FOUR -YEAR (EIGHT-SEMESTER)

HONOURS AND

HONOURS WITH RESEARCH

COURSE WITH

MATHEMATICS MAJOR

UNDER

CURRICULUM AND

CREDIT

FRAMEWORK

(CCF)

Graduate Attributes in Mathematics

The aspiring mathematician embarks on a journey woven from logic, proof, and the boundless beauty of numbers. As they progress, they cultivate a unique set of attributes, becoming not just masters of calculation, but architects of knowledge and contributors to the advancement of science and society.

1. **Disciplinary Expertise:** A deep understanding of the fundamental concepts, theories, and techniques across various subfields of mathematics forms the bedrock of their intellectual prowess. From abstract number theory to real-world applications in optimization and modeling, their knowledge empowers them to tackle diverse challenges with clarity and rigor.
2. **Algorithmic Architects:** They wield algorithms as tools, constructing computational solutions to complex problems. Be it optimizing financial models, forecasting weather patterns, or deciphering the inner workings of physical systems, their fluency in the language of algorithms equips them to bridge the gap between theory and practice.
3. **Crystal Clear Communicator:** The arcane language of mathematics becomes transparent in their articulation. They translate complex concepts into clear and concise explanations, fostering collaboration and nurturing the next generation of mathematical talent.
4. **Critical Problem Solver:** Faced with an enigmatic mathematical puzzle, their mind delves into a tapestry of logical deduction. They dissect assumptions, forge elegant solutions, and navigate intricate complexities with unwavering persistence.
5. **Inquiry Weaver:** A burning curiosity propels them forward. They craft insightful questions that challenge established paradigms and pave the way for groundbreaking discoveries. They meticulously conduct proofs, present their findings with conviction, and contribute to the ever-evolving dialogue of mathematical inquiry.
6. **Collaborative Virtuoso:** The spirit of teamwork flourishes in diverse mathematical ensembles. They seamlessly integrate their expertise, learn from fellow explorers, and cultivate a synergistic environment where knowledge thrives.
7. **Project Maestro:** Orchestrating research projects becomes an art form. They identify crucial resources, map strategic pathways, and navigate challenges with meticulous planning and unwavering ethical conduct.

8. **Digital Wizardry:** The computer becomes their laboratory, where algorithms paint vibrant landscapes of data. They wield advanced computational tools with mastery, transforming raw numbers into profound insights and unraveling the hidden patterns

within.

9. **Ethical Architect:** Integrity becomes the cornerstone of their work. They identify and navigate ethical dilemmas with transparency and fairness, upholding the highest standards of academic conduct and intellectual property.
10. **Global Citizen:** Their perspective transcends borders, embracing a deep understanding of the international landscape of mathematics. They see their contributions as threads woven into the global tapestry of scientific progress, driving advancements for the betterment of humanity.
11. **Lifelong Learner:** The quest for knowledge knows no bounds. They remain self-directed learners, constantly seeking new avenues to refine their skills, update their knowledge, and reshape their expertise. The journey through the boundless world of mathematics is a lifelong pursuit, fueled by unwavering dedication and a boundless passion for exploration.

These attributes paint a portrait of a graduate mathematician poised to make a significant impact on the world. They are not just skilled technicians, but architects of knowledge, collaborators, and leaders in the pursuit of understanding the very fabric of reality through the lens of mathematics.

Program Learning Outcomes (POs) in a B.Sc. (Major) Mathematics

Program Learning Outcomes (POs) in a Bachelor of Science (Major) Mathematics program outline the specific knowledge, skills, and abilities that students are expected to acquire by the end of their studies. These outcomes reflect the overall goals of the program and serve as a guide for curriculum development and assessment. Here are some key Program Learning Outcomes for a B.Sc (Major) Mathematics program:

