DEPARTMENT OF MATHEMATICAL SCIENCES
BODOLAND UNIVERSITY

PROGRAMME OUTCOME

The primary goal of this programme is to cultivate mathematical aptitude and to pique students' interests in problem-solving. It also aims to inspire young minds to pursue research in mathematical sciences and to train computational scientists who can work on real-world problems. Various branches of mathematics are chosen and designed for the M.Sc. Mathematics course with the goal of developing mathematical reasoning, sophistication in thought, and familiarity with a sufficient number of subjects, including application-oriented ones, to meet the current needs of various allied branches in science, as well as providing opportunities for research in higher mathematics.

Programme Specific Outcome of M.Sc. in Mathematics

1 To have sufficient exposure to global and local concerns that cover a wide range of mathematical disciplines.

2 Assist the learner in analysing problems, formulating hypotheses, evaluating and validating results, and drawing logical conclusions.

3 Develop critical thinking skills so that scientific research can be conducted objectively and without bias.

4 Continue to gain essential knowledge and skills for professional activities while demonstrating the highest ethical standards in the mathematical sciences.

5 Provide an advanced degree of understanding of mathematical principles and theories, as well as their application in the real world, enhancing employment chances in a wide range of professions.

SEMESTER I			
Sl No.	Paper Code	Paper Title	**Course Outcome**
01	MAT101	Algebra	After learning the course, the learner will be able to 1. Get the basic idea of Group theory. 2. Utilize the knowledge of group theory to learn ring and field. 3. Solve various problem related to CSIR NET.
02	MAT102	Differential Equations and Computer Applications	After learning the course, the learner will be able to 1. Explain the concept of Ordinary Differential Equations and Partial Differential Equations. 2. Find solutions of higher order linear, nonlinear, homogeneous and nonhomogeneous differential equations. 3. Solve series solution of 2nd order differential equations with reference to Legendre, Bessel, Gauss, Hyper geometric equations, Sturm-Liouville boundary value problem and find orthogonal set of functions. 4. Classify 2^{nd}-order differential equations in terms of hyperbolic, parabolic and elliptic. 5. Solve wave equations, diffusion (heat) equations and Laplace's equations in various co-ordinate systems.

			6. Use green's function for wave equations and Laplace transform in finding the solution of linear differential equations. 7. Use all the concepts of differential equations for higher study such as research, project etc. 8. Solve differential equations by using Python programming.
03	MAT103	Mechanics	After learning the course, the learner will be able to 1. Use the concepts of Lagrangian and Hamiltonian mechanics to solve problems in mechanics. 2. Utilize the knowledge of constraints and analyze different types of mechanical systems. 3. Analyze the concepts of generating function, canonical transformation, Poisson's bracket and Lagrange's bracket. 4. Get the idea of Hamilton-Jacobi equation and solve problems by using Hamilton-Jacobi method in mechanics.
04	MAT104	Real Analysis	After learning the course, the learner will be able to 1. Comparison of two infinite sets. 2. Significance of uniform convergence: The concept, which was first formalized by Karl Weierstrass, is important because several properties of the functions, such as continuity, Riemann integrability, and, with additional hypotheses, differentiability, are transferred to the limit. Basic idea of Fourier series. 3. to find the maximum or minimum value of a particular quantity. Such applications exist in economics, business, and engineering. 4. know the basic properties of functions of bounded variation and be able to apply them. understand applications of the theory of BV functions in variational problems in imaging and materials science. Application of Riemann-Stieltjes integrals in various fields. 5. Understand and appreciate the concept of a metric space and be able to recognize standard examples. Be familiar with the fundamental notions of continuity, convergence and compactness. Be able to utilise metric space arguments to obtain a variety of results.
05	MAT105	Tensor Analysis	After learning the course, the learner will be able to 1. Define Covariant and Contravariant Tensors; Outer multiplication, Contraction and Inner Multiplication, Quotient Law of Tensors, Reciprocal Symmetric Tensor; Relative Tensor; Fundamental Tensor; Group property of tensors; Tensor Field. 2. Find Christoffel's symbols; Differential equation of a Geodesic Covariant differentiation of tensors; Intrinsic derivative of a tensor; Divergence of a vector; Curl of a vector; Laplacian operator; Parallel displacement of a vector. 3. Get the idea of metric tensor; Riemannian metric; Riemannian space; Geodesic coordinates; Natural coordinates; Riemannian Christoffel's tensor; Covariant curvature tensor; Bianchi Identity; Flat space time. 4. Analyse Parallelism of vector of constant magnitude; Parallelism for vector of variable magnitude along a curve.
06	MAT106 Open Elective I	**Fundamental of Mathematics**	After learning the course, the learner will be able to 1. Learn about the number system, sets and their properties. 2. Analyze data collection using different types of measures. 3. Get the preliminary idea about sampling and sample surveys.
		History of Mathematics	After learning the course, the learner will be able to 1. Get the knowledge of Greek mathematicians as well as Egyptian and Babylonian era of mathematics. 2. Know about Mathematics in the Islamic World and the work developments of algebra, trigonometry and arithmetic in the Renaissance as well as analytic geometry in the seventeenth century. 3. Understand the beginnings of calculus introduced independently by Newton and Leibniz.

