Chaudhary Charan Singh University, Meerut
Department of Mathematics

Structure and Syllabus

for

First Three Years (Ist to VIth Semesters)

of

B.Sc. Honours / Honours with Research in Mathematics

(University Campus)

(A Four-Year Degree Program with Multiple Exits and Entries)

(National Education Policy-2020)

(29th May, 2026)

29/5/2026

Eligibility:

Students of 10+2 ($12^{th)}$ with Mathematics

Subject Prerequisites:

To study this subject, a student must have passed 12^{th} class with Mathematics.

Programme Outcomes (POs):

After successful completion of the Undergraduate Honours Programme, the students will be able to:

1. Acquire comprehensive knowledge and understanding of the chosen discipline and allied areas.
2. Apply critical thinking, analytical reasoning, and problem-solving skills in academic and real-life situations.
3. Demonstrate effective oral and written communication skills for academic and professional purposes.
4. Use modern tools, technology, and digital resources effectively for learning and research.
5. Develop research aptitude, innovation, and independent learning abilities.
6. Exhibit ethical values, social responsibility, and environmental awareness.
7. Pursue higher education, employment, entrepreneurship, and lifelong learning successfully.

Here's the reframed version with more active, outcome-focused language:

Programme Specific Outcomes (PSOs)

Upon successful completion of the B.Sc. Honours (Mathematics) programme, students will be able to:

PSO 1	**Demonstrate conceptual proficiency** in core mathematical disciplines including Algebra, Analysis, Differential Equations, Geometry, Linear Algebra, Numerical Analysis, Operations Research, Complex Analysis, and several other branches of pure and applied mathematics forming a rigorous academic foundation.
PSO 2	**Apply mathematical reasoning** and analytical thinking to investigate and resolve theoretical, computational, and real-world problems across mathematics and allied disciplines.
PSO 3	**Leverage computational tools** — including C Programming, MATLAB, Mathematica, Python, and Computer Algebra Systems — to carry out mathematical modelling, scientific computing, and data-driven analysis. SAGEMATH, Gurobi, CPLEX
PSO 4	**Integrate interdisciplinary perspectives** through exposure to Statistics, Data Science, Machine Learning, Environmental Studies, Indian Knowledge Systems, languages, and other value-added offerings, fostering holistic intellectual development.
PSO 5	**Engage with advanced mathematical domains** such as Cryptography, Graph Theory, Differential Geometry, Fuzzy Sets, Control Theory, Soft Computing, Biomathematics, and Mathematical Modelling to address complex problems.
PSO 6	**Cultivate research readiness** by developing scientific temper, independent inquiry, and critical thinking skills suited for postgraduate study and scholarly work in Mathematics, Statistics, and cognate fields.
PSO 7	**Uphold professional and civic values** including ethical conduct, environmental consciousness, social responsibility, collaborative teamwork, and effective communication in academic and professional settings.

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PSO 8	**Navigate diverse career pathways** with preparedness for competitive examinations, higher education, entrepreneurship, and employment in Mathematics, Statistics, Data Science, Computer Applications, and related sectors.

B.Sc. Honours/ Honours with Research (Mathematics)
A Four-Year Degree Program with Multiple Exits and Entries
Semester-wise Course Structure and Credits

Year	Sem.	Course Code	MJDSCC/ MJDSEC/ MNGEC/AEC/ SEC/ VAC	Paper Title	Credits L-T-P	Total Credits
I	I		MJDSCC I	Algebra	4-0-0	4
			MJDSCC II	Analysis-I	4-0-0	4
			MJDSCC III	Differential Calculus	4-0-0	4
			MNGEC I	1. Computer Fundamentals and Programming in C 2. Differential Calculus	4-0-0	4
			AEC I	From the Pool of Courses offered by the University	2	2
			SEC I	Mathematical Typesetting with LaTeX	1-0-1	2
			VAC I	Vedic Ankganit	2-0-0	2
	II		MJDSCC IV	Group Theory-I	4-0-0	4
			MJDSCC V	Geometry & Vectors	4-0-0	4
			MJDSCC VI	Ordinary Differential Equations	4-0-0	4
			MNGEC II	1. Matrix Theory 2. Basic Statistics 3. Ordinary Differential Equations	4-0-0	4
			AEC II	From the Pool of Courses offered by the University	2	2
			SEC II	Mathematica	1-0-1	2
			VAC II (From MOOCS)	Any one of the following: 1. Introduction to Information Technology 2. Logic & Sets 3. Effective Decision Making 4. Human Growth & Development		2

			MJDSCC VII	Ring Theory-I	4-0-0	4
			MJDSCC VIII	Integral Calculus	4-0-0	4
			MJDSCC IX	Discrete Mathematics	4-0-0	4
	III		MJDSEC I	Any one of the following: 1. Elementary Number Theory & Cryptography 2. Integral Transforms 3. Introduction to Fuzzy Sets	4-0-0	4
			MNGEC III	Real Analysis	4-0-0	4
			AEC III	From the Pool of Courses offered by the University	2	2
			SEC III	MATLAB for Beginners	1-0-1	2
			MJDSCC X	Analysis-II	4-0-0	4
			MJDSCC XI	Mechanics-I	4-0-0	4
			MJDSCC XII	Numerical Analysis	4-0-0	4
II	IV		MJDSEC-II	Any one of the following: 1. Linear Programming Problem and Applications (Gurobi/CPLEX) 2. Biomathematics 3. Mathematical Data Science	4-0-0	4
			MNGEC IV	Numerical Methods	4-0-0	4
			AEC IV	From the Pool of Courses offered by the University	2	2
			SEC IV	Computer Algebra System	1-0-1	2
			VAC III (From the Pool of Courses)	From the Pool of Courses offered by the University	2	2
			MJDSCC XIII	Metric Space	4-0-0	4
			MJDSCC XIV	Group & Ring Theory-II	4-0-0	4
			MJDSCC XV	Partial Differential Equations	4-0-0	4
			MJDSEC-III	Any one of the following 1.Mechanics-II 2. Introduction to Graph Theory 3. Differential Geometry	4-0-0	4

III	V		MNGEC V	1. Mathematical Python 2. Introduction to Reliability Theory	4-0-0	4
	VI		MJDSCC XVI	Operations Research	4-0-0	4
			MJDSCC XVII	Linear Algebra	4-0-0	4
			MJDSCC XVIII	Complex Analysis	4-0-0	4
			MJDSEC IV	Any one of the following: 1.Basics of Control Theory 2. Mathematical Modelling 3. Soft Computing Techniques	4-0-0	4
			MNGEC VI	1. Mathematical Statistics 2. Introduction to Machine Learning	4-0-0	4

Note: VIAPCW of **4 credits** after semester II for certificate/ II or IV for diploma/ II or IV or VI for Degree is mandatory.