1. **Mathematical Knowledge and Understanding:** Graduates should demonstrate a comprehensive understanding of foundational mathematical concepts, theories, and principles across various branches of mathematics, including but not limited to algebra, calculus, analysis, geometry, and discrete mathematics.
2. **Problem-Solving Proficiency:** Graduates should be proficient in applying mathematical techniques to solve complex problems. This involves the ability to analyze problems, formulate mathematical models, and apply appropriate methods for solution.
3. **Mathematical Reasoning and Proof:** Graduates should possess strong mathematical reasoning skills and be able to construct rigorous mathematical proofs. This includes understanding the logical structure of mathematical arguments and the ability to communicate proofs effectively.
4. **Advanced Calculus and Analysis:** Graduates should have a deep understanding of advanced calculus and mathematical analysis, including the convergence of sequences and series, limits, continuity, and the fundamental theorems of calculus.
5. **Algebraic Structures:** Graduates should be familiar with algebraic structures such as groups, rings, and fields, and be able to apply abstract algebraic concepts to various mathematical problems.
6. **Geometry and Topology:** Graduates should have a solid understanding of geometry and topology, including concepts such as symmetry, transformations, and the properties of geometric shapes.
7. **Applied Mathematics:** Graduates should be able to apply mathematical techniques to real-world problems in various scientific and engineering domains. This includes proficiency in mathematical modeling, data analysis, and numerical methods.
8. **Mathematical Software and Technology:** Graduates should be proficient in using mathematical software and technology to aid in problem-solving, visualization, and data analysis.

9. **Effective Communication:** Graduates should be able to communicate mathematical ideas clearly and effectively, both in written and oral forms, to diverse audiences, including peers and non-specialists.
10. **Independent Research Skills:** Graduates should demonstrate the ability to conduct independent research in mathematics. This includes formulating research questions, conducting literature reviews, and applying appropriate research methodologies.
11. **Ethical and Professional Conduct:** Graduates should adhere to ethical standards in mathematical research and practice, including proper citation of sources, integrity in data analysis, and responsible use of mathematical knowledge.
12. **Lifelong Learning:** Graduates should recognize the importance of lifelong learning in mathematics, staying abreast of new developments in the field, and continuously enhancing their mathematical skills and knowledge.

These Program Learning Outcomes collectively ensure that graduates of the B.Sc (Major) Mathematics program are well-prepared for a variety of career paths, including further study at the graduate level or employment in fields requiring strong analytical and mathematical skills.

DSCC/MAJOR Papers for 4-year B.Sc Mathematics (Hons.)

S. No.	POs	CC- 1	CC-2	CC-3	CC-4	CC-5	CC-6	CC-7	CC-8	CC-9	CC-10	CC-11	CC-12
1	Fundamental understanding of the field	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
2	Application of basic Mathematics concepts	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
3	Linkages with related disciplines	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
4	Procedural knowledge for professional subjects	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
5	Skills in related field of specialization	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
6	Ability to use in Mathematics problem	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
7	Skills in Mathematical modeling	✔	✔	✔	✔	✔	_	_	✔	_	✔	✔	✔
8	Skills in performing analysis and interpretation of data	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
9	Develop investigative Skills	✔	✔	✔	✔	✔	✔	_	✔	✔	✔	✔	✔
10	Skills in problem solving in Mathematics and related discipline	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
11	Develop Technical Communication skills	✔	✔	✔	✔	-	-	✔	✔	✔	✔	✔	✔
12	Developing analytical skills and popular communication	✔	✔	✔	✔	-	-	✔	-	_	_	✔	✔
13	Developing ICT skills	✔	✔	✔	✔	✔	✔	_	✔	✔	✔	✔	✔
14	Demonstrate professional behaviour with respect to attribute like objectivity, ethical values, self reading, etc	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Minor Papers for 4-year B.Sc Mathematics (Hons.)