SEMESTER II			
Sl No.	Paper Code	Paper Title	**Course Outcome**
01	MAT201	Complex Analysis	After learning the course, the learner will be able to 1. Get the basic idea of Analytical function, harmonic function. Also, to know the applications of analytic function, application of Cauchy Riemann equations. 2. Utilize the knowledge of Cauchy's Integral formula and inequality, Poison's formula, Liouville's Theorem, Maximum Modulus Theorem, Rouche's Theorem, Fundamental Theorem of Algebra, The Argument Principle. 3. Learn to solve Taylor's and Laurant's Series. Also applying these concepts to find the Residues at a Pole and Calculation of Residues. Applying residue theorem in Evaluation of improper real integrals 4. Get the preliminary idea of Cauchy Residue Theorem, Jordan's Inequality, Conformal mappings and Bilinear transformations.
02	MAT202	Continuum Mechanics	After learning the course, the learner will be able to 1. Analyze the problems of stress and strain and use Cauchy's stress principle, Equations of compatibility. 2. Utilize the knowledge of Lagrangian and Eulerian description of configuration. 3. Gain the knowledge of material derivative and use it to solve volume, surface and line elements. 4. Get the preliminary idea of Hook's law, Stokesian fluid and Newtonian fluid.
03	MAT203	Functional Analysis	After learning the course, the learner will be able to 1. explain fundamental properties of normed spaces, Banach Spaces, inner product spaces, Hilbert spaces, *lp* spaces, *Lp* spaces, Quotient space, Function spaces of normed linear spaces, Convergence and completeness. 2. analyse Hahn-Banach Theorem for real/ complex space, normed space, Open-Mapping Theorem, Closed Graph Theorem and Boundedness Theorem. 3. use Gram-Schmidt orthogonalization process, linear functionals and adjoints, self-adjoint, normal and unitary operators, orthogonal projections, spectral, bilinear forms and quadratic forms 4. explain Fourier expansion, orthonormal basis, Bessel's inequality, Projection theorem and Adjoint of an operator. 5. use all the concepts of functional analysis for higher study such as research, project etc.
04	MAT204	General Topology	After learning the course, the learner will be able to Understand and appreciate the concept of a Topology and be able to recognize standard examples. Be familiar with the fundamental notions of continuity, convergence and compactness.
05	MAT205	Mathematical Methods and Computer Applications	After learning the course, the learner will be able to 1. Solve Fredholm and Volterra integral equations. 2. Utilize the knowledge of Laplace and Fourier transform and use their properties to solve various types of differential equation 3. Solve various types of boundary value problems. 4. Get the preliminary idea of calculus of variation and Euler-Lagrange equation and their applications to relevant problems. 5. Solve Laplace transform, Fourier transform and Integral equations using Python programming.
06	MAT206 Open Elective II	**Applications of Mathematics in Real life**	After learning the course, the learner will be able to 1. Apply progressions and permutation & combination. 2. Get the knowledge to solve problems relating to Business and Economics. 3. Solve linear programming problems using graphical method.
		Mathematics Education	After learning the course, the learner will be able to 1. Get the knowledge of Philosophy of Mathematics and Mathematics Education.