Nomenclature

MJDSCC: Major Discipline Specific Core Course
MJDSEC: Major Discipline Specific Elective Course
MNGEC: Minor Generic Elective Course
AEC: Ability Enhancement Course
SEC: Skill Enhancement Course
VAC: Value Addition Course
VIAPCW: Vocational Course/Internship/Apprenticeship/Project/Community Outreach/ Workshop
L: Lecture, **T:** Tutorial, **P:** Practical or Practice

(Prof. Hare Krishna, Dean Science)　(Prof. Jaimala)　(Prof. Mukesh Kumar Sharma)

(Prof. A. K. Bhargava)　(Prof. Rishi Kumar Agarwal)　(Prof. Anurag Sharma)

(Prof. M. K. Sharma)　online (Prof. R. C. Dimri)　(Prof. Aditya Kaushik)

(Prof. Dinesh Khattar)　(Dr. Manoj kumar)

B.Sc. Honours/ Honours with Research (Mathematics)
A Four-Year Degree Program with Multiple Exits and Entries
Semester-wise Syllabus

Semester: I

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: First**
Course Code:	Course Type: MJDSCC-I
Core: **Compulsory**	Course Title: Algebra
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objective: To develop foundational understanding of sets, relations, functions, permutations, and binary operations. To introduce the theory of groups and algebraic structures. To study the fundamental concepts of polynomial equations and classical algebra. To familiarize students with analytical and algebraic techniques for solving equations.

Course Outcomes:

This course will enable the students to:

- ✓ Own necessary prerequisites and build substantial foundation for grasping abstract algebra and linear algebra.
- ✓ Introduce at groups, their basic concepts, types, examples, and properties.
- ✓ Determine number of positive/negative real roots of a real polynomial.
- ✓ Solve cubic and quartic polynomial equations with special condition on roots and in general.
- ✓ Use De-Moivre's theorem in a number of applications to solve numerical problems.

Unit	Topics	No. of Hours
I	Sets, Product of sets, Functions, Binary operation, Relations, Equivalence Relations, Partitions, Partial order relations, Residue classes of the set of integers, Permutations, Even and odd permutations, Cyclic Permutations, Cycles of a permutation, Disjoint permutation.	15
II	Binary operation on a set, Algebraic structure, Group, Finite and Infinite Groups, Abelian group, Quaternion group, Order of a finite group, Groups of Permutations, Alternating group, Integral powers of an element of a group, Order of an element of a group.	15
III	General properties of polynomials and equations, Fundamental theorem of algebra, Relations between the roots and the coefficients, Upper bounds for the real roots; Theorems on imaginary, integral and rational roots; Descartes' rule of signs.	15
IV	Newton's method for integral roots, Cardan's solution of the cubic equation, Descartes' solution of the quartic equation, De-Moivre's theorem for integer and rational indices and their applications, The nth roots of unity.	15

Essential/ Recommended Readings:

- I. N. Herstein, Topics in Algebra, John Wiley & Sons, 2006.
- Dickson, Leonard Eugene (2009). First Course in the Theory of Equations. John Wiley & Sons, Inc. The Project Gutenberg e Book: http://www.gutenberg.org/ebooks/29785
- Andreescu, Titu & Andrica, D. (2014). Complex numbers from A to . Z(2nd Ed.) Birkhäuser. ISBN 978-0-8176-8414-3 ISBN 978-0-8176-8415-0 (eBook) DOI 10.1007/978-0-8176-8415-0 Springer New York Heidelberg Dordrecht London
- Joseph A. Gallian, Contemporary Abstract Algebra, Brooks/Cole Cengage Learning, 2016
- Burnside, W. S., & Panton, A. W. (1979), The Theory of Equations, Vol.1. Eleventh Edition.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: First**
Course Code:	Course Type: MJDSCC-II
Core: **Compulsory**	Course Title: Analysis-I
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objective: This course puts forward some basic concepts of real-valued functions and its applications. The purpose of this course is to provide a foundation for understanding the different branches of mathematics.

Course Outcomes:

After completing this course:

- ✓ Students will acquire a thorough understanding of the fundamental properties of the real number line (R), including completeness and order structure.
- ✓ Students will be able to analyze the behavior of sequences of real numbers using convergence criteria and determine their convergence or divergence.
- ✓ Students will develop the ability to construct rigorous mathematical proofs to establish the convergence properties of sequences and series of real numbers.
- ✓ Students will possess the foundational knowledge necessary to comprehend and engage with advanced topics in mathematics.

Unit	Topics	No. of Hours
I	**Real Number System R:** The field and order axioms of real numbers, intervals, the unique factorization theorem for integers, upper bounds, maximum element, least upper bound (supremum), lower bounds, minimum element, greatest lower bound (infimum), the completeness axiom of real numbers, some properties of supremum and infimum, properties of integers deduced from the completeness axiom, the Archimedean property of the real number system, absolute values and the triangle inequality, the Cauchy-Schwarz inequality.	15

II	**Basic Properties of R:** Neighborhood, the structure of open sets in R, interior point, isolated point, closed set, Adherent point, Accumulation point, interior of a set, closure of a set in real numbers and their properties, Bolzano-Weiestrass theorem, Heine-Borel covering theorem.	15
III	**Sequence:** Real sequence and its convergence, theorems on limits of sequence, bounded and monotonic sequences, limit superior and limit inferior for bounded sequence, Cauchy's sequence, Cauchy general principle of convergence, subsequences, Bolzano-Weierstrass theorem for sequences.	15
IV	**Infinite Series:** Convergence and divergence of infinite series, the necessary condition for convergence of an infinite series with positive terms (ISPT), Cauchy' s general principle of convergence of series, convergence and divergence of geometric series, convergence of ISPT: Comparison test. D-Alembert's ratio test, Raabe's test, Logarithmic test, De Morgan and Bertrand's test, Cauchy's nth root test, Gauss Test, Cauchy's integral test, Cauchy's condensation test, alternating series, Leibnitz's test, absolute and conditional convergence.	15

Essential/ Recommended Readings:

1. S. C. Malik, S. Arora (2018): Mathematical Analysis, New Age Publications.
2. R. G, Bartle, D. R. Sherbert (2015): Introduction to Real Analysis (4th ed.). Wiley India Edition. New Delhi.
3. Stephen, Abbott (2015): Understanding analysis. Springer.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: First**
Course Code:	Course Type: MJDSCC-III
Core: **Compulsory**	Course Title: Differential Calculus
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The primary objective of this course is to introduce the basic tools of calculus, also known as "science of variation", which provides a way of viewing and analyzing the real-world.