S. No.	POs	MC- 1	MC- 2	MC- 3	MC- 4
1	Fundamental understanding of the field	✔	✔	✔	✔
2	Application of basic Mathematics concepts	✔	✔	✔	✔
3	Linkages with related disciplines	✔	✔	✔	✔
4	Procedural knowledge for professional subjects	✔	✔	✔	✔
5	Skills in related field of specialization	✔	✔	✔	✔
6	Ability to use in Mathematics problem	✔	✔	✔	✔
7	Skills in Mathematical modeling	✔	✔	✔	✔
8	Skills in performing analysis and interpretation of data	✔	✔	✔	✔
9	Develop investigative Skills	✔	✔	✔	✔
10	Skills in problem solving in Mathematics and related discipline	✔	✔	✔	✔
11	Develop Technical Communication skills	✔	✔	✔	✔
12	Developing analytical skills and popular communication	✔	✔	✔	✔
13	Developing ICT skills	✔	✔	✔	✔
14	Demonstrate professional behaviour with respect to attribute like objectivity, ethical values, self reading, etc	✔	✔	✔	✔

Skill Enhancement Course (SEC) for B.Sc. Mathematics (Hons.)

Sl. No	POs	SEC 1	SEC 2.2	SEC 3
1	Fundamental understanding of the field	✔	✔	✔
2	Application of basic Mathematical concepts	✔	✔	✔
3	Linkages with related disciplines	✔	✔	✔
4	Procedural knowledge for professional subjects	✔	✔	✔
5	Skills in related field of specialization	✔	✔	✔
6	Ability to use in Mathematics problem	-	✔	✔
7	Skills in Mathematical modeling	-	✔	✔
8	Skills in performing analysis and interpretation of data	-	✔	✔
9	Develop investigative Skills	-	✔	✔
10	Skills in problem solving in Mathematics and related discipline	✔	✔	✔
11	Develop Technical Communication skills	✔	✔	✔
12	Developing analytical skills and popular communication	✔	✔	✔
13	Developing ICT skills	✔	✔	✔
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, self-reading, etc	✔	✔	✔

Interdisciplinary Course (IDC) for B.Sc. Mathematics (Hons.)

Sl. No	POs	IDC
1	Fundamental understanding of the field	✔
2	Application of basic Mathematical concepts	✔
3	Linkages with related disciplines	✔
4	Procedural knowledge for professional subjects	-
5	Skills in related field of specialization	✔
6	Ability to use in Mathematics problem	✔
7	Skills in Mathematical modeling	-
8	Skills in performing analysis and interpretation of data	✔
9	Develop investigative Skills	-
10	Skills in problem solving in Mathematics and related discipline	✔
11	Develop Technical Communication skills	-
12	Developing analytical skills and popular communication	✔
13	Developing ICT skills	✔
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, self-reading, etc	✔

Course Learning Outcomes (CLO)

DSCC/ MAJOR PAPERS

MATH-H-CC1-1-Th

(same for MATH-H-MC 1-1-Th & MATH-H-MC 1-3-Th)

Calculus, Geometry & Vector Analysis

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Course learning outcome (COs):

Upon successful completion of this course, students will be able to:

Group A: Calculus

- Define and apply the concept of differentiability for functions at a point and in an interval.
- Interpret the meaning of the sign of a derivative and its relationship to increasing/decreasing behavior.
- Differentiate hyperbolic functions, higher order derivatives, and functions involving exponential and logarithmic terms.
- Utilize Leibnitz's rule for differentiation and apply it to specific types of functions.
- Identify and handle indeterminate forms using L'Hopital's rule.
- Derive and apply reduction formulae to integrate trigonometric functions, logarithmic functions, and product of trigonometric functions.
- Find the arc length of curves, including parametric curves, and calculate the area under a curve and the volume of a surface of revolution.

Group B: Geometry

- Analyze and categorize second-degree equations using rotation of axes and the discriminant.
- Represent conics (ellipses, parabolas, hyperbolas) in both rectangular and polar forms, and find tangents and normals for these curves.
- Define and identify various types of three-dimensional surfaces, including spheres, cylinders, and conicoids.
- Analyze plane sections of conicoids and identify surfaces such as cones, cylinders, ellipsoids, hyperboloids.
- Classify quadric surfaces based on their geometric properties.

Group C: Vector Analysis

- Perform the triple product and apply vector equations to solve problems in geometry and mechanics.
- Analyze and solve problems involving concurrent forces in a plane, theory of couples, and systems of parallel forces.
- Define and analyze vector-valued functions, including limits, continuity, differentiation, and integration.
- Utilize derivatives and integrals of vector functions to solve problems in various contexts.