			2. Know the Mathematics Education in Social and Political context; 3. Understand the structure in Mathematics. 4. Analyze the Gender stereotypes in Mathematics.
SEMESTER III			
Sl No.	Paper Code	Paper Title	**Course Outcome**
01	MAT301	Fuzzy Set Theory	After learning the course, the learner will be able to 1. Get the basic idea of fuzzy set theory. 2. Get the idea of utilization of fuzzy set theory in practical life. 3. Get the idea of fuzzy linear programming problem.
02	MAT302	Graph Theory	After learning the course, the learner will be able to 1. Get the basic idea of Graphs and Digraphs. Able to know about the concepts: Vertex degree, degree sequence, Subgraph, Graph isomorphism, Regular graph, complete graph, Bipartite, *k*-partite graph, walk, trail, path, cycle and length, also able to about the basic of Oriented digraph, Out degree, In degree, Adjacency matrix of a labelled graph and Weighted graph. They 2. Utilize the knowledge of the basic concepts student able learn about Tree, Spanning tree, shortest path, Point-connectivity (connectivity) and line-connectivity, Menger's theorem, Connectivity of digraph, traversability (Euler tour, Eulerian graph, Hamilton cycle and Hamiltonian graph), covering. Also, able to know covers and independent sets, Critical points and lines. 3. Using the concept of tree student are able to know the Enumeration of trees. Applying the concepts of Eulerian and Hamiltonian graph, student is able to solve The Chinese postman problem and Travelling salesman problem. 4. Get the preliminary idea of Intersection Graph, line graph and block graph, Cayley's formula, Gallai and König theorems. They also able to know Factorization: *n*-factor, 1-factorization, 2-factorization, Tutte's 1-factor theorem, Petersen's theorem, *f*-factors. The idea of planarity: Graph embeddings, Planar graph, Euler's formula, Kuratowski's theorem and Parameters of planarity.
03	MAT303	Number Theory	After learning the course, the learner will be able to 1. explain the concept of divisibility, Euclidean Algorithm, Chinese Remainder Theorem, Prime numbers and related fundamental theorems 2. express the concept of divisor functions, perfect numbers, Mersenne numbers and Fermat numbers. 3. Define Gauss function, Mobius function, Euler function, Congruences and its elementary properties and complete residue re-duced residue system. 4. explain Diophantine equations, quadratic residues and congruences, Legendre symbol and Jacobi symbol. 5. corelate number theory to problems arising in algebra, coding theory and other branches of mathematics.
04	MAT304	Numerical Analysis and Computer Applications	After learning the course, the learner will be able to 1. Apply Direct method for solving of linear equations: (Gauss elimination, Crout's method, LU decomposition, Cholesky decomposition. 2. Apply Iterative methods (Jacobi, Gauss-Siedel, Relaxation method). Jordan's method, Escalator method. 3. Solve Algebraic Eigen value problem: Power method, Inverse power method, Jacobi's method. 4. Apply Given's method. Orthogonal factorization, QR algorithm for Eigen value problem. 5. Solve linear equations in numerical analysis using Python programming.
05	MAT305	Special Theory of Relativity	After learning the course, the learner will be able to 1. Get the basic idea of inertial and non-inertial frames of reference. 2. Utilize the concept of Lorentz transformation in relativistic mechan-ics.