Course Outcomes: Through this course of Differential Calculus, students will

- ✓ Understand the concept of limits, continuity and uniform continuity, indeterminate form of functions.
- ✓ Understand continuity and differentiability in terms of limits and obtain successive differentiation and expansion of functions, derivation and applications of Rolle's theorem and mean value theorem.
- ✓ Apply the concepts of asymptotes, inflexion points, position, and nature of double points in tracing of Cartesian curves as well as parametric and polar curves.
- ✓ Learn to expand the function using Taylor's series.
- ✓ Be familiar with the concepts of limit, continuity and partial derivatives of functions of two

	variables. Understand the use of derivatives to explore the behaviour of a given function in locating and classifying its extrema. Learn to find tangents, normal, radius of curvature, envelops and evolutes.	
Unit	**Topics**	**No. of Hours**
I	**Limits and Continuity** Limits of functions ($\varepsilon - \delta$ and sequential approach), Uniqueness theorem on limits, Algebra of limits, Indeterminate forms, L' Hôpital's rule, Continuous functions and classification of discontinuities, Uniform continuity, Basic properties of continuous and uniformly continuous functions	15
II	**Differentiability and Mean Value Theorems** Differentiability of a real-valued function, Chain rule of differentiability, Algebra of differentiable functions, Rolle's theorem, Mean-value theorems and their applications, Intermediate value theorem for derivatives, Maxima and Minima for a single variable function on R.	15
III	**Successive Differentiation, Taylor's Theorem and Tracing of Plane Curves** Higher order derivatives and calculation of the *n*th derivative, Leibnitz's theorem; Taylor's theorem, Taylor's series expansions of sin x, cos x, e^x, log x, and a^x, Concavity, and inflexion points; Singular points, Asymptotes, Tracing of graphs of rational functions.	15
IV	**Tangent, Normals and Curvature** Tangents and normals, Cartesian and polar subtangent and subnormal, Intercepts, Length of the tangent and normal, Length of the perpendicular from the pole on tangent, Pedal equation of the curve, Curvature, Cartesian, polar and parametric formulae for radius of curvature, Envelopes and evolutes.	15

Recommended Readings:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pvt. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
2. Bartle, Robert G., & Sherbert, Donald R. (2011). *Introduction to Real Analysis* (4th ed.). John Wiley & Sons. Wiley India Edition 2015.
3. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.
4. Ross, Kenneth A. (2013). *Elementary Analysis: The Theory of Calculus* (2nd ed.).
5. G.B. Thomas and R.L. Finney (2007): Calculus, Pearson Education
6. Shanti Narayan (2005): Differential Calculus, S. Chand, New Delhi
7. Win Kreyszig, (2011): Advanced Engineering Mathematics, John Wiley & Sons.
8. Mukesh Kumar, A. P. Singh and Ashok Kumar (2018) Differential Calculus Medtech
9. Suggested digital platform: NPTEL/SWAYAM/MOOCS.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: First**
Course Code:	Course Type: (Minor) MNGEC-I

Course Type: Elective	Course Title: **Computer Fundamentals and Programming in C Language**
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objective: The course is designed to provide a working knowledge and skills of programming with C Language. Students will be able to develop logics which will help them to create programs. Also, by learning the basic programming constructs they can easily be able to grasp any other new computer languages in future.

Course Outcomes:

After completing this course, a student will have:

- ✓ Knowledge of computer architecture.
- ✓ An ability to operate computer systems.
- ✓ An ability to analyse a real-world problem and develop an algorithm.
- ✓ An ability to write computer software programs in C language. An ability to write C programs to compute statistical measures.

Unit	Topic	No. of Hours
I	**Basic Computer Structure:** Overview Of Computer System, Memory, C.P.U, I/O Units, Higher and Lower Levels Computer Languages. Basic Concepts of Computer Software, Compilers, Operating Systems and Statistical Software packages. Number systems (Binary, Octal, Hexadecimal Systems).	15
II	**Programming Methods:** Problem analysis, Algorithms, Flow charts, Programming designs, Criteria for a good programming method.	10
III	**C Programming Language:** Basic features of C Language, Constants, Variables and data types, Operators and expressions: arithmetic, relational and logical, Input and output statements with their formats, Decision making statements, Branching and looping, Arrays, User and system defined functions, Structures and pointers.	20
IV	**C Language Programs for statistical methods** such as Measures of central tendency, Dispersion and Moments.	15

Suggested Readings:

Balaguruswamy E. (1998). Programming in ANSI C, Tata Mc-Graw Hill Publishing company, Ltd. New Delhi.
Kanetkar Yashwant P. (1999). Let us C, BPB Publications, New Delhi.
Kernighan B.W and Ritchie Dennis M. (1997). The C Programming Language, Prentice Hall of India Pvt. Ltd. New Delhi.
Raja Raman V. (1999). Computer Programming In C, Prentice Hall of India Pvt. Ltd. New Delhi.
Byron S. (1999). Programming with C, (Schaum's Outline) Tata Mc Graw Hill Publishing Company Ltd. New Delhi
Deep K. Sinha, Priti Sinha (2020). Computer Fundamentals. BPB Publications, India.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: First**
Course Code:	Course Type: (Minor) MNGEC II
Course Type: Elective	Course Title: Differential Calculus
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

The primary objective of this course is to introduce the basic tools of calculus, also known as 'science of variation", which provides a way of viewing and analyzing the real-world.

Course Outcomes:

After completion of the course, students will

- ✓ Understand the concept of limits, continuity, uniform continuity, and indeterminate form of functions.
- ✓ Understand continuity and differentiability in terms of limits and obtain successive differentiation and expansion of functions, derivation and applications of Rolle's theorem and mean value theorem.
- ✓ Apply the concepts of asymptotes, inflexion points, position and nature of double points in tracing of Cartesian curves as well as parametric and polar curves.
- ✓ Learn to expand the function using Taylor's series.
- ✓ Understand the use of derivatives to explore the behaviour of a given function in locating and classifying its extrema. Learn to find tangents, normal, radius of curvature, envelops and evolutes.

Unit	Topics	No. of Hours
I	**Limits and Continuity** Limits of functions ($\varepsilon - \delta$ and sequential approach), Uniqueness theorem on limits, Algebra of limits, Indeterminate forms, L' Hôpital's rule, Continuous functions and classification of discontinuities, Uniform continuity, Basic Properties of continuous and uniformly continuous functions.	15
II	**Differentiability and Mean Value Theorems** Differentiability of a real-valued function, Chain rule of differentiability, Algebra of differentiable functions, Rolle's theorem and Mean-value theorem and their applications, Intermediate value theorem for derivatives, Maxima and Minima for a single variable function on R.	15
III	**Successive Differentiation, Taylor's Theorem and Tracing of Plane Curves** Higher order derivatives and calculation of the nth derivative, Leibnitz's theorem; Taylor's theorem, Taylor's series expansions of sin x, cos x, e^x, log x, and a^x, Concavity and inflexion points; Singular points, Asymptotes, Tracing of graphs of rational functions.	15

IV	**Tangents and Normals, Curvature** Tangents and normals, Cartesian and polar subtangent and subnormal, Intercepts, Length of the tangent and normal, Length of the perpendicular from the pole on tangent, Pedal equation of the curve, Curvature, Cartesian, polar and parametric formulae for radius of curvature, Envelopes and Evolutes.	15

Recommended Readings:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pvt. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
2. Bartle, Robert G., & Sherbert, Donald R. (2011). *Introduction to Real Analysis* (4th ed.). John Wiley & Sons. Wiley India Edition 2015.
3. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.
4. Ross, Kenneth A. (2013). *Elementary Analysis: The Theory of Calculus* (2nd ed.).
5. G. B. Thomas and R. L. Finney (2007): Calculus, Pearson Education
6. Shanti Narayan (2005): Differential Calculus, S. Chand, New Delhi
7. Win Kreyszig, (2011): Advanced Engineering Mathematics, John Wiley & Sons.
8. Mukesh Kumar, A. P. Singh and Ashok Kumar (2018) Differential Calculus Medtech
9. Suggested digital platform: NPTEL/SWAYAM/MOOCS.