Additional Outcomes:

- Students will develop strong problem-solving skills and critical thinking abilities within the realm of calculus, geometry, and vector analysis.
- They will enhance their communication skills by effectively demonstrating mathematical concepts verbally and through written representation.
- Students will gain a deeper appreciation for the interconnectedness of different areas of mathematics and their relevance to various fields of study.

MATH-H-CC2-2-TH
(same for MATH-H-MC 2-2-Th & MATH-H-MC 2-4-Th)
Basic Algebra
Full Marks: 100 (Theory: 75 and Tutorial: 25)

Course learning outcome (COs):

Upon successful completion of this course, students will be able to:

Group A: Complex Numbers and Equations

- **Complex Numbers:**
    - Represent complex numbers in polar forms and find n-th roots of unity.
    - Apply De Moivre's theorem to solve problems involving rotations and powers of complex numbers.
    - Analyze and differentiate functions of a complex variable (exponential, logarithmic, trigonometric, and hyperbolic).
- **Theory of Equations:**
    - Understand the relationship between roots and coefficients of polynomial equations.
    - Apply techniques like Descartes' rule of signs and Sturm's theorem to analyze the nature of roots.
    - Solve cubic and biquadratic equations using methods like Cardano's and Ferrari's formulas.
- **Inequalities:**
    - Utilize key inequalities like AM-GM and Cauchy-Schwartz to solve inequality problems.

Group B: Relations, Mappings, and Number Theory

- **Relations:**
    - Distinguish and analyze different types of relations (equivalence, partial order, linear order).
    - Understand equivalence classes and partitions associated with equivalence relations.
- **Mappings:**
    - Compose mappings and analyze their relationship with set operations.
    - Interpret and apply the concept of a preimage for a mapping and subset.

- **Number Theory:**
    - Apply the well-ordering property of integers and principles of mathematical induction to prove theorems.
    - Utilize the division algorithm and Euclidean algorithm to analyze divisibility and find greatest common divisors.
    - Understand and apply properties of prime numbers, including Euclid's theorem and the Fundamental Theorem of Arithmetic.
    - Solve systems of congruences using the Chinese remainder theorem.
    - Explore and utilize specific arithmetic functions like phi, tau, and sigma.

Group C: Linear Systems and Vector Spaces

- **Linear Systems:**
    - Solve systems of linear equations (homogeneous and non-homogeneous) and determine their existence and uniqueness.
    - Utilize the matrix equation Ax = b and row reduction techniques to find solutions and analyze echelon forms.
    - Understand the concepts of rank, invertible matrices, and pivot positions.
    - Represent solutions parametrically and interpret them geometrically.
- **Vectors and Vector Spaces:**
    - Perform operations on vectors in R^n and understand their algebraic and geometric properties.
    - Represent linear systems with vectors and analyze their solutions based on linear combinations.
    - Visualize the geometry of linear combinations and spanned subsets.
    - Understand the concepts of linear independence and its algebraic and geometric characterizations.

Additional Outcomes:

- Develop computational skills for solving various algebraic problems efficiently.
- Enhance proficiency in using mathematical software and technology for representing and analyzing mathematical concepts.
- Appreciate the historical development of certain mathematical ideas and their connections to scientific and engineering applications.

MATH-H-SEC 1-1-Th
C Language with Mathematical Applications
Full Marks: 100 (Theory: 75 and Tutorial: 25)

Course learning outcome (COs):

Upon successful completion of this course, students will be able to:

Programming Fundamentals:

- Explain the fundamental concepts of computer architecture and programming languages, including machine code, assembly language, high-level languages, and object-oriented languages.
- Demonstrate a strong understanding of constants, variables, data types, operators, and expressions in C programming.
- Apply decision-making constructs (if, if-else, switch) and control flow statements (while, do-while, for) to create structured programs.
- Effectively utilize arrays (one-dimensional, two-dimensional, and multi-dimensional) to organize and manipulate data.

Function Design and Implementation:

- Define and implement user-defined functions in C, understanding scope, return values, parameter passing, and recursion.
- Apply library functions from standard C libraries (stdio.h, math.h, string.h, stdlib.h, time.h) to perform common tasks.

Problem-Solving and Programming Skills:

- Analyze programming problems and design algorithms using appropriate C constructs and techniques.
- Write well-structured, readable, and efficient C programs to solve a variety of computational problems, including:
    - Numerical calculations (arithmetic, series summation, approximations)
    - Data processing (array manipulation, sorting, searching)
    - Mathematical problems (quadratic equations, linear systems, geometric calculations)
    - Text processing (strings, anagrams)
    - Decision-making and branching based on user input or data conditions

- File I/O operations (reading and writing data files)

Practical Application and Communication:

- Develop practical C programming skills through hands-on exercises and assignments, including the creation of a practical notebook.
- Demonstrate clarity and precision in writing C code and explaining programming concepts.
- Apply C programming skills to solve real-world problems in various domains, such as finance (compound interest), geometry, and problem-solving challenges.

MATH-MD-SEC 2.2-2-Th

Artificial Intelligence

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Course learning outcome (COs):

Upon successful completion of this course, students will be able to:

Unit 1: Introduction to Artificial Intelligence

- Define AI and its scope within the broader context of computer science.
- Trace the historical development of AI and identify key milestones and influential figures.
- Distinguish between artificial and human intelligence, outlining their distinctive characteristics and limitations.

Unit 2: AI Subfields and Technologies

- Explain the core principles of various machine learning approaches, including supervised, unsupervised, and reinforcement learning.
- Analyze the structure and function of deep learning neural networks, recognizing their strengths and challenges.
- Identify and describe applications of natural language processing (NLP) and computer vision in AI systems.

Unit 3: Applications of AI

- Discuss the utilization of AI in healthcare diagnostics, treatment planning, and medical image analysis.
- Evaluate the use of AI in financial applications like fraud detection, algorithmic trading, and risk assessment.
- Analyze the potential and challenges of autonomous vehicles and AI-powered traffic optimization in transportation systems.
- Critically examine the role of AI in customer service chatbots and its impact on user experience.
- Explore the development of personalized learning platforms and intelligent tutoring systems in the field of education.

Unit 4: Ethical and Social Implications of AI

- Identify and analyze potential biases and fairness concerns associated with AI algorithms and data.
- Discuss privacy and data protection issues arising from the development and deployment of AI systems.
- Evaluate the potential impact of AI on employment and job displacement, proposing mitigation strategies.
- Analyze the relationship between AI and social inequality, identifying potential risks and promoting responsible development.

Unit 5: Other Important Issues

- Critically assess existing ethical guidelines and best practices for responsible AI development and implementation.
- Discuss the role of AI in driving innovation and transformation across various sectors.
- Identify and analyze emerging trends and future directions in the field of AI.
- Explore the intersection of AI and creativity, including generative models and their potential artistic applications.

Additional Outcomes:

- Develop critical thinking and analytical skills through evaluating real-world AI applications and their implications.
- Enhance communication skills by effectively presenting arguments, insights, and concerns related to AI technology.
- Cultivate an informed and responsible perspective on the development and deployment of AI in society.

MATH-H-SEC 3-3-Th

Linear Programming and Rectangular Games

Full Marks: 100 (Theory: 75 and Tutorial: 25)

Course learning outcome (COs):

Upon successful completion of this course, students will be able to:

Unit 1: Introduction to Linear Programming

- Define linear programming problems and formulate them from real-life examples involving inequalities.
- Graphically solve simple linear programming problems and identify basic feasible solutions.
- Understand the concepts of matrix formulation, degeneracy, and non-degeneracy in B.F.S.

Unit 2: Convexity and Extreme Points

- Explain the concepts of hyperplanes, convex sets, cones, extreme points, convex hulls, and convex polyhedra.
- Analyze the relationship between feasible solutions of an L.P.P. and its convex set, extreme points, and optimal values.
- Differentiate between bounded and unbounded feasible regions and their implications for optimality.

Unit 3: The Simplex Method and Duality

- Implement the simplex method and two-phase method to solve linear programming problems.
- Understand the theoretical basis of feasibility and optimality conditions in the simplex method.
- Identify and resolve degeneracy issues in linear programming problems.
- Apply duality theory to understand the relationship between primal and dual problems and their optimal values.

Unit 4: Post-Optimal Analysis and Applications

- Analyze the impact of changes in cost and requirement vectors, coefficient matrix, and addition of variables/constraints on optimal solutions.
- Solve transportation and assignment problems using mathematical justifications and Hungarian method.

- Understand the Traveling Salesman problem and its complexity.

Unit 5: Rectangular Games and Interrelations

- Explain the concept of game problems and rectangular games with pure and mixed strategies.
- Identify and analyze saddle points and their existence in rectangular games.
- Determine optimal strategies and values of the game, applying necessary and sufficient conditions.
- Utilize dominance concepts and the fundamental theorem of rectangular games to solve problems.
- Compare and contrast the relationships between game theory and linear programming.

Additional Outcomes:

- Proficiently utilize software packages to formulate and solve linear programming problems.
- Develop a practical notebook documenting internal assignments and solutions for partial course fulfillment.
- Effectively communicate mathematical concepts and problem-solving techniques in both written and spoken forms.
- Apply critical thinking skills to analyze complex optimization scenarios and develop creative solutions.

MATH-H-IDC-1-Th
(same for MATH-H-IDC-2-Th and MATH-H-IDC-3-Th)
Mathematics in Daily Life
Full Marks: 75 (Theory: 50 and Tutorial: 25)

Course learning outcome (COs):

Overall:

Upon successful completion of "Mathematics in Daily Life," students will be able to:

- Recognize and apply foundational mathematical concepts to solve practical problems and make informed decisions in various everyday scenarios.
- Develop critical thinking and problem-solving skills by analyzing real-world data and situations through a mathematical lens.
- Effectively communicate and explain mathematical reasoning and solutions in a clear and understandable way.
- Appreciate the relevance and power of mathematics in diverse aspects of daily life, from personal finance and budgeting to understanding news and making responsible choices.

Specific Group-Level Outcomes:

Group A: Basics of Set Theory

- Organize and categorize information based on set operations like union, intersection, and complement, applicable to sorting items, managing schedules, or planning events.
- Visualize relationships between sets using Venn diagrams to understand connections and overlap in diverse contexts, like comparing dietary options or analyzing social groups.
- Utilize the formula for number of elements to estimate quantities or make informed decisions in daily situations.

Group B: Understanding Integers

- Apply divisibility rules to quickly assess quantities in shopping, cooking, or other activities involving calculations.
- Solve linear Diophantine equations to optimize resource allocation or find optimal combinations in scenarios like recipe balancing or budget planning.
- Utilize congruence of integers to create scheduling arrangements, game plans, or even solve puzzles, demonstrating its practical applications beyond abstract

mathematics.

Group C: Mathematical Logic

- Analyze information and arguments critically using logical connectives like OR, AND, and NOT, improving decision-making in daily life scenarios like evaluating news claims or weighing options.
- Identify tautologies and contradictions in everyday arguments to enhance critical thinking and logical reasoning skills.

Group D: Basics of Operations Research

- Formulate simple real-world problems as linear programs, such as optimizing travel routes, planning schedules, or allocating resources, and visualize solutions using the graphical method.
- Understand the concept of game theory and apply it to analyze competitive situations in daily life, like negotiations, resource sharing, or even game strategies.

Group E: Financial Mathematics

- Calculate and compare different interest rates for loans, investments, or savings, making informed financial decisions based on mathematical calculations.
- Apply annuity concepts to understand loan repayments, pension plans, or investment schemes, planning for their financial future.
- Navigate tax calculations and optimize financial decisions using basic mathematical principles.

Additional Outcomes:

- Develop confidence and comfort applying mathematical knowledge to real-world challenges.
- Foster a sense of curiosity and exploration, actively seeking and appreciating the presence of mathematics in everyday life.
- Communicate the value and relevance of mathematics beyond academic settings, showcasing its practical applications and empowering students to make informed decisions.