			3. Get the idea of Minkowski's space, analyze the geometrical interpretation of the consequences of Lorentz transformation. 4. Understand the relation between electrodynamics and the special theory of relativity and its importance.
05	MAT306	Dissertation	The outcome of this course is the completion of a dissertation report. The dissertation reports a research project conducted with the guidance of a supervisor. The dissertation reports should make a contribution to educational knowledge. This course will motivate the students to take up research in the future.
SEMESTER IV			
Sl No.	Paper Code	Paper Title	**Course Outcome**
01	MAT401(A)	Advanced Topology	After learning the course, the learner will be able to 1. Get the basic idea of uniformity, developed to study about uniform convergence, uniform continuity etc in general topology. 2. Basic idea of proximity spaces and its relation with general topology.
	MAT401(B)	Fluid Dynamics	After learning the course, the learner will be able to 1. Get the elementary idea of real fluids and ideal fluids and their properties. 2. Use the concept equation of continuity in various problems of fluid. 3. Utilize the knowledge of Lagrange's and Euler's equation of motion. 4. Illustrate different types of fluid motions in two dimensions. 5. Analyze vortex motion and their properties viz. Navier-Stoke's equation of motion. 6. Understand the behaviour of fluid flow using the concept of Reynold's number.
	MAT401(C)	Operator Theory	After learning the course, the learner will be able to 1. explain Banach algebras, Gelfand Transform, Gelfand-Mazur Theorem, commutative Banach algebras, spectral radius Formula and Stone-Weierstrass Theorem. 2. analyse operators on Hilbert Space and C*-Algebras, normal and self-adjoint sperators, C*-Algebras, weak and strong operator topologies and *-homomorphisms of C*-Algebras. 3. define compact operators, Fredholm operators, integral operators, Volterra and Fredholm integral Operators. 4. explain unbounded operators, Hilbert-Adjoint operators, spectral properties, unitary Operators and self-Adjoint Linear Operators 5. use all the concepts of Operator theory for higher study such as research, project etc.
02	MAT402(A)	Advanced Functional Analysis	After learning the course, the learner will be able to 1. define topological vector spaces, completeness, convexity, Weak topologies, Compact and convex sets**.** 2. explain fundamental properties of Banach Algebras, C* Algebras, Commutative Banach Algebras and Commutative C* Algebras and Representation of C* Algebras. 3. explain spectral theory and its properties, properties of resolvent, self-adjoint linear operators and positive operators. 4. analyse fixed point theory, basic fixed-point results on Banach fixed point theorem and its applications on differential equations and integral equations. 5. corelate functional analysis to problems arising in differential equations and other branches of mathematics.
	MAT402(B)	Dynamical Systems	After learning the course, the learner will be able to 1. Define Dynamical systems and its types as well as Iteration, Orbits, Types of Orbits, Other Orbits, The Doubling Function. 2. Do Graphical Analysis, Orbit Analysis, The Phase Portrait Analysis. 3. Get the idea of stability of a fixed point, equilibrium point, concept of limit cycle and torus, hyperbolicity, quadratic map period doubling phenomenon. 4. Analyze Bifurcations, The Quadratic Family, Transition to Chaos,