Program: **B.Sc. (Honours/ Honours with Research)**	
Year: First	Subject: Mathematics
Course Code:	**Semester: First**
Core: **Compulsory**	Course Type: SEC-I
Credits (in hours per week): 2	Course Title: Mathematical Typesetting with LaTeX
Internal Assessment: 30%	1L-0T-1P
	External Assessment: 70%

Course Objectives:

- ✓ Equip students with the skills to create, format, and design structured and visually appealing LaTeX documents.
- ✓ Enable students to proficiently typeset complex mathematical expressions and structures, ensuring clarity and precision in technical and scientific documentation.

Course Outcomes:

- ✓ Gain proficiency in creating and typesetting simple LaTeX documents.
- ✓ Develop advanced skills in mathematical typesetting.
- ✓ Learn to include and customize images and tables within LaTeX.
- ✓ Efficiently number, reference, and format equations and piecewise functions in LaTeX.

Unit	**Topics**	**No. of Hours**

I	**Getting Started with LaTeX:** Introduction to TeX and LaTeX, Formatting text and understanding LaTeX commands and environments, Creating and typesetting a simple LaTeX document, Designing pages, Creating a book with chapters and table of contents, Creating and customizing lists, including images, and creating tables with captions.	15
II	**Mathematical Typesetting:** Accents and symbols, Mathematical typesetting (elementary and advanced): Subscript/ Superscript, Roots, Ellipsis, Mathematical Symbols, Arrays, Delimiters, Multiline formulas, Putting one thing above another, Spacing and changing style in math mode, Fractions, Typesetting metrics and determinants, Piecewise function formatting, Numbering equations and referencing, Picture and graphics in LaTeX.	15

Essential/ Recommended Readings:

- Lamport, Leslie (1994). LaTeX: A Document Preparation System, User's Guide and Reference Manual (2nd ed.) Pearson Education. Indian Reprint.
- Kittwitz, Stefan (2021). Latex Beginner's Guide (2nd ed.) Packet Publishing Ltd.
- Binder, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: First**
Course Code:	Course Type: VAC-I
Core: **Compulsory**	Course Title: Vedic Ankganit
Credits (in hours per week): 2	2L-0T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

- ✓ Foster love for mathematics and promote joyful learning of mathematics through Vedic Mathematics. Enhance computation skills in students through Vedic Mathematics. Develop logical and analytical thinking, Discuss the rich heritage of mathematical temper of Ancient India.

Course Outcomes: On completion of the course, student will be able to

- ✓ Understand the concept of high-speed addition, subtraction.
- ✓ Apply the sutras and up sutras to find the multiplication and division.
- ✓ Analyze the various sutras for finding the squares and cubes of numbers
- ✓ Evaluate the quadratic equation by Anurupyena, Adyamadyenantyamanty Sutra. Apply Vedic knowledge to deal with matrices, find its determinant and inverse.

Unit	**Topics**	**No. of Hours**

I	Addition in Vedic Maths - without carrying and dot method, Subtraction in Vedic Maths - Nikhilam Navatascaramam Dashatah, Vinculum number, Multiplication in Vedic Maths - Base method (any two number up to three digits), Urdhva Tiryak sutra, Miracle Multiplication- any three digit number by series of 9's, Division by Urdhva Triyak sutra (Vinculum method).	10
II	Square of any two-digit number- Base method, Duplex method, Square of number ending with 5-ekadhikena Purvena sutra, Easy square roots-Dwandwa Yoga (Duplex) sutra, square root of 2-Baudhayana Shulba sutra, Cubing-yavadnam sutra, Cube root, Factoring the quadratic equation by Anurupyena, Adyamadyenantyamanty Sutra, Roots of quadratic equation, Partial fraction.	10
III	Matrices and its properties, Determinant- Paravartya yojayet, Anurupye sunayamanyat, Inverse of matrices.	10

Essential/ Recommended Readings:

1. Elements of Vedic Mathematics, Udayan S. Patankar, Sunil M. Patankar, TTU press (2018)
2. Vedic Mathematics, Swami Bharati Krishna Trithaji, Motilal Banarsidas, New Delhi. (1965)
3. Vedic Mathematics, Shivraj Singh, Anil Kumar, Dr Sonia Gupta Pragati Publication 2021.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: AEC-I
Core: **Compulsory**	Course Title: From Pool of the courses
Credits (in hours per week): 2	2L-0T-0P
Internal Assessment: 30%	External Assessment: 70%
AEC-I	Note: Students have to choose this course from the Pool of Courses offered by the University

Semester: II

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: MJDSCC-IV
Core: **Compulsory**	Course Title: Group Theory-I
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: To understand homomorphisms, isomorphisms, kernels, and related group theoretic results. To study subgroups, generated groups, and their algebraic properties. □ To learn cosets, cyclic groups, Lagrange's theorem, and their applications. To examine automorphisms, normal subgroups, and quotient groups.

Course Outcomes:

This course will enable the students to:

This course will enable the students to:

- ✓ Understand groups, subgroups, cosets, normal subgroups, quotient groups, and their properties in detail.
- ✓ Apply Lagrange's theorem to solve problems related to finite groups, to determine the order of subgroups and understand its implications.
- ✓ Analyze the structure and properties of subgroups generated by subsets. Classify subgroups of cyclic groups and understand their structure.
- ✓ Know about group homomorphisms, group isomorphisms, group automorphisms and to relate groups using these mappings.

Unit	Topics	No. of Hours
I	Group homomorphism and properties, Kernel of a homomorphism and related theorems, Group Isomorphism and properties, The relation of isomorphism in the set of all groups, Cayley's theorem.	15
II	Subgroups, Product of two subgroups, Number of elements in Product of two finite subgroups. Union and Intersection of subgroups, Subgroups generated by a subset of a group, generating system of a group.	15
III	Cosets and its properties, Index of a subgroup, Lagrange's theorem and its applications, Fermat's little theorem, Euler's theorem, Cyclic groups and properties, Generators of a cyclic group, Classification of subgroups of cyclic groups. Fundamental theorem of Cyclic groups.	15
IV	Automorphism of a group, Group of automorphisms of a group, Inner automorphism, Group of automorphisms of finite and infinite cyclic groups, Normal subgroups and their properties, Quotient groups and their properties.	15

Essential/ Recommended Readings:

1. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 2006
2. Joseph A Gallian, Contemporary Abstract Algebra, Brooks/Cole Cengage Learning, 2016
3. David S. Dummit & Richard M. Foote: Abstract Algebra, Wiley, 3rd Edition, 2011
4. J.B. Fraleigh, A First Course in Abstract Algebra, Addison-Wiley, 2003
5. Artin, Michael.(1991).Algebra(2nded.).PearsonEducation.IndianReprint2015.
6. Rotman, Joseph J. (1995). An Introduction to The Theory of Groups (4th ed.). Springer- Verlag, New York.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: MJDSCC-V
Core: **Compulsory**	Course Title: Geometry & Vectors
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The primary objective of this course is to introduce the understanding of the coordinate system. The other objective of this course is to understand the tracing the curves.

