

**SYLLABUS FOR FOUR YEAR UG PROGRAMME  
(Honours and Honours with Research)  
IN  
MATHEMATICS**

**SEM-I and SEM-II**

**Under National Education Policy (NEP)**

**Effective from 2023-2024**



**West Bengal State University  
Barasat  
Kolkata-700126  
West Bengal**

## Semester wise Course Structures

Sem ester	Course Type	Course Code	Name of the Course	Credit Pattern (L:T:P)	Marks	Credit
<b>I</b>	MAJOR	DS-1	<b>Algebra</b>	4:1:0	100	5
	MINOR	MA-1	<b>Algebra</b>	4:1:0	100	5
	MDC	MD-1	-----	2:1:0	50	3
	AEC	AE-1	To be offered by University			3
	SEC	SE-1	<b>C-Programming Language</b>	2:0:1	50	3
	VAC	VA-1	To be offered by University			3
<b>II</b>	MAJOR	DS-2	<b>Calculus</b>	4:1:0	100	5
	MINOR	MA-2	<b>Calculus</b>	4:1:0	100	5
	MDC	MD-2	-----			3
	AEC	AE-2	To be offered by University			3
	SEC	SE-2	<b>Programming Language-Python</b>	2:0:1	50	3
	VAC	VA-2	To be offered by University			3

# Detailed Major Syllabus

## SEM-I

### Course: DS-1

### Algebra (Marks:100, Credits: 5)

#### Unit -1 : Classical Algebra

De-Moivre's theorem for integer and rational indices and their applications, The n-th roots of unity. Definitions of exponential and trigonometrical functions of a complex variable, exponential values of sine and cosine. Periods of exponential and trigonometrical functions, Logarithm of a complex number and its properties, Definitions of  $a^z$ , Inverse circular functions, hyperbolic functions, along with exercises of all these concepts.

General properties of polynomials and polynomial equations, Fundamental theorem of algebra(statement only). Relation between roots and coefficients, Transformation of equation, Equation of squared differences of a cubic and the nature of the roots of a cubic, reciprocal equations, Binomial equations and their properties, special roots of  $x^n = 1$ , Descartes' rule of signs, Upper bounds for the real roots; Theorems on imaginary, integral and rational roots; Newton's method for integral roots, Cardan's solution of the cubic and the nature of the roots of the cubic, Descartes' and Ferrari's methods of solution of biquadratic equations, Sturm's theorem(statement only) and its applications.

The inequality involving  $AM \geq GM \geq HM$ , Extreme values of sum and product, theorem of weighted means, Weierstrass' & Cauchy's inequalities, m-th and generalized m-th power theorems.

#### Unit -2 : Number Theory

Equivalence relations and partitions, Functions, Invertible functions, One to one correspondence and cardinality of a set, Permutations, sign of a permutation, inversions, cycles and transpositions.

Well-ordering principle of non-negative integers, Principles of Mathematical Induction of positive integers, Division algorithm, Divisibility and Euclidean algorithm., g.c.d, Bezout's Theorem, Primes, Euclid's Lemma, Statement of Fundamental Theorem of Arithmetic, Euclid's proof of infinitely many primes, Congruence relation between integers, Euler  $\phi$  function, Euler's theorem, Fermat's Theorem.

### Unit – 3 : Matrix Theory

Matrix of real and complex numbers, Algebra of matrices (structure only); symmetric and skew symmetric matrices, Hermitian and skew- Hermitian matrices; Orthogonal and Unitary matrices. Determinants, Laplace expansions, cofactors, adjoint, inverse of a matrix, Cramer`s Rule.

Elementary row and Elementary column operations on matrices; elementary matrices; Echelon form; Triangular factorization of matrices:  $A = LU$ ,  $A = L D V$ ,  $PA = LU$ ,  $EA = R$ ; product of elementary matrices and inverse of a matrix.

Rank of a matrix; Determination of rank (relevant results are to be stated only); System of linear equations in matrix form  $AX = B$ ; Consistency and inconsistency ( by rank method); Types and determination of solution (by using notion of rank), Solving linear systems using Gaussian elimination, Gauss-Jordan row reduction, Reduced row echelon form, Equivalent systems.

Eigenvalues, Eigenvectors of matrices and their examples and properties, Characteristic polynomial of a matrix, Cayley-Hamilton theorem and its application for determining inverse of square matrix.

#### Books Recommended :

- TituAndreescu and DorinAndrica, Complex Numbers from A to Z, Birkhauser, 2006.
- Dickson, Leonard Eugene (2009), First Course in the Theory of Equations. John Wiley & Sons, Inc. The Project Gutenberg eBook:[http://www.gutenberg.org/ebooks/29785\\_3](http://www.gutenberg.org/ebooks/29785_3)
- W.S. Burnstine and A.W. Panton, Theory of equations, Vol. 1. Fourteenth Edition, S. Chand and Co Ltd, New Delhi.
- Burton, David M. (2011), Elementary Number Theory (7th ed.), McGraw-Hill Education Pvt. Ltd. Indian Reprint.
- S. Barnard and J.M. Child, Higher Algebra, Surjeet Pbl., New Delhi, 1990
- David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
- K.B. Dutta, Matrix and Linear algebra.
- K. Hoffman, R. Kunze, Linear algebra.
- Gilbert Strang, Introduction to Linear Algebra, 4th edition, Welleseley-Camberidge press, 2009.

# SEM-II

## Course: DS-2

### Calculus (Marks: 100, Credits: 5)

#### Unit – 1 : Limits, Continuity and Differentiability

Limit of a function,  $\varepsilon$ - $\delta$  definition of a limit, Infinite limits, Continuity and types of discontinuities; Differentiability of a function, Relation between differentiability and continuity, Successive differentiation, Leibnitz theorem and its applications to functions such as  $e^{ax+b} \sin x$ ,  $e^{ax+b} \cos x$ ,  $(ax+b)^n \sin x$ ,  $(ax+b)^n \cos x$ ; Partial differentiation, Euler's theorem on homogeneous functions and its converse.

#### Unit – 2 : Mean Value Theorems and its Applications

Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Geometrical interpretation of mean value theorems and applications to monotonic functions and inequalities; Taylor's theorem, Taylor's series, Maclaurin's series expansions of  $e^x$ ,  $\sin x$ ,  $\cos x$ ,  $\log(1+x)$ ,  $(1+x)^m$ ; Indeterminate forms.

#### Unit -3 : Integral Calculus

Integration of rational and irrational functions, Evaluation of definite integrals, Special integrals, Reduction formulae, derivations and illustrations of reduction formulae for the integration of  $\sin^n x$ ,  $\cos^n x$ ,  $\tan^n x$ ,  $\sec^n x$ ,  $(\log x)^n$ ,  $\sin^n x \cos^m x$ ,  $e^{ax} \cos^n x$ ,  $(x^2 + a^2)^n$  and their applications; Improper integrals, Beta and Gamma functions.

#### Unit – 4 : Applications

Tangent and Normal; Curvature; Asymptotes of general algebraic curves, Parallel asymptotes, Asymptotes parallel to axes; Envelopes; Maxima and Minima; Concavity and convexity, Points of inflexion; Tracing of Cartesian and polar curves; Length of plane curve and area bounded by plane curves, Volume and surface area of solids of revolution.

#### Graphical Demonstration (Teaching Aid)

1. Plotting of graphs of function  $e^{ax+b}$ ,  $\log(ax+b)$ ,  $1/(ax+b)$ ,  $\sin(ax+b)$ ,  $\cos(ax+b)$ ,  $|ax+b|$  and to illustrate the effect of  $a$  and  $b$  on the graph.
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves.

4. *Obtaining volume and surface of revolution of curves.*

5. *Tracing of conics in Cartesian coordinates/polar coordinates.*

**Books Recommended:**

- G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
- M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
- Gorakh Prasad, Differential Calculus (19th edition), Pothishala Pvt. Ltd., 2016.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
- Gorakh Prasad, Integral Calculus, Pothishala Pvt. Ltd., Allahabad, 2015.
- Gabriel Klambauer, Aspects of Calculus, Springer-Verlag, 1986.
- Howard Anton, I. Bivens& Stephan Davis, Calculus (10th edition), Wiley India, 2016.
- T. Apostol, Calculus, Volumes I and II.
- S. Goldberg, Calculus and Mathematical analysis.

# Detailed Minor Syllabus

## SEM-I

Course: MA-1

Algebra (Marks: 100, Credits: 5)

### Unit -1 : Classical Algebra

De-Moivre's theorem for integer and rational indices and their applications, The n-th roots of unity. Definitions of exponential and trigonometrical functions of a complex variable, Logarithm of a complex number and its properties, Definitions of  $a^z$ , Inverse circular functions, hyperbolic functions.

Relation between roots and coefficients, Transformation of equation, Equation of squared differences of a cubic, reciprocal equations, Binomial equations and their properties, Descartes' rule of signs, Upper bounds for the real roots; Cardan's solution of the cubic and the nature of the roots of the cubic, Ferrari's methods of solution of biquadratic equations.

The inequality involving  $AM \geq GM \geq HM$ , Extreme values of sum and product, theorem of weighted means, Cauchy's inequalities, m-th power theorem.

### Unit – 2 : Abstract Algebra

Equivalence relations and partitions, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set. Permutations, inversions, cycles and transpositions.

Definition and examples of groups, examples of abelian and nonabelian groups, the group  $Z_n$  of integers under addition modulo  $n$  and the group  $U(n)$  of units under multiplication modulo  $n$ , groups of symmetries of an equilateral triangle, the permutation group  $S_3$ , the general linear group  $GL(n, R)$ ,  $n \leq 3$ .

Subgroups, cyclic subgroups, the concept of a subgroup generated by a subset, Cosets, Index of subgroup, Lagrange's theorem and its converse, order of an element, Normal subgroups: their definition, examples, and characterizations.

Definition and examples of rings, examples of commutative and non-commutative rings,  $Z_n$ , the ring of integers modulo  $n$ , polynomial rings, Definitions of Subrings, Integral domains, skew-fields, fields and subfields, their examples and elementary properties.

### Unit – 3 : Linear Algebra

Matrix of real and complex numbers, Algebra of matrices(structure only); symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices; Orthogonal and Unitary matrices. Determinants, Laplace expansions, cofactors, adjoint, inverse of a matrix, Cramer`s Rule.

Vector space, Linearly dependent and independent set, Basis, Dimension, Linear Transformation and their elementary properties and examples, Matrix representation of Linear Transformation. Rank of a matrix; Determination of rank (relevant results are to be stated only); System of linear equations in matrix form  $AX = B$ ; Consistency and inconsistency (by rank method); Types and determination of solution (by using notion of rank), Solving linear systems using Gaussian elimination.

Eigenvalues, Eigenvectors, Eigenspace, Diagonalization of matrices, Characteristic polynomial of a matrix, Cayley-Hamilton theorem and its application for determining inverse of square matrix . Bilinear forms, real quadratic forms Sylvester`s law of inertia, positive definiteness.

#### Books Recommended :

- Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
- Dickson, Leonard Eugene (2009), First Course in the Theory of Equations, John Wiley & Sons, Inc. The Project Gutenberg eBook: [http://www.gutenberg.org/ebooks/29785\\_3](http://www.gutenberg.org/ebooks/29785_3)
- W.S. Burnstine and A.W. Panton, Theory of equations, Vol. 1. Fourteenth Edition, S. Chand and Co Ltd, New Delhi.
- S. Barnard and J.M. Child, Higher Algebra, Surjeet Pbl., New Delhi, 1990.
- Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
- Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., 1999.
- John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
- David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
- K.B. Dutta, Matrix and linear algebra.
- K. Hoffman, R. Kunze, Linear algebra.



## SEM-II

### Course: MA-2

### Calculus (Marks: 100, Credits: 5)

#### Unit – 1 : Limits, Continuity and Differentiability

Limit of a function,  $\varepsilon$ - $\delta$  definition of a limit, Infinite limits, Continuity and types of discontinuities; Differentiability of a function, Relation between differentiability and continuity, Successive differentiation, Leibnitz theorem and its applications to problems of type  $e^{ax+b} \sin x$ ,  $e^{ax+b} \cos x$ ,  $(ax+b)^n \sin x$ ,  $(ax+b)^n \cos x$ ; Partial differentiation, Euler's theorem on homogeneous functions and its converse.

#### Unit – 2 : Mean Value Theorems and its Applications

Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Geometrical interpretation of mean value theorems and applications to monotonic functions and inequalities; Taylor's theorem, Taylor's series, Maclaurin's series expansions of  $e^x$ ,  $\sin x$ ,  $\cos x$ ,  $\log(1+x)$ ,  $(1+x)^m$ ; Indeterminate forms.

#### Unit -3 : Integral Calculus

Integration of rational and irrational functions, Evaluation of definite integrals, Special integrals, Reduction formulae, derivations and illustrations of reduction formulae for the integration of  $\sin^n x$ ,  $\cos^n x$ ,  $\tan^n x$ ,  $\sec^n x$ ,  $(\log x)^n$ ,  $\sin^n x \cos^m x$  and their applications; Improper integrals, Beta and Gamma functions.

#### Unit – 4 : Applications

Tangent and Normal; Curvature; Asymptotes of general algebraic curves, Parallel asymptotes, Asymptotes parallel to axes; Envelopes; Maxima and Minima; Concavity and convexity, Points of inflexion; Tracing of Cartesian and polar curves; Length of plane curve and area bounded by plane curves, Volume and Surface area of solids of revolution.

#### Graphical Demonstration (Teaching Aid)

1. Plotting of graphs of function  $e^{ax+b}$ ,  $\log(ax+b)$ ,  $1/(ax+b)$ ,  $\sin(ax+b)$ ,  $\cos(ax+b)$ ,  $|ax+b|$  and to illustrate the effect of a and b on the graph.
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second

- derivative graph and comparing them.
3. Sketching parametric curves.
  4. Obtaining surface of revolution of curves.
  5. Tracing of conics in Cartesian coordinates/polar coordinates.

**Books Recommended :**

- G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
- M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
- Gorakh Prasad, Differential Calculus (19th edition), Pothishala Pvt. Ltd., 2016.
- R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer- Verlag, New York, Inc., 1989.
- Gorakh Prasad, Integral Calculus, Pothishala Pvt. Ltd., Allahabad, 2015.
- Gabriel Klambauer, Aspects of Calculus, Springer-Verlag, 1986.
- Howard Anton, I. Bivens & Stephan Davis, Calculus (10th edition), Wiley India, 2016.
- T. Apostol, Calculus, Volumes I and II.
- S. Goldberg, Calculus and Mathematical analysis.

# Syllabus for Multidisciplinary Course (MDC)

## SEM-I / II / III

### Course: MD-1/ MD-2/ MD-3

#### Basic Mathematics (Marks: 50, Credits: 3)

**Sets, Relations & Functions:** Sets, subsets, set operations, Venn diagram, relations, equivalence relations, mappings, functions, domain & co-domain, one-to-one and onto functions, inverse function; logarithmic, exponential functions and their elementary properties, periodic functions, trigonometric functions.

**Probability and Statistics:** Events, probability of an event, conditional probability, Bayes' theorem and their applications, discrete random variable and its probability distribution, expectation (mean) and variance of a single random variable.

Computation or calculation of mean, median, mode, variance and standard deviation for ungrouped and grouped data.

**Matrix and Determinants:** Matrix, order of Matrix, Types of Matrix, equality of matrices, Algebra or operations of Matrices, symmetric & skew symmetric matrices, elementary operations of a matrix, inverse of matrix, Inverse of a matrix by elementary operations (up to order  $3 \times 3$ ).

Determinant, properties of determinants, cofactor, adjoint and inverse of a square matrix (up to order 3); determination of rank of matrix, solution of system of linear equations using (i) inverse of a matrix, and (ii) Cramer's Rule; conditions of consistency & inconsistency (all up to order 3).

**Co-ordinate Geometry (2D):** Distance between two points, slope of a line, angle between two lines, conditions for parallelism and perpendicularity of lines, equations of a straight line in various forms; distance of a point from a line and distance between two parallel lines. Standard equations of circle and parabola, ellipse and hyperbola. Latus rectum of parabola, ellipse and hyperbola, co-ordinates of their foci, eccentricity of ellipse and hyperbola (problems using formulae only).

**Linear Programming Problem (LPP):** Graphical solution of a system of Linear inequations in two variables. Linear Programming Problem (LPP) and its mathematical formulations, objective function, linear constraints, graphical method of solving LPP, feasible region, feasible solution, corner (extreme) point, optimal solution.

**Books Recommended:**

- R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
- P.R. Halmos, Naive Set Theory, Springer, 1974.
- E. Kamke, Theory of Sets, Dover Publishers, 1950.
- A.M.Gun, M.K. Gupta, B. Dasgupta, An Outline of Statistical Theory, Vol1 & Vol2, TheWorld Press PVT, 2003.
- Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
- N.G. Das, Statistical Methods, combined edition (volumes I & II), Mc Graw Hill Education PVT Ltd, New Delhi, 2015.
- A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers, 1983.
- Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
- F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
- Gilbert Strang, Introduction to Linear Algebra, 4th edition, Welleseley-Camberidge press, 2009.
- K. Hoffman, R. Kunze, Linear algebra.

# Syllabus for Skill Enhancement Course (SEC)

## SEM-I

### Course: SE-1

#### C-Programming Language (Marks: 50, Credits: 3)

##### Unit 1 : Basics of Computer Programming

Definition, Requirement of programming language, Machine language, high-level programming languages, machine code of a program: compilation process, Problem solving approaches: algorithm and flowchart.

##### Unit 2 : Fundamentals of Programming

Built in Data Types: int, float, double, char; Constants and Variables; first program: printf( ), scanf( ), compilation etc., keywords, Arithmetic operators: precedence and associativity, Assignment Statements: post & pre increment/decrement, logical operators: and, or, not.

##### Unit 3 : Statements

Relational operators, if-else statement, Iterative Statements: for loop, while loop and do-while loop; controlling loop execution: break and continue, nested loop.

##### Unit 4 : Arrays

Definition & requirement, declaration & initialization, indexing, one dimensional array: finding maximum, minimum, simple sorting and searching.

##### Unit 5 : Multi-dimensional arrays

Matrix Manipulations (Addition, Multiplication, Transpose)

Arrays and Pointers, Memory allocation and deallocation: *malloc( )* and *free( )* functions.

##### Unit 6 : Functions

How to declare, define and invoke a function, Variables' scope, local & global variables and function parameters, Pointers, arrays as function parameters, *return* statement, Header files and their role. Illustrate different examples like swapping values, compute  $n!$ ,  ${}^n C_r$ , find max/min from a list of elements, sort a set of numbers, matrix addition/multiplication etc.

#### Books Recommended :

- B. W. Kernighan and D. M. Ritchi, The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.
- Y. Kanetkar, Let Us C ; BPB Publication, 1999.
- C. Xavier, C-Language and Numerical Methods, New Age International.

## SEM-II

### Course: SE-2

### Programming Language-Python (Marks: 50, Credits: 3)

#### Unit-1 : Introduction

History and Importance of Python, Installing and Running Python, Executing Python programs, Python Interpreter and Interactive Mode.

Debugging: Syntax Errors, Runtime Errors, Semantic Errors.

#### Unit-2 : Variables and Expressions

Values and Types, variables, expressions, statements, comments, Operator Precedence, Arithmetic Expression, Boolean Expressions, Mixed-Mode Arithmetic and type conversion, type( ), Input( ), print( ), id( ), int( ), str( ), float( ), Elementary Programming.

#### Unit-3 : Conditionals, Loops, Functions and Strings

**Conditionals:** Conditional (if), Alternative (if-else), Chained conditional (if-elif-else).

**Loops:** Loop Structures/Iterative Statements – while loop, range( ) function, for loop; break statement, continue statement.

**Functions:** Built-in Functions, User Defined Functions, Function Call and Returning Values, Parameter Passing, Recursive Functions.

**Strings:** String slices, Immutability, String functions, String methods-find, join, split, lower, upper, len( ).

#### Unit-4 : Lists, Tuples and Dictionaries

**Lists :** List Operations, List Concatenation, List slices, List methods - append, extend, insert, pop, sort, Max( ), Min( ), List loop, Mutability, Aliasing.

**Tuples :** Creation, Accessing, Updating, Deleting Elements in a Tuple, Tuple Assignment, Tuple as Return Value, Nested Tuples, Basic Tuple Operations.

**Dictionaries:** Dictionary Operations, Built-in Dictionary Functions & Methods.

#### Unit-5 : Files and Modules

**Files:** Opening and Closing Files, Reading and Writing Files, Errors and Exceptions, Handling Exceptions.

**Modules:** Introduction, Module Loading and Execution, Math Module - sin( ), cos( ), exp( ), sqrt( ), Random Module, Time Module; Packages.

### **Python Programming Examples:**

Calculating the factors of an integer, Checking Prime numbers, Generating multiplication tables, Finding the roots of a quadratic equation, Symbolic math using SymPy library, Converting strings to mathematical expressions, Solving a system of linear equations, Plotting Functions.

### **Books Recommended :**

- W.J. Chun, Core Python Programming, Prentice Hall, 2013.
- Kenneth A. Lambert, Fundamentals of Python, Cengage, 2015.
- E. Balagurusamy, Introduction to Computing and Problem Solving Using Python, McGraw Hill India, 2016.
- Timothy A. Budd, Exploring Python, McGraw Hill India.