			Symbolic Dynamics. 5. Understand Chaos. Fractals, The Julia Set, The Mandelbrot Set.
	MAT402(C)	Category Theory	After learning the course, the learner will be able to 1. Get the basic idea of Heyting algebra in Category Theory. Basic idea of proximity spaces and its relation with general topology. 2. Basic idea of Set-valued functor categories. Order Adjoints and interior operation in Topology as an order adjoint. Some special types of categories and their significance in different field of Mathematics.
03	MAT403(A)	Fuzzy Logic and Fuzzy Control System	After learning the course, the learner will be able to 1. Get the basic idea of Fuzzy Logic 2. Utilize the knowledge of fuzzy logic to Expert Systems 3. Get the idea of control systems 4. Get the idea of applications of Fuzzy Logic.
	MAT403(B)	Relativity and Cosmology	After learning the course, the learner will be able to 1. Get the basic idea of principle of equivalence, Mach's principle, Einstein's field equation and general relativistic Kepler problem. 2. Utilize the knowledge of Schwarzschild interior and exterior solutions. 3. Solve Einstein's field equations with cosmological terms. 4. Derive Friedmann-Robertson-Walker metric. 5. Get the preliminary idea of cosmological principle and cosmological models. 6. Use the concepts of Hubble' parameter, Deceleration parameter, Redshift to study the behavior of the universe. 7. Learn about of age of the universe, Big Bang, early universe.
	MAT403(C)	Operations Research	After learning the course, the learner will be able to 1. formulate and solve Linear Programming Problem, Graphical Solution and Duality in Linear Programming. 2. analyse Simplex Method, Queuing system- Poisson and Non-Poisson. Queuing theory and its operating characteristic queuing model –M/M/1, M/M/C, M/G/1. 3. solve and explain two- person zero-sum games, pay-off Matrix, Graphic solution of 2 x n and m x 2 games, General rule for Dominance and Modified Dominance. 4. express Markov process, state transition matrix, steady state conditions, Markov algorithm and some special cases**.** 5. explain General Non-Linear Programming Problem (GNLPP), Kuhn-Tucker conditions for NLPP and Saddle Point Problem. 6. use all the concept for decision making, strategies, complex business problems etc.
04	MAT404(A)	Advanced Graph Theory	After learning the course, the learner will be able to 1. Get the basic idea of Matching, maximum, maximal and perfect matching, augmented path, matching in bipartite graph; *c*-matching, domination, dominating set and dominating number, connected, independent and total dominating set. Also, able to know vertex and edge colouring, Chromatic number and edge chromatic number, Complex Network. 2. Utilize the knowledge of Matching on Berge's theorem, König's theorem for maximum matching, Hall's theorem, closed neighbourhood. 3. Learn to solve bounds for chromatic number, Student know the applications of graph theory in Complex Networks: complex networks, network traversal, Construction of Euler tour, Finding a Hamilton cycle, Trees in transportation networks, Routing in communication networks, Random networks, Computer networks, social networks analysis, Structural balance, Affiliation networks, Equivalence and Structural equivalence. 4. Get the preliminary idea of the four colour theorem and the five colour conjecture, uniquely colourable graph, Critical graph, Chromatic polynomial, Brooks' theorem, Vizing's theorem, Generalization of Graph: Hypergraph & Semigraph, Dual of hypergraph, Cycles in

			hypergraph, conformal hypergraphs, Representative graph of a hypergraph, matching in hypergraph, degrees in semigraph, Subsemigraph and partial subsemigraph, *s*-Path, *s*-cycle, Edge bipartite semigraph, Dendroids
	MAT404(B)	Advanced Numerical Analysis	After learning the course, the learner will be able to 1. Find Numerical Solution of Ordinary Differential equations: Euler's method, modified Euler's method, Runge's method, Runge-Kutta method, Predictor-corrector method, Milne's method, Adams-Bash forth method, Boundary-value problems, Finite-difference method. 2. Find Numerical Solution of Partial Differential equations: Finite-Difference approximations to partial derivatives, Elliptic equations, Solution of Laplace equation, Solution of Poisson's equation. 3. Find Solution of elliptic equations by relaxation method, parabolic equations, hyperbolic equations. 4. Apply least square polynomial approximation, polynomial approximation by use of orthogonal polynomials, approximation with Chebyshev polynomials.
	MAT404(C)	Advanced Number Theory	After learning the course, the learner will be able to 1. define arithmetical functions, Dirichlet multiplication, elementary theorems on the distribution of primes and Chebyshev's functions. 2. explain quadratic residues, quadratic reciprocity law, applications of the reciprocity law and Gauss sums. 3. analyze Dirichlet series, Euler products, Riemann zeta function and Dirichlet L-functions. 4. define partitions, generating functions, Euler's Pentagonal number theorem, Jacobi triple product identity, Jacobi's identity, recursion formula for p(n) and Ramanujan's partition identities. 5. use all the concepts of advanced number theory for higher study such as research, project etc.
05	MAT405	Dissertation	The outcome of this course is the completion of a dissertation report. The dissertation reports a research project conducted with the guidance of a supervisor. The dissertation reports should make a contribution to educational knowledge. This course will motivate the students to take up research in the future.