Course Outcomes:

- ✓ Identification and tracing of the different conics.
- ✓ Identification of the equation of sphere, finding family of spheres passing through a circle, tangent planes and normal lines to a sphere.
- ✓ Learn to find equation of cone, enveloping cone, cylinder, and enveloping cylinder.
- ✓ Find equation of tangent plane to different conicoid and enveloping cone of a conicoid. Understand the concept of paraboloids and generating lines.

Unit	Topics	No. of Hours
I	Multiple products; Scalar triple products, Vector triple products, Properties of scalar and vector triple products, Differentiation and integration of vectors, Gradient, Divergence and Curl, Green's, Gauss and Stoke's theorem.	20
II	System of Co-ordinates, Distance between two given points, Direction cosines, Relation between the direction cosines. Method for finding the direction cosines of a vector, Projections, Angle between two lines of a vector, The plane, General equation of a plane and related results, The straight line, General form of a straight line and related results.	15
III	Sphere: Plane section of a sphere. Sphere through a given circle. Intersection of two spheres, radical plane of two spheres. Cones: Right circular cone, enveloping cone and reciprocal cone.	15
IV	Cylinder: Right circular cylinder and enveloping cylinder. The Central conicoid, Important properties of the central conicoid in standard form.	10

Essential/ Recommended Readings:

1. Analytical Solid Geometry by Shanti Narayan and P. K. Mittal, S. Chand & Company Ltd. 7th Edition, 2007.
2. A text Book of Analytical Geometry of Three Dimensions, by P.K. Jain and Khaleel Ahmed, Wiley Eastern Ltd., 1999.
3. Co-ordinate Geometry of two and three dimensions by P. Balasubrahmanyam, K.Y. Subrahmanyam, G.R. Venkataraman, Tata-McGraw-Hill, New Delhi, 2010.
4. Robert J. T Bell, An Elementary Treatise on Coordinate Geometry of three dimensions, Macmillan India Ltd., 1923
5. P. R. Vittal, Analytical Geometry 2d&3D, Pearson, 2013
6. S. L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London. 2018
7. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: MJDSCC-VI
Core: **Compulsory**	Course Title: Ordinary differential equations
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objective: An Ordinary Differential Equations (ODE) course equips students to model real-world phenomena mathematically. Objectives focus on solving equations analytically and numerically, understanding theoretical properties like existence and uniqueness, and interpreting how mathematical results reflect physical behavior in science and engineering.

Course Outcomes:

- ✓ Find general solutions to homogeneous and non-homogeneous differential equations.
- ✓ Solve ordinary differential equations under appropriate assumptions.
- ✓ Analyze the system of ordinary differential equations.
- ✓ Evaluate properties of stability for linear and non-linear systems

Unit	Topics	No. of Hours
I	Formation of differential equations, Geometrical meaning of a differential equation, Equation of first order and first degree, Equation in which the variables are separable, Homogeneous equations, Exact differential equations and equations reducible to the exact form, Linear equations.	15
II	First order higher degree equations solvable for x, y, p, Clairaut's equation and singular solutions, orthogonal trajectories, Linear differential equation of order greater than one with constant coefficients, Cauchy- Euler form.	15

III	Second and Higher Order Differential Equations General solution of homogeneous equation of second order, Principle of superposition for a 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, Applications of second order differential equations to mechanical vibrations.	15
IV	Bessel and Legendre functions and their properties, Orthogonal properties, Recurrence formula and generating Function.	15

Essential/ Recommended Readings:

1. Ross, S.L. "*Differential equations*". Wiley Publication, 3rd edition, 2014.
2. Tyn Myint U, Ordinary differential equations, Elsevier North-Holland, 1978
3. Simmons G.F. "Ordinary Differential Equations with Applications". TMH, 2003.
4. Joshi, M.C. "*Ordinary Differential Equations (Modern Perspective)*". Narosa Publishing House, 2006.
5. Wolfgang Walter, Ordinary different Equation, 1998
6. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Two**
Course Code:	Course Type: Minor (MNGEC)
Core: **Elective**	Course Title: **Matrix Theory**
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course objectives: The objective of a Matrix Theory course is to equip students with the mathematical foundations of linear algebra and matrix operations. It focuses on solving linear systems, analyzing linear transformations, and mastering advanced techniques like eigenvalues, eigenvectors, and matrix decompositions used in science, technology, and data analysis.

Course outcomes:

After completing this course, a student will have:

- ✓ Knowledge of matrices, its transpose and conjugate transpose.
- ✓ Knowledge of symmetric, skew-symmetric, Hermitian and skew–Hermitian matrices.
- ✓ Concepts of rank, elementary transformation and inverse of a matrix. Knowledge of vector spaces and sub-spaces.
- ✓ Ability to solve system of linear equations. Knowledge of various types of quadratic forms.

Unit	Topic	No. of Hours
I	Algebra of matrices, transpose, conjugate and conjugate transpose of a matrix with their properties. Symmetric, Skew-symmetric, Hermitian and	15

	Skew–Hermitian matrices with their characteristics and related theorem, associative and distributive laws of matrices, trace of matrix with its properties. Concept of idempotent, Involuntary and Nilpotent matrices, adjoint of a square matrix, Inverse of a matrix and the related theorems.	
II	Concept of rank, rows and column elementary transformations, Inverse theorem of rank through E-transformation. Rank of a product of two matrices, Normal form of a matrix, reduction of matrix to its normal form, elementary matrices and their inverses. Vector and vector–space, Linearly dependent and independent set of vectors with related theorems, Sub-Space of an n-vector space, Basis of a sub space.	15
III	System of linear homogeneous and non-homogeneous equations, Theorem related to linearly independent solutions of linear homogeneous equations. Necessary and sufficient conditions for the consistency of a system of non-homogeneous equations. Characteristic matrix, equation and roots of a square matrix, Caley Hamilton theorem and inverse of a matrix by using this theorem, Unitary and Orthogonal matrices, Inner product of vectors and length of a vector, Orthogonal vectors.	15
IV	Quadratic forms, Congruence of quadratic forms, Canonical form, reduction of quadratic forms into their canonical forms, Elementary congruent transformation, Definite, semi-definite and indefinite quadratic forms, Orthogonal reduction of a real symmetric matrix.	15

Suggested Readings:

1.Narayan, S., A Text Book of Matrices, S. Chand & Co. Ltd., New Delhi. (2010)
2.Bishwas S., A Text Book of Matrix Algebra, Khanna Publications, New Delhi. (2012)
3.Saran, N., Introduction to matrices, Pragati Books Private Limited. (2013)

Programme/ Class: **B.Sc. (Hons.)**	Subject: **Mathematics** MNGEC
Year: **First**	Semester: **Second**
Course Code:	Course Type: Minor (MNGEC)
Core: **Compulsory (Elective)**	Course Title: **Basic Statistics**
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: Ability to understand concepts of collecting Primary and Secondary data. Knowledge of methods for summarizing data sets, including common graphical tools(such as boxplots, histograms etc.). Interpret histograms and boxplots. Ability to describe data with measures of central tendency and measures of dispersion. Ability to understand the concept of probability along with basic laws and axioms ofprobability. Ability to understand the terms mutually exclusive and independence and theirrelevance.

