Department of Mathematics

- **Proposed list of courses to be offered for first three semesters**

Semester	Core Courses	Mathematics as single Minor	Credit
I	Algebra and Calculus I	Numerical Analysis	4
II	Algebra and Calculus II	Complex Analysis	4
III	Differential Equations	Basic Statistics	4

- **Multidisciplinary Courses to be offered from Dept. of Mathematics**

Semester	Courses	Credit
I	Foundation of Mathematics	3
II	Combinatorics, Partial Fractions and Measures of Central Tendency	3
III	Introduction to programming with MATLAB	3

DETAILED SYLLABUS

SEMESTER I	ALGEBRA AND CALCULUS-I	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of Mathematics at Class XI & XII

Course Objectives:

1. To achieve conceptual understanding of basic number theory, connection of complex numbers and trigonometry, matrices.
2. To have a deeper insight of the developments of the generalized notions of trigonometry.
3. To use matrix methods for solving linear equations.
4. To gain proficiency in calculus computations and to calculate the higher order derivatives and apply them in proper situations.

Course Outcome:

After successful completion of the course, the students will be able to

CO 1: apply De Moivre's theorem in a number of applications to solve numerical problems.
CO 2: recognize the essential tool of matrices and linear algebra in a comprehensive manner.
CO 3: evaluate the roots of complex numbers
CO 4: compute and analyze functions using limits, derivatives and apply the techniques of differentiation in analyzing different functions.

Module 1: Basic Number Theory	**12 Hours**

Cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Fundamental Theorem of Arithmetic, Congruence relation between integers.

Module 2: Matrices	**14 Hours**

Symmetric, Skew-symmetric and Orthogonal matrices, Rank of a Matrix, Row reduction and Echelon form, Inverse of a matrix, System of linear equations.

Module 3: Complex Numbers	**12 Hours**

Polar representation of complex numbers, De Moivre's theorem and its applications. Roots of a complex number, Trigonometrical and exponential functions of complex arguments. Hyperbolic Functions.

Module 4: Differential Calculus	**22 Hours**

Limit, Continuity and Differentiation, Indeterminate forms and L' Hospital's rule, Asymptotes, Curvature, Successive differentiation, Leibnitz' theorem, Rolle's Theorem, Lagrange's Theorem. Taylor's and Maclaurin's series, Partial derivatives, Extreme values of functions (of single and multiple variables), Error approximation, Euler's theorem on Homogeneous functions, Total derivatives.

Total Lecture hours	**60 hours**

Text Book(s)

1. Dickson, L. E., First Course in The Theory of Equations. John Wiley & Sons, Inc. New York. The Project Gutenberg **EBook** (1922)
2. Hoffman K., Kunze R. A., Linear Algebra, 2nd Ed, Prentice-Hall, Inc., Englewood Cliffs, NewJersey (1971)
3. Anton H., Bivens I. and Davis S., Calculus (10th Edition), John Wiley and sons (Asia), Pt Ltd.,Singapore (2012)
4. Bartle Robert G., Sherbert Donald R., Introduction to Real Analysis, John Wiley & Sons, Inc. NewYork (2000)

Reference Books

1.	Mapa S.K., Higher Algebra (Classical), Asoke Prakashan, Calcutta (2000)
2.	Andreescu T, and Andrica D., Complex Numbers from A to Z, Birkhauser, Boston, USA (2000)
3.	Das B. C.& Mukherjee B. N., Differential Calculus, U. N. Dhur and Sons Pvt. Ltd, Kolkata (2014)

SEMESTER II	ALGEBRA AND CALCULUS-II	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of Mathematics at Class XI & XII

Course Objectives:

1. To demonstrate the techniques to solve polynomial equations of higher degree
2. To calculate and interpret geometrically triple product of vectors and to form equations ofstraight line, plane, sphere in vector form
3. To learn techniques for. producing a rough idea of overall shape of different curves
4. To apply integrals in physical problems

Course Outcome:

After successful completion of the course, the students will be able to

CO 1: describe the graphical representation of a polynomial, maximum and minimum valuesof a polynomial, acquire the concept of symmetric functions

CO 2: evaluate the vector triple product and product of four vectors and find the equation of straight lines, planes in vector form

CO 3: trace the curves of various functions in different forms like Cartesian, parametric and polar

CO 4: attain a basic understanding of Beta and Gamma functions and apply the knowledge of integration in finding areas and volumes of surfaces of revolution.

Module 1: Theory of Equations — **20 Hours**

General properties of polynomials, Graphical representation of a polynomials, maximum and minimum values of a polynomials, General properties of equations, Descartes' rule of signs positive and negative rule, Relation between the roots and the coefficients of equations. Symmetric functions, Applications symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.

Module 2: Vector Algebra — **10 Hours**

Triple product of vectors, Vector four product and their properties, Reciprocal system of vectors, Vector equation of straight line, plane and sphere.

Module 3: Tracing of Curves — **10 Hours**

Concavity and inflection points, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves.

Module 4: Integral Calculus — **20 Hours**

Reduction formulae, Evaluation of definite and improper integrals, Beta and Gamma functions and their properties, Multiple integrals, Arc length of parametric curves, Application of definite integrals to evaluate surface areas and volume of solids of revolution

Total Lecture hours — **60 hours**

Text Book(s)

1. Dickson, L. E., First Course in the Theory of Equations. John Wiley & Sons, Inc. NewYork. The Project Gutenberg **EBook** (1922)
2. Thomas G.B. and Finney R.L., Calculus, 9th Ed., Pearson Education, Delhi (2014)
3. Spiegel M. R., Schaum's outlines Vector Analysis, Tata McGraw Hill (Education) India Pvt. Ltd, New Delhi (2009)
4. Bartle Robert G., Sherbert Donald R., Introduction to Real Analysis, John Wiley & Sons, Inc. NewYork (2000)

Reference Books

1. Strauss M. J., Bradley G. L. and Smith, K. J. Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, (2007).
2. Narayan S., Mittal P. K., A Text Book of Vector Analysis, S. Chand Publishing, Uttar Pradesh (1955)
3. Das B. C.& Mukherjee B. N., Integral Calculus, U. N. Dhur and Sons Pvt. Ltd, Kolkata (2014)

SEMESTER III	DIFFERENTIAL EQUATIONS	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of Mathematics at Class XI & XII

Course Objectives:

To introduce the students to the exciting world of ordinary differential equations, mathematical modeling and their applications.

Course Outcome:

After successful completion of the course, the students will be able to

CO 1: learn basics of differential equations and mathematical modelling.

CO 2: solve first order non-linear differential equations and linear differential equations of higher order using various techniques.

Module 1: First Order Ordinary Differential Equations	**30Hours**

Linear equations and Bernoulli equations, Orthogonal trajectories and oblique trajectories; Basic theory of higher order linear differential equations, Wronskian, and its properties; Solving differential equation by reducing its order.

Module 2: Second Order Linear Differential Equations	**30 Hours**

Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations.

Total Lecture hours	**60 hours**

Text Book(s)

1. Simmons G. F., Differential Equations with applications 3rd Edition, CRC Press, Chapman and Hall Book (2017)
2. Sneddon, I. N. Elements of Partial Differential Equations, Dover Publications. Indian Reprint (2006)

Reference Books

1. Raisinghania M. D., Advanced Differential Equations, S. Chand & Company Pvt. Ltd (2014)
2. Ahsan, Z. Differential Equations and their Applications, 2nd Ed., PHI, Pvt. Ltd., New Delhi (2004).

- **Mathematics as a Single Minor**

PAPERS	TITLE
Minor I	NUMERICAL ANALYSIS
Minor II	COMPLEX ANALYSIS
Minor III	BASIC STATISTICS

Minor I	NUMERICAL ANALYSIS	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of Mathematics at Class XI & XII

Course Objectives:

1. To train students to understand why the methods work, what type of errors to expect, and when an application might lead to difficulties
2. To learn well-known numerical techniques to solve physical problems and evaluate the results

Course Outcome:

After successful completion of the course, the students will be able to
CO 1: calculate the errors, source of error and its effect on any numerical computations.
CO2: compute the values of a tabulated function at points not in the table..
CO3: apply numerical methods to obtain approximate solutions to mathematical problems
CO4: learn how to solve problems of definite integrals numerically.

Module 1: Error Analysis — **6 Hours**

Errors, Different type of errors. Representation of numbers in computer, Computer arithmetic, Zeros in floating point number.

Module 2: Finite Differences — **20 Hours**

Operators –finite differences, average, differential, etc., their inter-relations. Difference of polynomials, Interpolation, Uniqueness of interpolating polynomial, Newton's forward and backward interpolation formulae, Newton's divided difference formula, Lagrange's interpolation formula, Inverse interpolation, Central difference, Errors in different interpolation formulae.

Module 3: Numerical Integration — **10 Hours**

Quadrature: Trapezoidal rule, Simpson's quadrature (1/3 and 3/8 rule). Error in Quadrature formulae.

Module 4: Solutions of Equations — **24 Hours**

Solution of algebraic and transcendental equation: Bisection method, Regula-falsi method, Iteration method, Newton-Raphson method and its geometrical interpretation. Solution of system of equations: Gauss elimination method, Gauss Seidal Method, Gauss Jordan method.

Total Lecture hours — **60 hours**

Text Book(s)

1. Gerald C. F. and Wheatley P. O., Applied Numerical Analysis, Pearson, 7th Edition (2004)
2. Jain M. K., Iyengar S., Jain R. K., Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, 6th edition (2012)

Reference Books

1. B. S. Grewal, Numerical Methods in Engineering & Science, Khanna Publishers, Delhi (2013)
2. F. Scheid, Schaum's outline of theory and problems of numerical analysis, McGraw Hill Professional, (1988)

Minor II	COMPLEX ANALYSIS	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of Mathematics at Class XI & XII

Course Objectives:

1. To study the techniques of complex variables and functions together with their derivatives.
2. To investigate theorems in Complex Integrals.

Course Outcome:

After successful completion of the course, the students will be able to

CO 1: analyze limit, continuity and differentiation of functions of complex variables, understand Cauchy-Riemann equations, analytic functions and various properties of analytic functions.

CO2: understand integral formulae and apply these to evaluate complex contour integrals, represent functions as Taylor and Laurent series and the convergence of power series

Module 1: Complex Differentiation and Cauchy Riemann Equation	**30 Hours**

Properties of complex numbers, regions in the complex plane, functions of complex variable, Mappings. Limits, continuity, Derivative of a complex function, Differentiation formulae, Analytic function, Elementary analytic functions (exponential, trigonometric, logarithm), Cauchy-Riemann equations, Sufficient conditions for differentiability, Harmonic functions, Milne-Thompson method.

Module 2: Complex Integration and Cauchy's Theorem	**30 Hours**

Complex Line integral, Real line integral, Simply and Multiply connected regions. Green's theorem in the plane (Complex form), Cauchy's theorem, Cauchy – Goursat theorem, Morera's theorem, consequences of Cauchy's theorem, Cauchy's integral formulae, Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series.

Total Lecture hours	**60 hours**

Text Book(s)

1. Speigel M.R., Schaum Outline Complex Variables, McGraw Hill Companies Inc. (2009)

Reference Books

1. Brown J. W. and Churchill R. V., Complex Variables and Applications (Eighth Edition), McGraw – Hill International Edition, (2009)

Minor III	BASIC STATISTICS	L	T	P	C
		3	1	0	4

Pre-requisite: Knowledge of Mathematics at Class XI & XII

Course Objectives:

1. To make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness.
2. To render the students to several examples and exercises that blend their everyday experiences with their scientific interests.

Course Outcome:

After successful completion of the course, the students will be able to

CO 1: learn about probability and moment generating functions.

CO 2: know about various distributions such as Binomial, Poisson and Normal distributions.

CO 3: measure the scale of association between two variables, and to establish a formulation helping to predict one variable in terms of the other, i.e., correlation and linear regression.

Module 1: Introduction to Probability	**15 Hours**

Random experiment, Sample space, Events, Definition of probability and examples, Addition law of probability, Conditional probability, Baye's Theorem

Module 2: Random Variable	**15 Hours**

Random Variable, Probability distribution: Discrete and Continuous, Mean and Variance of probability distribution, Binomial distribution, Poisson's and Normal distribution

Module 3: Introduction to Statistics	**15 Hours**

Measures of central Tendency, Measures of dispersion, Moments and moment generating function, Skewness and Kurtosis

Module 4: Bivariate Data	**15 Hours**

Bivariate data: Definition, Scatter diagram, Simple and multiple correlation, Rank correlation, Simple linear Regression, Lines of regression, Principle of least squares and fitting of straight lines.

Total Lecture hours	**60 hours**

Text Book(s)

1. Hogg R. V., McKean J.W., & Craig A. T., Introduction to Mathematical Statistics (7th ed.). Pearson Education, Inc., (2013).
2. Miller I. & Miller M., John E. F., Mathematical Statistics with Applications (8th ed.), Pearson. Dorling Kindersley (India), (2014).
3. Ross S. M. Introduction to Probability Models (11th ed.). Elsevier Inc., (2014).

Reference Books

1. Mood, A. M., Graybill, F. A. & Boes, D. C., Introduction to the Theory of Statistics (3rd ed.). McGraw-Hill Education Pvt. Ltd. Indian Edition (2017)

- **Multidisciplinary Courses to be offered from Dept. of Mathematics**

Semester	Courses	Credit
I	Foundation of Mathematics	3
II	Combinatorics, Partial Fractions and Measures of Central Tendency	3
III	Introduction to programming with MATLAB	3

DETAILED SYLLABUS

MDC-I	Foundation of Mathematics	L	T	P	C
		2	1	0	3

Pre-requisite: Knowledge of Mathematics at high school

Course Objectives:

1. To describe the relations between sets regarding membership, equality, subset, and proper subset using proper notation
2. To draw and interpret set relations and operations and use those to solve problems
3. To explain and interpret the concepts of divisibility and number theorems.

Course Outcome:

After successful completion of the course, the students will be able to

CO 1: understand sets, relations, functions and discrete structures.

CO 2: use logical notations to define and reason about fundamental mathematical concepts such as sets relations and functions

CO 3: solve system of linear equations with the help of the knowledge from number theory and can be able to establish logical relationship between a set of numbers

Module 1: Sets — **15 Hours**

Sets, subsets, Set operations, the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.

Module 2: Relations and Functions — **15 Hours**

Product set, Composition of relations, Types of relations, Functions, types of functions and their properties, Composition of functions.

Module 3: Basic Number Theory — **15 Hours**

Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Fundamental Theorem of Arithmetic, Principles of Mathematical Induction.

Total Lecture Hours — **45 hours**

Text Book(s)

1. Lipschutz S., Schaum's Outline-Theory and Problems of Set Theory and realted topics (Ebook), McGraw Hill Companies Inc. (1964)
2. Conradie, W., Goranko, V., Logic and Discrete Mathematics: A Concise Introduction, Wiley

Reference Book(s)

3. Sarkar, S.K. A Textbook of Discrete Mathematics, S. Chand & Co. Ltd, New Delhi

MDC-II	Combinatorics, Partial Fractions and Measures of Central Tendency	L	T	P	C
		2	1	0	3

Pre-requisite: Knowledge of Mathematics at high school

Course Objectives:

1. To motivate students towards intrinsic interest in statistical thinking
2. To apply the Fundamental principle of counting to find out the total number of outcomes in problem
3. To enable students to split the fractions into numerous sub fractions.

Course Outcome:

After successful completion of the course, the students will be able to
CO 1: understand how to apply basic counting techniques to solve combinatorial problems
CO 2: recognize simple or repeated linear factors along with quadratic factors in a rational function.
CO 3: define and calculate mean, median, mode.

Module 1: Combinatorics and recurrence relations	**15 Hours**

Permutations, Combinations, permutations with repetitions, combinations with repetitions, recurrence relations and their solutions.

Module 2: Partial Fraction	**15 Hours**

Polynomial, Rational Fraction, Proper and Improper fractions, Partial fractions, resolving into partial fractions

Module 3: Measures of Central Tendency	**15 Hours**

Measures of Central Tendency: Mean, Median and Mode. Applications, Advantages and disadvantages of Mean, Median and Mode.

Total Lecture Hours	**45 hours**

Text Book(s)

1. Barnard S., Child J.M, Higher Algebra (Ebook), Macmillan & Co Ltd (1959)

Reference Book(s)

1. Hall H. S., Night S. R., Higher Algebra, Arihant Publications Ltd, Meerut (2016)

MDC-III	Introduction to Programming with MATLAB	L	T	P	C
		2	1	0	3

Pre-requisite: Basic idea of mathematics

Course Objectives:

1. To impart the knowledge to the students with MATLAB software.
2. To enhance programming knowledge in Research and Development.

Course Outcome:

After successful completion of the course, the students will be able to

CO 1: use basic commands of MATLAB

CO 2: understand the basics functions of MATLAB

CO 3: plot the 2D, 3D figures

Module 1: Introduction to MATLAB — **15 Hours**

Getting help with commands in MATLAB, Vector and matrix generation, Subscripting and the colon notation, matrix and array operations and their manipulations, introduction to some inbuilt functions related to array operations. m-files: scripts and functions, editing, saving m-files, and interaction between them.

Module 2: Simple graphics in MATLAB — **15 Hours**

Plotting of graphs of function, Plotting the graphs of polynomial of degree 4 and 5, Sketching parametric curves

Module 3: Two & three-dimensional graphics — **15 Hours**

Basic plots, change in axes and annotation in a figure, multiple plots in a figure, saving and printing figures, mesh plots, surface plots and their variants e.g., contour plots, sphere, and animations.

Total Lecture Hours — **45 hours**

Text Book(s)

1. Gilat A., MATLAB: An Introduction with Applications, 4th edition, Wiley; Fourth edition, (2012)

Reference Book(s)

1. Pratap R., Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford, (2010)

- **Mathematics as a Major**

SEMESTER	DSCC (Credit)
I	1. Algebra and Calculus I (4)
II	2. Algebra and Calculus II (4)
III	3. Differential Equations (4)
IV	4. Complex Analysis (4)
	5. Real Analysis I (4)
	6. Group Theory (4)
	7. Elective I- Sets and Logic/Introduction to Probability (4)
V	8. Finite Differences & Vector Calculus (4)
	9. Analytic Geometry (4)
	10. Ring Theory (4)
	11. Elective II- Introduction to Statistics/ Discrete Mathematics (Graph Theory + Number Theory) (4)
VI	12. Mechanics (4)
	13. Real Analysis II and Metric Spaces (4)
	14. Linear Algebra (4)
	15. Elective III- Numerical Analysis/ R Programming (4)
	16. **Elective IV-** Operation Research/ Spherical Trigonometry and Astronomy (4)
VII	17. **Mathematical Transforms (Laplace & Fourier) and Integral Equations (4)**
	18. **Project I (4)**
	19. **Research Methodology (4)**
	OR
	20. Elective V: General Topology / Ordinary Differential equation of higher order (4)
	21. Elective VI: Advanced Abstract Algebra / Tensor Analysis (4)
VIII	22. **Graph Theory/ Partial Differential Equations with Lab (4)**
	23. **Fuzzy sets and their applications/ Special Theory of Relativity /Number Theory (4)**
	24. **Theory of Random Processes / Fluid Dynamics/ Mathematics for Data Science (4)**
	25. **Project II (8)**
	OR
	26. Any two courses (each of credit 4) from the following list: (Continuum Mechanics, General Theory of Relativity, Wave theory, Functional Analysis, Lebesgue Measure, Dynamical System)