VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

BACHELOR OF SCIENCE WITH MATHEMATICS (MULTIDISCIPLINARY STUDIES)

3-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes (CCFUP), 2023 & NEP, 2020

VIDYASAGAR UNIVERSITY

BACHELOR OF SCIENCE IN MATHEMATICAL & COMPUTER SCIENCES with MATHEMATICS

(*Under CCFUP, 2023*)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. in Math. Comp. Sc. with Mathematics	2nd	III	**SEMESTER-III**							
			Major-A2	MATPMJ02	**T: Algebra** ***(To be studied by students taken* Mathematics *as Discipline- A)***	4	3-1-0	15	60	75
			Major-A3	MATPMJ03	**T: Differential Equations and Vector Calculus** ***(To be studied by students taken* Mathematics *as Discipline- A)***	4	3-1-0	15	60	75
			SEC	SEC03	***To be taken from SEC-03 of Discipline C.***	3	0-0-3	10	40	50
			AEC	AEC03	Communicative English-2 (***common for all programmes***)	2	2-0-0	10	40	50
			MDC	MDC03	Multidisciplinary Course-3 (***to be chosen from the list***)	3	3-0-0	10	40	50
			Minor-3 (Disc.-C3)	MATMIN03	**T: Differential Equations and Vector Calculus** ***(To be studied by students taken* Mathematics *as Discipline- C)***	4	3-1-0	15	60	75
					Semester-III Total	20				375
		IV	**SEMESTER-IV**							
			Major-B2		***To be decided*** ***(Same as MajorA2 for* Mathematics *taken as Discipline-B)***	4	3-1-0	15	60	75
			Major-B3		***To be decided*** ***(Same as Major–A3 for* Mathematics *taken as Discipline-B)***	4	3-1-0	15	60	75
			Major (Elective) -1	MATMJE-01	**T: Linear Programming / Partial Differential Equations & Applications/ Group Theory-1** *(any one)* ***(To be studied by students taken* Mathematics *as Discipline- A)***	4	3-1-0	15	60	75
			AEC	AEC04	MIL-2 (***common for all programmes***)	2	2-0-0	10	40	50
			Minor -4 (Disc.-C4)	MATMIN04	**T: Numerical Analysis** ***(To be studied by students taken* Mathematics *as Discipline- C)***	4	3-1-0	15	60	75
			Summer Intern.	IA	Internship / Apprenticeship- **as given in the syllabus**	4	0-0-4	-	-	50
					Semester-IV Total	22				400
					TOTAL of YEAR-2	42	-	-	-	775

MJP = Major Programme (Multidisciplinary), MI = Minor, A/B = Choice of Major Discipline; C= Choice of Minor Discipline; SEC = Skill Enhancement Course, AEC = Ability Enhancement Course, MDC = Multidisciplinary Course, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical, MIL = Modern Indian Language

MAJOR (MJ)

MJ A2/B2: Algebra **Credits 04**

MJ A2/B2T: Algebra **Credits 04 [60L]**

Course contents:

UNIT-1:
Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.
Theory of equations: Relation between roots and coefficients, transformation of equation, Descartes rule of signs, cubic and biquadratic equation.
Inequality: The inequality involving AM≥ GM≥ HM, Cauchy-Schwartz inequality.

UNIT-2:
Equivalence relations. Functions, composition of functions, Invertible functions, one-to-one correspondence and cardinality of a set. Well-ordering property of positive integers, division algorithm, divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical induction, statement of Fundamental Theorem of Arithmetic.

UNIT-3:
Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence.

UNIT-4:
Definition of vector space of R^n;-inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n, dimension of subspaces of R^n, rank of a matrix, eigenvalues, eigenvectors and characteristic equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

Suggested Readings:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
4. K.B. Dutta, Matrix and linear algebra.
5. K. Hoffman, R. Kunze, Linear algebra.
6. W.S. Burnstine and A.W. Panton, Theory of equations.