Course Outcomes:

After completing this course, a student will have:

- ✓ Ability to understand concepts of collecting Primary and Secondary data.
- ✓ Knowledge of methods for summarizing data sets, including common graphical tools(such as boxplots, histograms etc.). Interpret histograms and boxplots.
- ✓ Ability to describe data with measures of central tendency and measures ofdispersion.
- ✓ Ability to understand the concept of probability along with basic laws and axioms of probability.
- ✓ Ability to understand the terms mutually exclusive and independence and their relevance.
- ✓ Ability to identify the appropriate method (i.e. union, intersection, conditional, etc.)for solving a problem.
- ✓ Ability to apply basic probability principles to solve real life problems.
- ✓ Ability to understand the concept of random variable (discrete and continuous),concept of probability distribution.
- ✓ Knowledge of the concepts of correlation and simple linear regression and Perform correlation and regression analysis.
- ✓ Ability to interpret results from correlation and regression

Unit	Topic	No. of Hours
I	Primary and Secondary data and their collection, Types of classification: Chronological, Geographic, Qualitative and Quantitative, Construction of frequency distributions, Cumulative frequency distribution. Tabulation of data, preparing a table, Types of tables, Diagrammatic representation of data using various Bar diagrams, Area diagrams, Pie chart, Graphs: Histogram, Frequency Polygon, Frequency curve, Ogive Curve.	15
II	Meaning of Measures of Central Tendency, Characteristics of a good average, Arithmetic mean, Geometric mean, Harmonic mean, Median, Mode, Partition values: Quartiles and Percentiles. Their properties, merits, demerits and applications of the above measures, Weighted Means. Measures of Dispersion: Range, Quartile Deviation, Inter-quartile Range, Mean Deviation, and Standard Deviation, coefficient of variation with their merits, demerits and applications. Concepts of Skewness and Kurtosis.	15
III	Meaning of correlation, Types of correlation, Scatter diagram, Karl-Pearson correlation coefficient with its properties, Spearman's Rank Correlation. Meaning of Regression analysis, Lines of Regression of Y on X and of X on Y, method of Least squares, Fitting of a Straight line and Parabola, properties of Regression lines.	15
IV	Sample space, Equally likely cases, Mutually exclusive cases, independent events, definitions of probability, Addition and Multiplication rules of probability, Conditional probability. Definition of random variables and its probability distributions, Discrete and Continuous random variable functions of a random variable and its calculation.	15

Suggested Readings:

1.K.K. Sharma, Arun Kumar, A. Chaudhary (2006): Statistics in Management Studies, Krishna Publication Media Pvt. Ltd., Meerut.
2. S.C. Gupta (2015): Business Statistics, Sultan Chand & Sons, New Delhi.
3. S.C. Gupta, & V.K. Kapoor (2016): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
4. Hogg, Mckean, Craig (2007): Introduction to Mathematical Statistics, Pearson Education, Inc.
5. George W. Snedecor, William G. Cochran, (1989): Statistical Methods, Iowa State University Press, Ames, Iowa.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: MNGEC
Minor: Minor Generic Elective	Course Title: Ordinary Differential Equations
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objective: An Ordinary Differential Equations (ODE) course equips students to model real-world phenomena mathematically. Objectives focus on solving equations analytically and numerically, understanding theoretical properties like existence and uniqueness, and interpreting how mathematical results reflect physical behavior in science and engineering.

Course Outcomes:

- ✓ Find general solutions to homogeneous and non-homogeneous differential equations.
- ✓ Solve ordinary differential equations under appropriate assumptions.
- ✓ Analyze the system of ordinary differential equations.
- ✓ Evaluate properties of stability for linear and non-linear systems

Unit	Topics	No. of Hours
I	Formation of differential equations, Geometrical meaning of a differential equation, Equation of first order and first degree, Equation in which the variables are separable, Homogeneous equations, Exact differential equations and equations reducible to the exact form, Linear equations.	15
II	First order higher degree equations solvable for x, y, p, Clairaut's equation and singular solutions, orthogonal trajectories, Linear differential equation of order greater than one with constant coefficients, Cauchy- Euler form.	15
III	Second and Higher Order Differential Equations General solution of homogeneous equation of second order, Principle of superposition for a 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	15

	coefficients, Method of variation of parameters, Applications of second order differential equations to mechanical vibrations.	
IV	Bessel and Legendre functions and their properties, Orthogonal properties, recurrence Formula and generating Function.	15

Essential/ Recommended Readings:

1.Ross, S.L. Differential equations. Wiley Publication, 3rd edition, 2014.
2.Tyn Myint U, Ordinary differential equations, Elsevier North-Holland, 1978
3.Simmons G.F. Ordinary Differential Equations with Applications. TMH, 2003.
4.Joshi, M.C. Ordinary Differential Equations (Modern Perspective). Narosa Publishing House, 2006.
5.Wolfgang Walter, Ordinary Different Equation, 1998
6.Suggested digital platform: NPTEL/SWAYAM/MOOCs

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: SEC-II
Core: **Compulsory (Elective)**	Course Title: Mathematica
Credits (in hours per week): 2	1L-0T-1P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

- ✓ Equip students with foundational skills in Mathematica.
- ✓ Provide knowledge of mathematical and graphical tools in Mathematica to analyze and visualize mathematical functions.

Course Outcomes:

- ✓ Gain proficiency in essential Mathematica functions.
- ✓ Utilize the Mathematica notebook interface and basic programming constructs.
- ✓ Perform advanced mathematical operations.
- ✓ Create and customize 2D and 3D plots, histograms, scatter plots, and interactive visualizations.

Unit	Topics	No. of Hours
I	**Getting Started with Mathematica** Wolfram Cloud: Sign-in, usage, mobile app, Introduction to Mathematica, Notebook Interface, Mathematica as a Calculator, Using Built-in Functions, Variables and Functions, Lists, Basic Programming Constructs, Importing and Exporting Data, Manipulating Expressions, Mathematical Operations.	15
II	**Mathematics and Graphics** Mathematical functions, Function Domain and Range, Limits, Differentiation, Maximum and Minimum, Integration. Matrices, Polynomials, Equation Solving, Graphic Data: Creating and customizing histograms, scatter plots, and	15

	bar charts, Basic Plotting: Creating 2D plots, customizing plot appearance, and adding labels and legends, Advanced Plotting Techniques: 3D plotting, parametric plots, and interactive visualizations.

Essential/ Recommended Readings:

- Wellin, P. (2013). Programming with Mathematica: An Introduction (1st ed.). Cambridge University Press.
- Hastings, C., Mischo, K., Michael M. (2015). Hands-on start to Wolfram Mathematica (1st ed.). Champaign: Wolfram Media, Inc.
- Stephen Wolfram (2003). The Mathematica Book, 5th Edition, Wolfram Media, USA.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: VAC-II
Core: **Compulsory (Elective)**	Course Title: Vedic Ankganit
Credits (in hours per week): 2	2L-0T-0P
Internal Assessment: 30%	External Assessment: 70%
VAC II (From MOOCs))	Note: Students have to choose this course from MOOCs

1. **Introduction to Information Technology [2 Credit]:** From MOOCs
2. **Logic and Sets [2 Credit]**

Introduction to Logic and Logical Propositions, Truth Table, Negation, Conjunction and Disjunction, Implications, Biconditional Propositions and Converse and Contra Positive Propositions, Inverse Propositions and Precedence of Logical Operators , Logical Equivalences, Predicates and Quantifiers: Quantifiers, Binding Variables and Negations, Introduction to Sets and Subsets, Set Operations and The Laws of Set Theory, Venn Diagrams, Examples of Finite and Infinite Sets, Finite Sets and Counting Principle, Empty Set, Properties of Empty Set, Standard Set Operations, Classes of Sets, Power Set of a Set, Difference and Symmetric Difference of Two Sets, Set Identities, Generalized Union and Intersections, Relation on Sets, Product Set Composition of Relations , Types of Relations, Partitions of a Set, Equivalence Relations 1, Equivalence Relations 2, Partial Ordering Relations and n –ary Relations.

3. **Effective Decision Making [2 Credit]**

Basics of Decision Making & Problem Solving, Decision making- an Introduction, To understand the concept of decision making. To understand nature of decision making. To understand characteristics of decision making. To understand various types of decisions. To understand the various factors affecting decision making. To understand the various theories of decision making. Background Decision making.

4. **Human Growth and Development [2 Credit]** Concepts and Theories of Human Development, Meaning, Definition & Principles of Growth Development, Development periods in human life span (Prenatal development, Infancy, Childhood, Adolescence, Adulthood), Heredity and environment on development, Domains of Human Growth and Development, Theories of Erikson, Piaget & Kohlberg, Social Learning Theory (Albert Bandura), Ecological Theory (Bronfrenbrenner), Holistic Theory of Development (Steiner), Meaning & Definition of Personality, Theories of Personality, Pre-natal Development – Conception, Pre-natal Development & Birth, Sensation, Sensation: Definition and Sensory Process, Attention: Definition and Affecting Factors, Perception: Definition and Types, Memory, Thinking, and Problem Solving, Physical and Emotional Growth and Development, Emerging capabilities across domains related to cognition - metacognition, creativity, ethics, Issues related to puberty, Gender Stereotyping Morality & Development, Influence of Development on the growing child, Psychological well-being, Formation of Identity and Self-Concept, Concept of Diversity and Type of Diversity, Diversity in Learning & Delivering the Diverse Learning Needs, Independent Living Skills – Meaning, Importance, Component, Transition to Adulthood – Sexuality, Marriage and Employment.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: AEC-II
Core: **Compulsory**	Course Title: From Pool of the courses
Credits (in hours per week): 2	2L-0T-0P
Assessment	Internal + External
AEC-II	Note: Students have to choose this course from the Pool of Courses offered by the University

Semester-III

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Third**
Course Code:	Course Type: MJDSCC-VII
Core: **Compulsory**	Course Title: Ring Theory-I
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

- ✓ **Course Objectives:** Ring Theory-I is to understand rings, integral domains, fields, and their fundamental properties. To study divisibility, polynomial rings, and algorithms for polynomials over fields. To learn ring homomorphisms, isomorphisms, kernels, and related theorems. To examine ideals, quotient rings, Euclidean rings, and their algebraic properties.

Course Outcomes:

This course will enable the students to:

- ✓ Understand rings and its types, subrings, subfields, ideals, quotient rings, and their properties in detail.
- ✓ Differentiate among integral domains, fields, and division rings (or skew fields).Understand and utilize quotient rings (residue class rings)
- ✓ Recognize and utilize maximal ideals, prime ideals, Principal ideals, Euclidean rings, the ring of Gaussian integers, and their properties.
- ✓ Know about ring homomorphisms, ring isomorphisms, ring endomorphisms and to relate ring using these mappings.

Unit	Topics	No. of Hours
I	Rings, Elementary properties of Ring, Ring with or without zero divisors, Integral domains and field, Division ring or skew field, The ring of Gaussian integers, Subrings, Subfields, Characteristic of a ring.	15
II	Divisibility in an integral domain, Units and associates, Irreducible elements and GCD, Polynomial rings over an Integral domain, Polynomials rings over a Field, Division algorithm for polynomials over a field, Euclidean algorithm for polynomials over a field.	15
III	Rings of endomorphisms of an abelian group, Ring homomorphism, Ring Isomorphism, Kernel of a ring homomorphism and related theorems, Fundamental theorem on homomorphism of rings.	15
IV	Ideals, Principal ideal, Principal ideal ring and properties, Prime ideal and properties, Maximal Ideals and properties, Quotient rings or residue class rings. Euclidean rings and properties.	15

Essential/ Recommended Readings:

1. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 2006.
2. Joseph A Gallian, Contemporary Abstract Algebra, Brooks/ Cole Cengage Learning, 2016.
3. David S. Dummit & Richard M. Foote: Abstract Algebra, Wiley, 3rd Edition, 2011.
4. Hungerford, Thomas W. (2012). Abstract Algebra: An Introduction (3rd ed.). Cengage Learning.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Third**
Course Code:	Course Type: MJDSCC-VIII
Core: **Compulsory**	Course Title: Integral Calculus
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The primary objective of an Integral Calculus course is to master the concept of the definite integral as the limit of a Riemann sum, develop proficiency in calculating both definite and indefinite integrals, and apply these tools to solve real-world problems involving areas, volumes, work, and physical phenomena

Course Outcomes:

- ✓ Evaluate indefinite and definite integrals and reduction.
- ✓ Learn to apply definite integrals. Understand the Beta and Gamma functions, their properties, and applications.
- ✓ Apply definite integral to find arc length, volumes of solids with different methods.
- ✓ Familiarize with the concept of multiple integrals, their evaluation and applications.

Unit	Topics	No. of Hours
I	**Reduction Formulae** Reduction formulae for Trigonometric functions, Reduction formulae for Algebraic functions and Reduction formulae for transcendental functions, Numerical Examples.	15
II	**Beta and Gamma Functions** Beta function, Definition, Properties of Beta functions, another form of Beta function, Transformations of Beta function, Gamma Function, Properties of Gamma functions, Transformations of gamma function, Relation between Beta and Gamma, Duplication formula, Numerical Examples.	15
III	**Multiple Integrals** Double Integrals, Properties of a double integra, Evaluation of Double integrals, Double integral in polar coordinates, Triple integral, Evaluation of Triple integral, Change of the order of Integration, Change of variables in double integral, Dirichlet's integral and Liouville's integral; Dirichlet's theorem for three variables and n variables, Liouville's Extension of	15

	Dirichlet's Theorem.	
IV	**Area, Surface Area and Volumes** Area of Curves given by cartesian equations and polar equations, rectification, length of curves in cartesian, parametric and polar forms, Surface area of curves, Revolution about the axis of x and axis of y and curve is in polar coordinates, and Volumes of solids of revolution rotation being x-axis and rotation being y-axis, and curve is given polar coordinates.	15

Essential/ Recommended Readings:

1. Gorakh Prasad, Integral Calculus, Benares Mathematical Society, Publication, 2015
2. R.G. Bartle & D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, 2011
3. H. Anton, I. Birens and S. Davis, Calculus, John Wiley & Sons, Inc., 2002.
4. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2007.
5. Shanti Narayan & Dr. P.K. Mittal Integral Calculus, S. Chand., 2016
6. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2011
7. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning.
8. Frank Ayres, Jr. & Elliott Menselson, Differential and Integral Calculus, Schaum's Outlines, 1990
9. Suggested digital platform: NPTEL/SWAYAM/MOOCS.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Third**
Course Code:	Course Type: MJDSCC-IX
Core: **Compulsory**	Course Title: Discrete Mathematics
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The primary objective of Discrete Mathematics is to build a foundational framework for computational and algorithmic thinking. It equips students with the logical reasoning and mathematical tools necessary to model real-world scenarios, write precise formal proofs, and solve complex problems in computer science and engineering

Course Outcomes:

After completing this course, a student will have the knowledge:

- ✓ of the basic concepts of discrete mathematics used in computer science and other disciplines that involve formal reasoning. The topics include logic, counting, relations, Hasse diagram and Boolean algebra.
- ✓ in mathematical reasoning, combinatorial analysis, discrete structures and applications of lattice theory and Boolean algebra with their properties and applications.
- ✓ of design of circuits, logic gates, Karnaugh maps and skills to proof by using truth tables.
- ✓ to apply the basics of the automation theory, transition function and table.

I	**Propositional Logic-** Proposition logic, Basic logic, Logical connectives, truth tables, Tautologies, contradiction, modus ponens and modus tollens, validity, predicate logic, universal and existential quantification, proof by implication, converse, inverse contrapositive, contradiction, direct proof by using truth table.	15
II	**Relation-** Definition, types of relation, domain and range of a relation, pictorial representation of relation, properties of relation, partial ordering relation, representation of POSETS using Hasse diagram, chains, maximal and minimal point, greatest lower bound, least upper bound, Lattices and algebraic system, basic properties, sublattices.	15
III	**Boolean Algebra-** Basic definitions and examples, Sub algebra, Boolean functions, Disjunctive normal form, Complete disjunctive normal form, conjunctive normal form, logic circuits, logic networks, design of circuits from given properties, logic gates, and Karnaugh maps.	15
IV	**Combinatorics-** Inclusion- exclusion, recurrence relations (nth order recurrence relation with constant coefficients, Homogeneous recurrence relations, Inhomogeneous recurrence relations), generating function (G.F.) (closed form expression, properties of G.F., solution of recurrence relations using G.F., solution of combinatorial problem using G.F.	15

Essential/ Recommended Readings:

1. C. L. Liu (1986): Discrete Mathematics, Tata McGraw Hill,

2. Trembley and Manohar (2008): Discrete Mathematics with computer application, Tata McGraw Hill.

3. Kenneth H. Rosen (2012): Discrete Mathematics and Its Applications, McGraw-Hill.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Third**
Course Code:	Course Type: MJDSEC-I
Core: **Elective**	Course Title: Elementary Number Theory & Cryptography
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The objective of Elementary Number Theory & Cryptography is to bridge foundational mathematical concepts with modern digital security. It teaches students the properties of integers, divisibility, and prime numbers to design, analyze, and secure cryptographic algorithms like RSA.

Course Outcomes:

This course will enable the students to:

- ✓ have hands-on easy and interesting mathematical concepts and their use cases.
- ✓ develop problem solving skills using mathematical concepts.

✓ relate mathematics with day-to-day applications in digital world
✓ learn basic text hiding techniques.
✓ know the utility of mathematics and foster interest in it.

Unit	Topics	No. of Hours
I	Natural numbers, primes, Composites, integers, factorization, Binary, decimal, and ternary representation of integers. Greatest common divisors (GCD), Least common multiple (LCM), Relation between GCD and LCM, Simple questions including word problems.	15
II	Divisibility, Division algorithm, Euclidean algorithm, modular arithmetic, congruence and its properties, Simple questions including word problems.	15
III	Introduction to cryptography, History of cryptography, Cryptographic goals, XoR function, Hash function, Elementary idea of symmetric key cryptography (SKC) and public key cryptography (PKC), Merits, demerits of SKC and PKC, difference between SKC and PKC.	15
IV	Elementary idea of classical ciphers: Substitution and transposition ciphers, Monoalphabetic and polyalphabetic ciphers, Stream ciphers and block ciphers. From Caesar cipher to public key cryptography, Elementary idea of RSA cryptosystem.	15

Essential/ Recommended Readings:

1. David M. Burton: Elementary Number Theory, McGraw Hill Education; 7 ed., 2017.
2. William Stallings, Cryptography and Network Security: Principles and Practices, Pearson; 6th Edition, 2013.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Third**
Course Code:	Course Type: MJDSEC-I
Core: **Elective**	Course Title: Integral Transform
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The primary objective of the Integral Transforms course is to teach students how to convert complex mathematical problems from the time or spatial domains into simpler algebraic forms. This equips learners with advanced techniques to solve ordinary differential equations (ODEs), partial differential equations (PDEs), and real-world boundary value problems.

Course Outcomes:

✓ Understand the foundation of Laplace Transforms including Laplace transforms of derivatives and
integrals.

- ✓ Idea of inverse Laplace transform and its properties. Identify and apply Laplace transforms to solve ODE and PDE.
- ✓ Familiarization with Fourier series, its convergence, properties and its applications.
- ✓ Understand the basic idea of Fourier Transforms including Fourier transforms of derivatives and integrals.

Unit	Topics	No. of Hours
I	Integral Transform, Laplace transforms, Linearity property of Laplace transform, Functions of Exponential order, Laplace transform using Shifting theorems, