. Kelvin's minimum energy theorem. Axially symmetric flows. Liquid streaming past a fixed sphere. Motion of a sphere through a liquid at rest at infinity. Equation of motion of a sphere. Three-dimensional sources, sinks, doublets and their images. Stoke's stream function.	15hrs
Section – IV Irrotational motion in two-dimensions. Complex velocity potential. Milne-Thomson circle theorem. Two-dimensional sources, sinks, doublets and their images. Blasius theorem. Two- dimensional irrotational motion produced by motion of circular and co-axial cylinders in an infinite mass of liquid.	15hrs

References:

1. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985
2. M.E. O'Neill and F. Chorlton, Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.
3. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
4. W.H. Besant and A.S. Ramsay, A Treatise on Hydromechanics Part I and II, CBS Publishers, New Delhi.
5. Bansi Lal, Theoretical Fluid Dynamics, Skylark Pub., New Delhi.

Mapping of PLOs with Course Contents of 25PN-MTH-308

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Kinematics, stream lines, velocity potential, continuity equation .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Acceleration, pressure, Euler's equations, Bernoulli's equation, circulation .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Irrotational motion, kinetic energy, axially symmetric flows, three-dimensional sources and sinks .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Complex potential, Milne-Thomson theorem, two-dimensional flow, Blasius theorem .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of fluid dynamics with physics, engineering, and applied sciences .	M
PLO 6	Ethical and Professional Responsibility	Ethical reasoning in modeling, logical consistency in fluid equations .	M
PLO 7	Employment ready and entrepreneurial skills	Section II & IV: Problem-solving for fluid flow, engineering applications	S

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Semester-III

Name of the Course	Statistical Inference	Course Code: 25PN-MTH309	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Apply estimation concepts such as unbiasedness, sufficiency, and efficiency, and use the Rao-Blackwell and Lehmann-Scheffé theorems to find MVUEs.

CLO 2: Construct and evaluate hypothesis tests using Neyman-Pearson lemma, likelihood ratio tests, and decision-theoretic approaches.

CLO 3: Understand non-parametric methods, including order statistics and their distributions, for inference without distributional assumptions.

CLO 4: Perform non-parametric tests like Wilcoxon, sign, Kolmogorov-Smirnov, and Mann-Whitney U tests for various hypothesis problems..

Section – I Estimation: Introduction to the problem of estimation, Concepts of Unbiasedness, Sufficiency, Completeness, Consistency, Efficiency. Minimum Variance Unbiased Estimator (MVUE), Neymann Factorization theorem. Exponential Family of Distributions and its Properties, Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators (statement and applications). Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square.	**15hrs**
Section – II Statistical hypotheses, critical region, size and power of a test, most powerful test, randomized and non randomized test, Neyman Pearson lemma and its applications, uniformly most powerful unbiased test, Likelihood Ratio test and its applications, Power functions of UMP tests with simple illustrations. Elements of decision problems: Loss function, risk function, estimation and testing viewed as decision problems. Bayes rule.	15hrs
Section – III Non Parametric Theory: Concept of Non Parametric and Distribution Free Methods, Order Statistics, their Marginal and Joint Distributions. Distributions of Median and Range. Moments of Order Statistics. Asymptotic Distribution of Order Statistics.	15hrs
Section – IV Non Parametric Tests: Ordinary Sign test, Wilcoxon Signed Rank test, and their Comparison (one sample and paired sample problems). General problem of Ties. Goodness of Fit problem : Chi-Square test and Kolmogrov–Smirnov one sample test, and their comparison. Two sample problem: Kolmogrov–Smirnov two sample test, Wald – Wolfwitz Run test, Mann –Whiteney U test, Median test.	15hrs

References:

1. Freund J.E. (1992): Mathematical Statistical, 5th Edition, Prentice Hall of India.
2. Hogg R.V. and Craig A.T. (2012): Introduction of Mathematical Statistics, 7th Edition, Collier Macmillon Publishers.
3. Mood A.M., Graybill E.A. and Bose D.C. (2011): Introduction to the Theory of Statistics, 3rd Edition, McGraw Hill.
4. Rao, C.R. (2001): Linear Statistical Inference and its Applications, 2nd edition Wiley Eastern.
5. Rohtagi V.K. and A. K. Md. Ehsanes Saleh (2015): An Introduction to Probability and Statistics, 3rd Edition, John Wiley and Sons.
6. Goon A.M., Gupta M.K. and Dasgupta B. (2013) : An Outline of Statistical Theory, Vol. 2 The World Press Publishers Pvt. Ltd. Calcutta.

Semester-IV

Name of the Course	Differential Geometry	Course Code: 25PN-MTH-404	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Describe the basic features of curves and parametric families of surfaces in Euclidean space.
CLO2 Be familiar with the concepts of envelope, edge of regression and developable surfaces.
CLO3 Acquire knowledge of the normal curvature of a surface and its connection with the first and second fundamental forms.
CLO4 Understand the concepts of surface of revolution, asymptotic lines, curvature and torsion, isometric parameters and minimal curves.
CLO5 Have knowledge of geodesics on a surface, their characterization, torsion of geodesic, Bonnet theorem and its implication for a geodesic triangle.

Section – I One Parameter family of Surfaces: Envelope, Characteristics, Edge of regression, Developable surfaces. Developables Associated with a Curve: Osculating developable, Polar developable, Rectifying developable.	15 hrs
Section – II Two- parameter Family of Surfaces:Envelope, Characteristics points, Curvilinear coordinates, First order magnitudes, Directions on a surface, The normal, Second order magnitudes, Derivatives of n.	15 hrs
Section III Curves on a Surface: Principal directions and curvatures, First and second curvatures, Euler's theorems, Dupin's indicatrix, The surfaces $z = f(x,y)$, Surface of revolution. Conjugate directions, Conjugate systems. Asymptotic lines, Curvature and torsion, Isometric parameters, Null lines, minimal curves.	15 hrs
Section IV Geodesics and Geodesic Parallels:Geodesics: Geodesic property, Equation of Geodesics, Surface of revolution, Torsion of Geodesic. Curves in Relation to Geodesics: Bonnet's theorem, Joachimsthal's theorems, Vector curvature, Geodesic curvature κ_g, Other formulae for κ_g, Bonnet's formula.	15 hrs

Books Recommended:

1. A.K. Singh and P.K. Mittal , A Textbook of Differential Geometry, Har-Anand Publications.
2. C.E. Weatherburn, Differential Geometry of Three Dimensions, Radhe Publishing House.
3. Erwin Kreyszig, Differential Geometry, Dover Publications Inc., New edition.

Mapping of PLOs with Course Contents of 25PN-MTH-404

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Envelope, edge of regression, developable surfaces .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Two-parameter families, curvilinear coordinates, magnitudes, normal, derivatives .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Curves on surfaces, principal directions, curvatures, surfaces of revolution .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Geodesics, Bonnet theorem, geodesic curvature, implications for triangles .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of differential geometry with physics, engineering, and advanced mathematics .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in geometric modeling .	M
PLO 7	Employment ready and entrepreneurial skills	Section II-IV: Surface properties, geodesics, minimal curves	M

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-IV

Name of the Course	**Theory of Field Extensions**	**Course Code: 25PN-MTH-405**	**Course: DEC Credits:4**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Use diverse properties of field extensions in various areas.
CLO 2: Establish the connection between the concept of field extensions and Galois theory.
CLO 3: Describe the concept of automorphism, monomorphism and their linear independence in field theory
CLO 4: Compute the Galois group for several classical situations.
CLO 5: Solve polynomial equations by radicals along with the understanding of ruler and compass constructions.

Section-I Extension of fields: Elementary properties, Simple Extensions, Algebraic and transcendental Extensions. Factorization of polynomials.	15 hrs
Section-II Splitting fields, Algebraically closed fields, Separable extensions, Galios fields, Perfect fields.	15 hrs
Section-III Galios theory: Automorphism of fields, Monomorphisms and their linear independence, Fixed fields.	15 hrs
Section-IV Normal extensions, Normal closure of an extension, The fundamental theorem of Galois theory.	15 hrs

References:

1. I.S. Luther and I.B.S. Passi, Algebra, Vol. IV-Field Theory, Narosa Publishing House, 2012.
2. Ian Stewart, Galios Theory, Chapman and Hall/CRC, 2004.
3. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.
5. S. Lang, Algebra, 3rd editioin, Addison-Wesley, 1993.
6. Ian T. Adamson, Introduction to Field Theory, Cambridge University Press, 1982.
7. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.

Mapping of PLOs with Course Contents of 25PN-MTH-405

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Elementary properties, simple, algebraic, transcendental extensions .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Splitting fields, separable extensions, Galois fields .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Automorphism, monomorphisms, fixed fields .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Normal extensions, fundamental theorem of Galois theory .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of field extensions with algebra, Galois theory, and advanced mathematics .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in mathematical proofs .	M
PLO 7	Employment ready and entrepreneurial skills	Section III & IV: Problem-solving for advanced algebraic structures.	M

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Semester-IV

Name of the Course	Finite Element Methods	Course Code: 25PN-MTH-406	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Understand the general theory of Finite Element method and its difference with finite difference method
CLO2: Use the role and significance of shape functions in finite element formulations and use of linear, quadratic, and cubic shape functions for interpolation
CLO3: Formulate some important 1, 2 and 3 dimensional elements.
CLO4: Apply the weighted residual and variational approaches in solving some boundary value problems

Section – 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.	15 hrs
Section – II Numerical integration, construction of shape functions: linear elements (one dimensional bar element, two dimensional-triangular and rectangular elements, three dimensional tetrahedron element).	15 hrs
Section - III Higher order elements: one dimensional quadratic element, two dimensional triangular element, rectangular element, three dimensional tetrahedron element: quadratic element and higher order elements	15 hrs
Section – 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.	15 hrs

References:

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

Mapping of PLOs with Course Contents of 25PN-MTH-406

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: General theory, discretization, shape functions, stiffness matrix, boundary conditions .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Shape functions for 1D, 2D, 3D elements, numerical integration .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Higher-order elements, interpolation, advanced formulations .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Weighted residual and variational approaches, boundary value problems, computer procedures .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of finite element methods with engineering, physics, and applied sciences .	M
PLO 6	Ethical and Professional Responsibility	Ethical reasoning in modeling, logical consistency in numerical solutions .	M
PLO 7	Employment ready and entrepreneurial skills	Section IV: Computer procedures for finite element analysis	S

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Semester-IV

Name of the Course	Mechanics of Solids-II	Course Code: 25PN-MTH-407	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Be familiar with the concept of generalized plane stress and solution of two-dimensional biharmonic equations.

CLO 2: Solve the problems based on thick-walled tube under external and internal pressures.

CLO 3: Understand the concept of torsional rigidity, lines of shearing stress and solve the problems of torsion of beams with different cross-sections.

CLO 4: Describe Ritz method, Galerkin method, Kantrovich method and their applications to the torsional problems.

Section-I **Two-dimensional Problems:** Plane strain and Plane stress. Generalized plane stress. Airy stress function for plane strain problems. General solutions of a Biharmonic equation. Stresses and displacements in terms of complex potentials. Thickwalled tube under external and internal pressures. Rotating shaft.	15 hrs
Section-II **Torsion of Beams:** Torsion of cylindrical bars. Torsional rigidity. Torsion and stress functions. Lines of shearing stress, Simple problems related to circle, ellipse and equilateral triangle cross-section.	15 hrs
Section-III **Variational Methods:** Reciprocal theorem of Betti and Rayleigh. Deflection of elastic string by Transverse load; Deflection of central line of Beam, Deflection of elastic membrane. The Ritz method-one & two dimensional, The Galerkin method, The method of Kantrovitch.	15 hrs
Section-IV **Viscoelasticity:** Spring & Dashpot, Maxwell & Kelvin Models, Three parameter solid, Correspondence principle & its application to the Deformation of a viscoelastic Thick-walled tube in Plane strain.	15 hrs

References:

1. I.S. Sokolnikof, Mathematical theory of Elasticity, Tata McGraw Hill Publishing company Ltd. New Delhi, 1977.
2. Teodar M. Atanackovic and Ardeshiv Guran, Theory of Elasticity for Scientists and Engineers, Birkhausev, Boston, 2000.
3. A.K. Mal & S.J. Singh, Deformation of Elastic Solids, Prentice Hall, New Jersey, 1991.
4. C.A. Coluson, Waves.
5. A.S. Saada, Elasticity-Theory and Applications, Pergamon Press, New York, 1973.
6. D.S. Chandersekharian and L. Debnath, Continuum Mechanics, Academic Press.

Mapping of PLOs with Course Contents of 25PN-MTH-407

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Plane strain, plane stress, thick-walled tubes, Airy stress function .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Torsion of beams, torsional rigidity, stress functions .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Variational methods, Ritz, Galerkin, Kantrovich methods .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Viscoelasticity, Maxwell & Kelvin models, deformation problems .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of elasticity theory with engineering, physics, and applied sciences .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in modeling and analysis .	M
PLO 7	Employment ready and entrepreneurial skills	Section II & III: Problem-solving for engineering design and analysis.	S

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Semester-IV

Name of the Course	Applied Statistics	Course Code: 25PN-MTH-408	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Students are expected to illustrate linear models, analysis of variance, experimental designs and factorial designs.

CLO2: Students will be able to understand conceptual knowledge of Reliability theory and statistical quality control theory.

Section – I Linear Models: Standard Gauss Markov Models, Estimability of Parameters, Best Linear Unbiased Estimator (BLUE), Method of Least Squares, Gauss-Markov Theorem, Variance- Covariance Matrix of BLUE's. Analysis of Variance for One- Way, Two -Way for Fixed, Mixed and Random Effects Models, Tukey's Test for Non- Additivity.	15 hrs
Section – II Two Variable Linear Regression Model- Least Squares Estimators of Coefficients and Their Properties, Inference in Least Squares Model, General Linear Regression Model, Least Squares Estimator and Its Properties, Inference in General Linear Regression Model. Generalized Least Squares Estimation.	15 hrs
Section – III Tests of Linear Restrictions On Regression Coefficients, Use of Extraneous Information On Regression Coefficients – Restricted Regression, Restricted Least Squares and Its Properties, Mixed Regression and Properties of Mixed Regression Estimator, Specification Errors Analysis- Inclusion and Deletion of Explanatory Variables, Effect On Estimation of Parameters and Disturbance Variance	15 hrs
Section – IV Reliability theory: Basic concepts of life testing experiments, reliability, hazard function and their relationship. System reliability concepts: Parallel system, Series system and k out of n system, Non-series parallel systems, Systems with mixed mode failures. Standby redundancy: Simple standby system, k-out-of-n standby system. Hazard Models: Introduction, Constant Hazard, Linearly Increasing Hazard, Weibull Model, On density function and distribution function, distribution functions and reliability analysis, choice of distributions, expected value, System of random variables and their functions, functions of a single random variable.	15 hrs

References:

1. 1. Wu, C. F. J. and Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization 2nd edition, John Wiley.
2. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics, 2nd edition, John Wiley and Sons.
3. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 7th Edition, Wiley India Pvt. Ltd.
4. Goon A. M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I a.& II,8th Edn. The World Press, Kolkata.
5. Mukhopadhyay, P (2011):Applied Statistics, 2nd edition revised reprint, Books andAllied(P) Ltd.
6. Cochran, W.G. and Cox, G.M. (1992): Experimental Design. 2nd Edition, Asia Publishing House.
7. Das, M.N. and Giri, N.C. (2017): Design and Analysis of Experiments. 3rd Edition , Wiley Eastern Ltd.
8. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol.II, 8th Edition. World Press, Kolkata.
9. Kempthorne, O. (2005): The Design and Analysis of Experiments. 2nd Edition, John Wiley.
10. Montgomery, D. C. (2012): Design and Analysis of Experiments, John Wiley.
11. Balagurusami, E. (2002) Reliability Engineering, Tata McGraw Hill, New Delhi.

12. L.S. Srinath, Reliability Engineering, East- west Press pvt. ltd. 2016.
13. K. K. Aggarwal: Reliability Engneering, Springer- Science+ business Media, B.V.
14. Barlow, R. E., & Proschan, F. (1975). Statistical theory of reliability and life testing.
15. Gertsbakh, I. (2013). Reliability theory with applications to preventive maintenance. Springer.

Mapping of PLOs with Course Contents of 25PN-MTH-408

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Linear models, ANOVA, estimability, BLUE, Gauss-Markov theorem .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Linear regression, inference, generalized least squares .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Restricted regression, specification errors, mixed regression .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Reliability theory, hazard models, system reliability .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of statistical methods with quality control, experimental design, and reliability engineering .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in data analysis and reporting .	M
PLO 7	Employment ready and entrepreneurial skills	Section II & IV: Problem-solving for statistical analysis and quality control	S

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Name of the Course	Algebraic Number Theory	Course Code: 25PN-MTH-409	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Analyze Gaussian integers, primes, and unique factorization in rings like $\mathbb{Z}[i]$ and $\mathbb{Q}(\omega)$.
CLO 2: Classify algebraic numbers, apply Liouville's theorem, and use the primitive element theorem in algebraic fields.
CLO 3: Compute norms, traces, discriminants, and construct integral bases in algebraic number fields.
CLO 4: Study ideals, factorization, and Dedekind domains, and apply theorems like CRT and Dedekind's to number field extensions.

Section-I Algebraic Number and Integers : Gaussian integers and its properties, Primes and fundamental theorem in the ring of Gaussian integers, Integers and fundamental theorem in $Q(\omega)$ where $\omega^3 = 1$, Algebraic fields, Primitive polynomials, The general quadratic field $Q(\sqrt{m})$, Sections of $Q(\sqrt{2})$, Fields in which fundamental theorem is false, Real and complex Euclidean fields, Fermat theorem in the ring of Gaussian integers, Primes of $Q(\sqrt{2})$ and $Q(\sqrt{5})$.	15 hrs
Section-II Countability of set of algebraic numbers, Liouville theorem and generalizations, Transcendental numbers, Algebraic number fields, Liouville theorem of primitive elements, Ring of algebraic integers, Theorem of primitive elements.	15 hrs
Section-III Norm and trace of an algebraic number, Non degeneracy of bilinear pairing, Existence of an integral basis, Discriminant of an algebraic number field, Ideals in the ring of algebraic integers, Explicit construction of integral basis, Sign of the discriminant, Cyclotomic fields, Calculation for quadratic and cubic cases.	15 hrs
Section-IV Integral closure, Noetherian ring, Characterizing Dedekind domains, Fractional ideals and unique factorization, G.C.D. and L.C.M. of ideals, Chinese remainder theorem, Dedekind theorem, Ramified and unramified extensions, Different of an algebraic number field, Factorization in the ring of algebraic integers.	15 hrs

References:

1. Esmonde and M Ram Murty, Problems in Algebraic Number Theory, GTM Vol. 190, Springer Verlag, 1999.
2. G.H. Hardy and E.M. Wright, An Introduction to the Theory of Numbers 2008
3. W.J. Leveque, Topics in Number Theory – Vols. I, III Addition Wesley. 2012
4. H. Pollard, The Theory of Algebraic Number, Carus Monogrpah No. 9, Mathematical Association of America. 1998
5. P. Riebenboim, Algebraic Numbers – Wiley Inter-science. 1972
6. E. Weiss, Algebraic Number Theory, McGraw Hill. 2012

Mapping of PLOs with Course Contents of 25PN-MTH-409

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Gaussian integers, primes, fundamental theorem, algebraic fields .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Algebraic numbers, Liouville's theorem, primitive element theorem .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Norms, traces, discriminants, integral bases .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Ideals, Dedekind domains, CRT, Dedekind's theorem, factorization .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of algebraic number theory with advanced mathematics and cryptography .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in abstract mathematical proofs .	M
PLO 7	Employment ready and entrepreneurial skills	Section III & IV: Problem-solving for advanced algebraic structures	M

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-IV

Name of the Course	Mathematical Aspects of Seismology	Course Code: 25MTH410	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Analyze progressive, harmonic, and plane waves, and solve wave equations in various coordinate systems.

CLO 2: Explain the principles of superposition, D'Alembert's solution, and inhomogeneous wave equations in wave propagation.

CLO 3: Describe earthquake phenomena, P and S wave characteristics, and their propagation in Earth's interior.

CLO 4: Investigate surface waves (Rayleigh and Love), reflection/refraction at interfaces, and solve Lamb's problems for elastic solids.

Section – I Waves: General form of progressive waves, Harmonic waves, Plane waves, the wave equation. Principle of superposition. Progressive types solutions of wave equation. Stationary type solutions of wave equation in Cartesian, Cylindrical and Spherical coordinates systems. Equation of telegraphy. Exponential form of harmonic waves. D' Alembert's formula. Inhomogeneous wave equation.	15 hrs
Section – II Introduction to Seismology: Earthquakes, Location of earthquakes, Causes of Earthquakes, Observation of Earthquakes, Aftershocks and Foreshocks, Earthquake magnitude, Seismic moment, Energy released by earthquakes, Interior structure of the Earth. Reduction of equation of motion to wave equations. P and S waves and their characteristics. Polarization of plane P and S waves.	15 hrs
Section – III Surface waves: Rayleigh waves and Love waves. Snell's law of reflection and refraction. Reflection of plane P and SV waves at a free surface. Partition of reflected energy. Reflection at critical angles. Reflection and refraction of plane P and SH waves at Solid-Solid Interface.	15 hrs
Section – IV Two dimensional Lamb's problems in an isotropic elastic solid: Area sources and Line Sources in an unlimited elastic solid. A normal force acts on the surface of a semi-infinite elastic solid, tangential forces acting on the surface of a semi-infinite elastic solid. Three dimensional Lamb's problems in an isotropic elastic solid: Area or Volume sources and Point sources in an unlimited elastic solid, Area or Volume source and Point source on the surface of semi-infinite elastic solid.	15 hrs

Books Recommended:

1. C.A. Coulson and A. Jefferey, Waves, Longman, New York, 1977.
2. M. Bath, Mathematical Aspects of Seismology, Elsevier Publishing Company, 1968.
3. W.M. Ewing, W.S. Jardetzky and F. Press, Elastic Waves in Layered Media, McGraw Hill Book Company, 1957.
4. C.M.R. Fowler, The Solid Earth, Cambridge University Press, 1990
5. P.M. Shearer, Introduction to Seismology, Cambridge University Press,(UK) 1999.
6. K. E. Bullen, B. A. Bolt, An Introduction to the theory of Seismology, 4th Edi., 1985.
7. A. Ben-Menahem, S.J. Singh; Seismic Waves and Sources, Springer-Verlag, 1981.

Mapping of PLOs with Course Contents of 25PN-MTH-410

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Progressive, harmonic, and plane waves, wave equation, D'Alembert's formula .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Earthquake phenomena, P and S wave characteristics, wave propagation in Earth .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Surface waves, reflection/refraction, energy partitioning .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Lamb's problems, area/line sources, 2D/3D solutions for elastic solids .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of wave theory with geophysics, seismology, and applied mathematics .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in modeling seismic phenomena .	M
PLO 7	Employment ready and entrepreneurial skills	Section II & IV: Problem-solving for seismological and engineering applications.	S

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Semester-IV

Name of the Course	Cryptography	Course Code: 25PN-MTH-411	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

CLO1: Understand the operations with congruence's, linear and non-linear congruence equations.

CLO2: 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.

CLO3: Apply the theorems: Fermat's last theorem, prime number theorem and zeta function.

CLO4: Understand and use the numbers: Perfect numbers, Fermat numbers, Mersenne primes and amicable numbers, Fibonacci numbers.

Section-I Modular arithmetic, congruence, primitive roots, cryptography introduction, Caesar Cipher, Diffie-Hellman RSA public key cryptosystem, Knapsack cryptosystem, application of primitive roots to cryptography.	15 hrs
Applications of cryptography in primality testing and factorization of large composite numbers, remote coin flipping. Elliptic curve based cryptography.	15 hrs
Section-III Perfect numbers, Fermat numbers, Mersenne primes and amicable numbers, Fibonacci numbers, representation of integers as sum of Squares.	15 hrs
Section-IV Linear and non-linear Diophantine equations, Fermat's last theorem, prime number theorem and zeta function..	15 hrs

References:

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

Mapping of PLOs with Course Contents of 25PN-MTH-411

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Modular arithmetic, congruence, Caesar cipher, RSA, Diffie-Hellman, primitive roots .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Primality testing, factorization, remote coin flipping, elliptic curve cryptography .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Perfect numbers, Fermat numbers, Mersenne primes, Fibonacci numbers .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Diophantine equations, Fermat's last theorem, prime number theorem, zeta function .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of cryptography with number theory, computer science, and information security .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in cryptographic applications .	M
PLO 7	Employment ready and entrepreneurial skills	Section II & III: Cryptographic problem-solving for real-world applications	S

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Semester-IV

Name of the Course	Advanced Complex Analysis	Course Code: 25PN-MTH-412	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the basics of logarithmically convex function that helps in extending maximum modulus theorem.

CLO2: Be familiar with metric on spaces of analytic, meromorphic and analytic functions, equi-continuity and normal families leading to Arzela-Ascoli and related theorems.

CLO3: Appreciate the richness of simply connected region which connects various fields topology, analysis and algebra.

CLO4: Know how big the range of an entire function is as well as Picard and related theorems.

Section – I Analytic continuation, Uniqueness of analytic continuation, Spaces of analytic functions, Hurwitz's theorem, Montel's theorem, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation. Monodromy theorem.	15 hrs
Section – II Entire function; Canonical products, Weierstrass' factorisation theorem, Exponent of Convergence, Order of an entire function, Jensen's formula, Borel's theorem. Hadamard's factorization theorem, Hadamard's three circles theorem.	15 hrs
Section – III The range of an analytic function. Bloch's theorem. The Little Picard theorem. Schottky's theorem. Montel Caratheodory theorem, The Great Picard theorem.	15 hrs
Section – IV Conformal mapping; Riemann mapping theorem, Harmonic function on a disk, Dirichlet problem. Green's function. Harnack's inequality and theorem, Univalent function, Meromorphic function, Gamma function and its properties.	15 hrs

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. Fundamental of Complex Analysis with Applications to Engineering and Sciences. Pearson Education, 2014.
5. Lang, S. Complex Variable. Springer, 2013.
6. Conway J. B. Functions of One Complex Variable. Springer, 2000.

Mapping of PLOs with Course Contents of 25PN-MTH-412

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Analytic continuation, Hurwitz's theorem, Montel's theorem, power series, monodromy theorem .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Entire functions, factorization theorems, order, convergence, Jensen's and Hadamard's theorems .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Range of analytic functions, Bloch's, Picard's, Schottky's, Montel-Caratheodory theorems .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Conformal mapping, Riemann mapping, harmonic functions, Dirichlet problem, Gamma function .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of complex analysis with topology, algebra, and applied sciences .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in mathematical proofs .	M
PLO 7	Employment ready and entrepreneurial skills	Sections II & IV: Function theory, conformal maps, applications, Green's function	M

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Mapping of PLOs with Course Contents of 25PN-MTH-309

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Estimation concepts, unbiasedness, sufficiency, efficiency, Rao-Blackwell and Lehmann-Scheffé theorems	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Hypothesis testing, Neyman-Pearson lemma, likelihood ratio tests, decision-theoretic approaches .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Non-parametric methods, order statistics, their distributions .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Non-parametric tests, Wilcoxon, sign, Kolmogorov-Smirnov, Mann-Whitney U tests .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of statistical inference with applied sciences, real-world data analysis .	M
PLO 6	Ethical and Professional Responsibility	Ethical reasoning in statistical modeling, logical consistency in inference .	M
PLO 7	Employment ready and entrepreneurial skills	Section II & IV: Practical hypothesis testing and non-parametric methods for employment	S

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-III

Name of the Course	Analytical Number Theory	Course Code: 25PN-MTH310	Course: DEC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Analyze the distribution of primes, properties of Fermat and Mersenne numbers, and approximation of irrationals using Farey series and Hurwitz theorem.
CLO 2: Understand arithmetic in $\mathbb{Z}_n$, primitive roots, and the structure of multiplicative groups and quadratic residues modulo n.
CLO 3: Apply the Riemann zeta function, solve Diophantine equations, and explore representations of numbers as sums of squares and the Waring problem.
CLO 4: Study arithmetic functions, perfect numbers, Möbius inversion, and compute orders and averages of number-theoretic functions

Section-I Distribution of primes, Fermat and Mersenne numbers, Farey series and some results concerning Farey series, Approximation of irrational numbers by rationals, Hurwitz theorem, Irrationality of e and π.	15hrs
Section-II The arithmetic in Z_n, The group U_n, Primitive roots and their existence, the group $U_p{}^n$ (p-odd) and $U_2{}^n$, The group of quadratic residues Q_n, Quadratic residues for prime power moduli and arbitrary moduli, The algebraic structure of U_n and Q_n.	15hrs
Section-III Riemann Zeta Function $\zeta(s)$ and its convergence, Application to prime numbers,$\zeta(s)$ as Euler product, Evaluation of $\zeta(2)$ and $\zeta(2k)$. Diophantine equations $ax + by = c$, $x^2+y^2 = z^2$ and $x^4+y^4 = z^4$, The representation of number by two or four squares, Waring problem, Four square theorem, The numbers g(k) & G(k), Lower bounds for g(k) & G(k).	15hrs
Section-IV Arithmetic functions $\phi(n)$, $\tau(n)$, $\sigma(n)$ and $\sigma_k(n)$, U(n), N(n), I(n), Definitions and examples and simple properties, Perfect numbers, Mobius inversion formula, The Mobius function μ_n, The order and average order of the function $\phi(n)$, $\tau(n)$ and $\sigma(n)$.	15hrs

References:

1. G.H. Hardy and E.M. Wright, An Introduction to the Theory of Numbers. 2008
2. D.M. Burton, Elementary Number Theory. 2002
3. N.H. McCoy, The Theory of Number by McMillan. 1966
4. I. Niven, I. and H.S. Zuckermann, An Introduction to the Theory of Numbers. 1960
5. A. Gareth Jones and J Mary Jones, Elementary Number Theory, Springer Ed. 1998.

Mapping of PLOs with Course Contents of 25PN-MTH-310

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Distribution of primes, Farey series, Hurwitz theorem .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Arithmetic in Zn, primitive roots, quadratic residues, group structure .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Riemann zeta function, Diophantine equations, sums of squares, Waring problem .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Arithmetic functions, Möbius inversion, perfect numbers, averages .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of number theory with algebra, analysis, and cryptography .	M
PLO 6	Ethical and Professional Responsibility	Logical consistency, ethical reasoning in mathematical proofs .	M
PLO 7	Employment ready and entrepreneurial skills	Section IV: Arithmetic functions, Möbius inversion, computational number theory.	M

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Semester-III

Name of the Course	**Introduction to LaTeX**	**Course Code: 25PN-MTH-EEC301**	**Course: EEC Credits:3**
Maximum Marks	**Practical: 20(Internal)+50(External)=70**	**Time of Examinations**	**3 Hours**

Course Learning Outcomes (CLO):

1. Understand the basics of LaTeX and various commands associated with it.
2. Understand how to link data, statistical methods, and actionable questions.

Practical/ Computational Work

Practical: 20(Internal)+50(External)=70

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 25 Marks ; ii) Viva-voce and practical record: 25 Marks

Introduction to LaTeX: Applications, Features, Document structure, section, paragraphs, packages, typing lists, typesetting Mathematical equations in LaTeX, Addition a picture, adding title in document, typing mathematical symbols.

Generating a table of contents in LaTeX, adding hyperlink, adding Bibliography, adding footnotes, creating tables in LaTeX, Plot generation from csv file, plotting and visualizing data.

Introduction to R Programming: Basic syntax, Data types and objects, variables, constants, sources of data, data categorisation, Operators and its types, Control statements and Functions, Vectors, Matrices, List, Data Frames, Factors and Tables,

Regular Expression and String Manipulation, Input/output in R, Graphs in R Programming, Application of R in descriptive statistics: Probability, Sampling Distributions, T-test, Correlation and regression analysis.

List of Practicals

1. Getting started with simple document.
2. Create a numbered list, and try typesetting the following (using either inline or display environments as appropriate):
   (a) You know that e0 = exp 0 = 1 and log 1 = 0, but did you know that e-x → 0 as x →∞?
   (b) Write the second part of the sentence above using limit notation, as a display equation.
   (c) If W ∼ χ21 then P(W > 3.84) ≈ 0.05.
   (d) $\sum_{i=1}^{n} i = \frac{n(n+1)}{2}$
3. Write the following set of equations in augmented matrix form.
   $$y + 2z = 1$$
   $$x + 2y + 3z = 2$$
   $$3x + y + 2z = 4$$
4. Create a simple table in LaTeX. Add data in table. Add centering, a caption and a label.
5. Add a title to your document. Add sections, one for each practical, like in these notes. If you have used one large list environment, you will need to split it into several smaller lists, but this is not difficult.
6. Insert your chosen picture into your document, using a figure environment with appropriate scaling.
7. Add a caption after the picture and a label after the caption. Add a reference to your picture somewhere in your text.
8. Plot a blue curve for f(x) = cos x on the same picture, with a label.
9. Plot an orange curve for f(x) = 1 20 exp x on the same picture, with a label.

References:

1. Arora S. & Malik L., R Programming for Beginners, University Press, 2020.
2. Grolemund G., Wickham H., R for Data Science, O'Reilly Media, 2016.
3. Lander J.P., R for Everyone: Advanced Analytics and Graphics, Addison Wesley Data & Analytic Series, 2014.
4. Leslie Lamport, LaTeX, A document preparation system, User's Guide and reference manual, 2nd edition, Addison Wesley.
5. Stefan Kottwitz. LaTeX Beginner's Guide, 1st edition, Packet Publishing,

Mapping of PLOs with Course Contents of 25PN-MTH-EEC301

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Introduction to LaTeX, document structure, mathematical equations, tables, figures .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Linking data, statistical methods, actionable questions, practical LaTeX and R integration .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Plot generation, visualizing data, hyperlinking, bibliography, advanced document features .	M
PLO 4	Research Aptitude and Global Competency	Practical application of LaTeX and R in research documentation and data analysis .	M
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of LaTeX and R with statistics, research, and technical writing .	M
PLO 6	Ethical and Professional Responsibility	Ethical presentation of data, logical consistency in document preparation .	M
PLO 7	Employment ready and entrepreneurial skills	Practical LaTeX skills for academic and professional document preparation	S

S: Strong; MS: Moderate to Strong; M: Moderate.W:Weak

Option I

SEMESTER-IV(Credits :23 ; Total Marks: 570)

	Nomenclature of Course	Course Code	Credits Distribution			Total Credits	Total Workload	Marks				
			L	T	P		Total Contact Hours	Theory		Practical		Total Marks
								Internal	External	Internal	External	
CC-12	Functional Analysis	25PN-MTH-401	4			04	4	30	70			100
CC-13	Integral Equations and Calculation of Variations	25PN-MTH-402	4			04	4	30	70			100
PC-4	Programming using MATLAB	25PN-MTH-403	1		2	03	1+4=5			20	50	70
	Any one of the followings											
DEC-5	Differential Geometry	25PN-MTH-404	4			04	4	30	70			100
	Theory of Field Extensions	25PN-MTH-405	4			04	4	30	70			100
	Finite Element Methods	25PN-MTH-406	4			04	4	30	70			100
	Any one of the followings											
DEC-7	Mechanics of Solids-II	25PN-MTH-407	4			04	4	30	70			100
	Applied Statistics	25PN-MTH-408	4			04	4	30	70			100
	Algebraic Number Theory	25PN-MTH-409	4			04	4	30	70			100
	Any one of the followings											
DEC-8	Mathematical Aspects of Seismology	25PN-MTH-410	4			04	4	30	70			100
	Cryptography	25PN-MTH-411	4			04	4	30	70			100
	Advanced Complex Analysis	25PN-MTH-412	4			04	4	30	70			100

Semester-IV

Name of the Course	Functional Analysis	Course Code: 25PN-MTH-401	Course: CC Credits:4
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Verify norm properties, completeness, compactness-dimension relation, boundedness-continuity of operators, operator convergence, and compute dual spaces.

CLO 2: Distinguish between Banach spaces and Hilbert spaces, decompose a Hilbert space in terms of orthogonal complements.

CLO 3: Check totality of orthonormal sets and sequences, represent a bounded linear functional in terms of inner product, classify operators into self-adjoint, unitary and normal operators

CLO 4: Extend linear functionals, compute adjoints, and check reflexivity of spaces. Apply uniform boundedness, open mapping, and closed graph theorems, and analyze convergence of operators, functionals, and sequences.

Section-I Metric Space, sequences, Cauchy sequences, complete metric spaces and examples, Baire's theorem. Cantor intersection theorem and Banach fixed point principle, normed linear spaces. Banach spaces, examples of Banach spaces and subspaces.	15 hrs
Section-II Continuity of linear maps, Equivalent norms, normed spaces of bounded Linear maps, bounded linear functionals, dual spaces of $l^p, \mathbb{R}^n$ and reflexivity, Hilbert spaces and examples, orthogonality, orthonormal sets, Bessel's inequality, Parsevals's theorem,the conjugate space of a Hilbert space.	15 hrs
Section-III Representation of bounded functional on Hilbert space, adjoint operators, self-adjoint operators, normal and unitary operators, weak and strong convergence, completely continuous operators.	15 hrs
Section-IV Hahn-Banach theorem and its applications, uniform boundedness principle, open mapping theorem, projections on Banach spaces, closed graph theorem. Adjoint operators, Reflexivity.	15 hrs

References:

1. A. Taylor and D. Lay, Introduction to functional analysis, Wiley, New York, 1980.
2. B.V. Limaye, Functional Analysis, 2nd ed., New Age International, New Delhi, 1996.
3. C. Goffman and G. Pedrick, First course in functional analysis, Prentice-Hall, 1974.
4. E. Kreyszig, Introductory Functional Analysis with applications, John Wiley & Sons, NY, 1978.
5. J. B. Conway, A course in Functional Analysis, Springer-Verlag, Berlin, 1985.

Mapping of PLOs with Course Contents of 25PN-MTH-401

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Metric spaces, sequences, completeness, Banach spaces .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Linear maps, dual spaces, Hilbert spaces, orthogonality .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Bounded functionals, adjoint, self-adjoint, unitary, normal operators .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Hahn-Banach, uniform boundedness, open mapping, closed graph theorems .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of functional analysis with advanced mathematics and research topics .	M
PLO 6	Ethical and Professional Responsibility	Rigorous logical reasoning, ethical approach to mathematical proofs .	M
PLO 7	Employment ready and entrepreneurial skills	Section III & IV: Analytical and logical skills for advanced mathematics.	M

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-IV

Name of the Course	**Integral Equations and Calculation of Variations**	**Course Code: 25PN-MTH-402**	**Course: CC Credits:4**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO 1: Apply methods to solve Volterra integral equations and related initial value problems.
CLO 2: Solve Fredholm integral equations using kernel methods and analyze solution existence..
CLO 3: Construct and use Green's functions to solve boundary value problems.
CLO 4: Formulate and solve variational problems using Euler–Lagrange equations and constraints.

Section-I Linear Integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series. Laplace transfrom method for a difference kernel. Solution of a Volterra integral equation of the first kind.	15 hrs
Section-II Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations, Resolvent kernel as a sum of series. Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels. Approximation of a kernel by a separable kernel, Fredholm Alternative, Non homonogenous Fredholm equations with degenerate kernels.	15 hrs
Section-III Green function, Use of method of variation of parameters to construct the Green function for a nonhomogeneous linear second order boundary value problem, Basic four properties of the Green function, Alternate procedure for construction of the Green function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function, Hilbert-Schmidt theory for symmetric kernels.	15 hrs
Section-IV Motivating problems of calculus of variations, Shortest distance, Minimum surface of resolution, Brachistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler equation for one dependent function and its generalization to 'n' dependent functions and to higher order derivatives. Conditional extremum under geometric constraints and under integral constraints.	15 hrs

References:

1. A.J. Jerri, Introduction to Integral Equations with Applications,A Wiley-Interscience Publication, 1999.
2. R.P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.
3. W.V. Lovitt, Linear Integral Equations, McGraw Hill, New York.
4. F.B. Hilderbrand, Methods of Applied Mathematics, Dover Publications.
5. J.M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall, New Jersy, 1963.

Mapping of PLOs with Course Contents of 25PN-MTH-402

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Section I: Volterra integral equations, methods of solution, resolvent kernel .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Section II: Fredholm integral equations, kernel methods, solution existence .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Section III: Green's functions, boundary value problems, Hilbert-Schmidt theory .	S
PLO 4	Research Aptitude and Global Competency	Section IV: Calculus of variations, Euler-Lagrange equations, constraints .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of integral equations and variational methods with physics, engineering .	M
PLO 6	Ethical and Professional Responsibility	Rigorous logical reasoning, ethical approach to mathematical modeling .	M
PLO 7	Employment ready and entrepreneurial skills	Section III & IV: Problem-solving for real-world applications	M

S: Strong; MS: Moderate to Strong; M: Moderate. W:Weak

Semester-IV

Name of the Course	Programming using MATLAB	Course Code: 25PN-MTH-403	Course: PC Credits:3 (1+2)
Maximum Marks	Practical: 20(Internal)+50(External)=70	Time of Examinations	3 Hours

Course Learning Outcomes (CLO):

CLO 1. Working introduction to the MATLAB technical computing environment.
CLO 2. Students the use of a high-level programming language, MATLAB.
CLO 3. Reinforce a structured, top-down approach to formulate and solve problems.
CLO 4. Apply a variety of common numeric techniques to solve and visualize mathematical related computational problems.

Practical/ Computational Work

Practical: 20(Internal)+50(External)=70

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
i) Written Practical/ Lab work : 25 Marks
ii) Viva-voce and practical record: 25 Marks

Introduction: Features of MATLAB, MATLAB window, Command Window, Workspace, Command History, working with the MATLAB user interface, Basic commands, Assigning variables, Operations with variables, Data files and Data types, Character and string.
Arrays and Vectors: Column vectors, Row vectors, creating rows and columns matrix, Matrix Operations, finding transpose, determinant and inverse, solving arithmetic equations. Operators and special characters, Mathematical and logical operators, solving Polynomials equations.
Loops and Conditional Statements: if, if-else, switch, Loop control: for, while, continue, break, return.
Working with script: Script file, M file, executing script files.
Plotting: plotting vector and matrix data, plot labelling, curve labelling, creating 2D and 3D plots, plotting multiple data sets, specifying line styles and colors, multiple plots in one figure, subplots.
Functions: Writing user defined functions, built in functions, function calling, types of functions, MATLAB programming, Calculus, Numerical Integration and Differentiation, Linear Algebra, Algebraic equations, solving differential equations and ODE, solving Limits, Transforms (Fourier, Laplace, etc.)

List of Practicals

Following is the list of programmes to be performed in the Lab using MATLAB:

1. Basic mathematical computation.
2. Program to generate Matrix with addition, subtraction and multiplication of matrices.
3. Solving System of Linear equations with two variables.
4. Program to use inbuilt functions and creating new functions.
5. Plotting the graph of function of two variables
6. Program to Differentiate and Integrate.
7. Program to study Interpolation and Regression.
8. Program to solve Fourier analysis.
9. Program to solve Ordinary Differential Equations
10. To plot Graph of Various Functions like sin x, cos x, etc.
11. To find Eigenvalues and Eigenvectors of given matrix.
12. Solving polynomial equations with the method studied.
13. Solving Partial Differential equations
14. Solving boundary value problems.
15. Program to solve Newton's, Bisection methods.
16. Program to solve given optimization problem.
17. Program to solve Euler's method, Runge-Kutta's methods of solving ODE.

References:

1. Jaan Kiusalaas, "Numerical Methods in Engineering with MATLAB", Cambridge University Press, 2016.

2. Rudra Pratap. "Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers", Paperback.
3. S.N. Alam and S.S. Alam, "Understanding Matlab: A Textbook for Beginners". Paperback, 2013.
4. Singh Y. Kirani, Chaudhuri B. B., "Matlab Programming", Paperback.
5. Timmy Siauw and Alexandre Bayen, "An Introduction to MATLAB Programming and Numerical Methods for Engineers", Academic Press, 2015.

Mapping of PLOs with Course Contents of 25PN-MTH-403

PLO No.	PLO Description	Mapped Course Content/CLO	Overall Mapping Level
PLO 1	Basic Knowledge and Critical Thinking	Introduction to MATLAB, basic commands, variables, data types, operators .	S
PLO 2	In-depth Knowledge and Problem-solving Abilities	Arrays, vectors, matrix operations, solving equations, conditional statements, loops .	S
PLO 3	Creativity, Analytical Innovation, and Computation Skills	Functions, plotting, numerical integration, differentiation, solving ODEs and PDEs .	S
PLO 4	Research Aptitude and Global Competency	Application of MATLAB in solving engineering, scientific, and mathematical problems .	MS
PLO 5	Holistic, Multidisciplinary Skill Enhancement	Integration of MATLAB programming with applied mathematics, engineering, and data analysis .	M
PLO 6	Ethical and Professional Responsibility	Ethical use of data, logical consistency in programming and modeling .	M
PLO 7	Employment ready and entrepreneurial skills	Practical MATLAB skills for scientific and engineering problem-solving.	S

S: Strong; MS: Moderate to Strong; M: Moderate,W:Weak