Course Outcomes (COs):

After completing this course, students will be able to:

a) Represent complex ns in polar form, apply De Moivre's theorem, and analyze the properties of polynomial equations, including root-coefficient relationships and transformations.
b) Apply fundamental inequalities, such as AM-GM-HM and Cauchy-Schwarz, to mathematical problems and proofs.
c) Understand equivalence relations, functions, and cardinality, and apply the division algorithm, Euclidean algorithm, and congruence relations in number theory.
d) Solve systems of linear equations using row reduction, echelon forms, and matrix methods, and apply them to real-world problems.
e) Analyze vector spaces, linear transformations, and matrix properties, including invertibility, subspaces, and rank.
f) Compute eigenvalues, eigenvectors, and characteristic equations, and apply the Cayley-Hamilton theorem to matrix operations.

MJ A3/B3: Differential Equations & Vector Calculus **Credits 04**

MJ A3/B3T: Differential Equations & Vector Calculus **Credits 04 [60L]**

Course contents:

Unit 1

Lipschitz condition and Picard's Theorem (Statement only). The general solution of the homogeneous equation of second order, principle of superposition for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Unit 2

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

Unit 3

Equilibrium points, Interpretation of the phase plane, Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

Unit 4

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions.

Suggested Readings:

1. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case
2. Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York, 2009.
3. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
4. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
5. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.

Course Outcomes (COs):

After completing this course, students will be able to:

a) Understand the Lipschitz condition, Picard's Theorem, and the fundamental concepts of second-order differential equations, including the principle of superposition and Wronskian properties.
b) Solve linear homogeneous and non-homogeneous differential equations using methods such as undetermined coefficients and variation of parameters.
c) Analyze systems of linear differential equations, apply the operator method, and solve homogeneous linear systems with constant coefficients.
d) Interpret equilibrium points and phase plane analysis and apply power series methods to solve differential equations around ordinary and regular singular points.
e) Perform vector operations, understand vector functions, and compute their limits, derivatives, and integrals.
f) Demonstrate the graphical representation of solutions to second- and third-order differential equations to visualize their behavior.

Major Elective -1 (MDP)

Major (Elective)-1: Linear Programming **Credits 04**

MJE-1T: Linear Programming **Credits 04 [60L]**

Course contents:

Unit 1

Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two- phase method. Big- M method and their comparison.

Unit 2

Duality, formulation of the dual problem, primal- dual relationships, economic interpretation of the dual. Transportation problem and its mathematical formulation, northwest- corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

Unit 3

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.

Reference Books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice- Hall India, 2006
4. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Course Outcomes (COs):

After completing this course, students will be able to:

a) **Understand and apply** fundamental concepts of probability, including random variables, probability distributions, expectation, and moment-generating functions in real-world scenarios.
b) **Analyze joint distributions**, conditional expectations, and bivariate normal distributions, and apply regression and correlation techniques for statistical modeling.
c) **Apply key statistical theorems** such as Chebyshev's inequality, the Law of Large Numbers, and the Central Limit Theorem to analyze large data sets and Markov processes.
d) **Formulate and solve** linear programming problems using the graphical and simplex methods, and understand concepts of convexity, optimality, and artificial variables.
e) **Utilize duality theory** to interpret primal-dual relationships, solve transportation and assignment problems using optimization techniques, and apply Hungarian and Vogel's methods.
f) **Apply game theory principles** to solve two-person zero-sum games, analyze mixed strategies, and use linear programming techniques for game solutions.

OR

Major (Elective)-1: Partial Differential Equations & Applications Credits 04

MJE-1T: Partial Differential Equations & Applications Credits 04 [60L]

Course contents:

Unit 1

Partial differential equations – Basic concepts and definitions. Mathematical problems. First- order equations: classification, construction and geometrical interpretation. Method of characteristics for obtaining general solution of quasi linear equations. Canonical forms of first-order linear equations. Method of separation of variables for solving first order partial differential equations.

Unit 2

Derivation of heat equation, wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order linear equations to canonical forms.

Unit 3

The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string. Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end. Equations with non-homogeneous boundary conditions. Non-homogeneous wave equation. Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem

Reference Books:

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, Differential equations, 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, Differential equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
4. Sneddon, I. N., Elements of Partial Differential Equations, McGraw Hill.
5. Miller, F. H., Partial Differential Equations, John Wiley and Sons.
6. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press.

Course Outcomes (COs):

After completing this course, students will be able to:

a) **Understand and classify** partial differential equations (PDEs), apply the method of characteristics for solving first-order quasi-linear PDEs, and utilize separation of variables for first-order PDEs.
b) **Derive and analyze** fundamental second-order PDEs, including the heat equation, wave equation, and Laplace equation, and classify them as hyperbolic, parabolic, or elliptic.
c) **Solve initial and boundary value problems** using the Cauchy problem, Cauchy-Kowalewskaya theorem, and separation of variables, and analyze wave and heat conduction problems.
d) **Apply concepts of central force and constrained motion** to model and solve problems in physics, including varying mass systems, ballistics, planetary motion, and Kepler's second law.

These outcomes ensure students gain a strong foundation in PDEs, their physical applications, and mathematical modeling techniques.

OR

Major (Elective)-1: Group Theory-1 **Credits 04**

MJE-1T: Group Theory-1 **Credits 04 [60L]**

Course contents:

Unit 1
Symmetries of a square, dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups.

Unit 2
Subgroups and examples of subgroups, centralizer, normalizer, centre of a group, product of two subgroups.

Unit 3
Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

Unit 4
The external direct product of a finite number of groups (definition and examples only), normal subgroups, factor groups, Cauchy's theorem for finite abelian groups (only statement).

Unit 5
Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.

Reference Books:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
4. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
6. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

Course Outcomes (COs):
After completing this course, students will be able to:

a) **Understand and analyze** the symmetries of geometric objects, dihedral groups, permutation groups, and quaternion groups, along with their fundamental properties.
b) **Identify and explore** subgroups, including centralizers, normalizers, centers, and the product of subgroups, to understand group structures.
c) **Classify and apply** properties of cyclic groups, permutation groups, alternating groups, and cosets, and utilize Lagrange's theorem with its consequences, including Fermat's Little theorem.
d) **Demonstrate knowledge** of external direct products, normal subgroups, factor groups, and fundamental results such as Cauchy's theorem for finite abelian groups.
e) **Apply group homomorphisms and isomorphisms**, verify Cayley's theorem, and utilize the first, second, and third isomorphism theorems to analyze group structures.

These outcomes help students build a strong foundation in group theory, essential for higher mathematics and applications in various fields.

MINOR (MI)

Minor (MI)-3: Differential Equations & Vector Calculus **Credits 04 (Full Marks: 75)**

MI-3T: Differential Equations & Vector Calculus **Credits 04**

Course contents:

Unit 1
Lipschitz condition and Picard's Theorem (Statement only). The general solution of the homogeneous equation of second order, principle of superposition for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Unit 2
Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions.

Unit 3
Equilibrium points, Interpretation of the phase plane, Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

Unit 4
Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions.

Suggested Readings:

1. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case
2. Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York, 2009.
3. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
4. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
5. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.

Course Outcomes (COs):

After completing this course, students will be able to:

a) Understand the Lipschitz condition, Picard's Theorem, and the fundamental concepts of second-order differential equations, including the principle of superposition and Wronskian properties.
b) Solve linear homogeneous and non-homogeneous differential equations using methods such as undetermined coefficients and variation of parameters.
c) Analyze systems of linear differential equations, apply the operator method, and solve homogeneous linear systems with constant coefficients.
d) Interpret equilibrium points and phase plane analysis and apply power series methods to solve differential equations around ordinary and regular singular points.
e) Perform vector operations, understand vector functions, and compute their limits, derivatives, and integrals.
f) Demonstrate the graphical representation of solutions to second- and third-order differential equations to visualize their behavior.

Minor (MI)-4: Numerical Methods **Credits 04 (Full Marks: 75)**

MI-4T: Numerical Methods **Credits 04**

Course Outcomes (COs):

After completing this course, students will be able to:

a) Understand the fundamentals of numerical algorithms, including convergence, types of errors, and their impact on computational methods.
b) Solve transcendental and polynomial equations using numerical methods such as Bisection, Newton-Raphson, Secant, Regula-Falsi, and Fixed Point Iteration, and analyze their rate of convergence.
c) Apply numerical techniques like Gaussian elimination, Gauss-Jordan, Gauss-Seidel, and LU decomposition to solve systems of linear algebraic equations, along with their convergence analysis.
d) Utilize interpolation techniques, including Lagrange and Newton's methods, finite difference operators, and numerical differentiation techniques based on interpolation and finite differences.
e) Perform numerical integration using Newton-Cotes formulas, Trapezoidal, Simpson's, Weddle's, Boole's, and Gauss quadrature methods, and apply least square polynomial approximation for solving algebraic eigenvalue problems.
f) Solve ordinary differential equations using numerical methods such as Euler's method, Modified Euler's method, and Runge-Kutta methods of different orders.

Course contents:

Unit 1

Algorithms. Convergence. Errors: relative, absolute. Round off. Truncation.

Unit 2

Transcendental and polynomial equations: Bisection method, Newton's method, secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods.

Unit 3

System of linear algebraic equations: Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU decomposition

Unit 4

Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.

Numerical differentiation: Methods based on interpolations, methods based on finite differences.

Unit 5

Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. midpoint rule, Composite trapezoidal rule, composite Simpson's $1/3^{rd}$ rule, Gauss quadrature formula.

The algebraic eigen value problem: Power method. Approximation: Least square polynomial approximation.

Unit 6

Ordinary differential equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

Reference Books

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering
3. Computation, 6th Ed., New age International Publisher, India, 2007.
4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
5. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private Limited, 2013.
6. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
7. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH Publishing Co.
8. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
9. M.Pal, Numerical Analysis for Scientists and Engineers: Theory and C Programs, Narosa, New Delhi, 2007.

SKILL ENHANCEMENT COURSE (SEC)

(To be studied by students taken Physics as Discipline- C)

SEC-03 P: Same as SEC-03 (MATSEC03) of Mathematics (Hons) programme **Credits 03**
Full Marks: 50

INTERNSHIP/APPRENTICESHIP (INT)

Credit-04 Marks: 50 **(120 hours, 8 weeks)**

Guideline for internship/apprenticeship:

The internship program will commence at the beginning of the third semester and will be evaluated upon its completion at the end of the fourth semester.

1. Two or more neighbouring colleges can exchange students for internship programs. Mentors at the partnering colleges may offer these students courses related to their curriculum. The program content will vary depending on the mentor. It could include theoretical courses such as Mathematical Analysis, Numerical Analysis, Applied Mathematics, Financial Mathematics, or Industrial Mathematics, or hands-on training using programming techniques.
2. A student may visit an industry for industry-related issues or a research institution, laboratory, or university to engage in research-related activities under the guidance of an industry official, scientist, or professor.
3. A student may work at a company's outlet or similar type of office, hotel, hospital, nursing home, etc. to collect statistical data and analyse it with any statistical method under the supervision of the respective official or a faculty of his/her own college teacher or a teacher from another college/university/industry person.
4. A student may pursue an internship under the supervision of a teacher within their own college, focusing on allied subjects like Statistics, Economics, or Computer Science (for Mathematics major only).
5. Interns may engage in advanced learning in topics beyond their course curriculum, under the guidance of their respective mentor.
6. Interns may be assigned to design a webpage for his/her own college or department under the mentor's guidance.
7. Interns may be assigned to prepare study materials in MS-Word or MS PowerPoint or LaTeX on topics assigned by their mentor.
8. Interns may be assigned to develop a video lecture on any topic of their own choice with a proper title page for the video under the mentor's guidance.
9. Interns may be allowed to work as quantitative researchers in financial institutions such as banks, insurance companies, or financial consulting firms.

General instructions:

a) Each intern must maintain a daily logbook of activities.
b) At the end of the internship, a completion certificate must be obtained from the mentor, supervisor, or concerned authority.
c) Interns are expected to strictly adhere to the assigned tasks and deadlines.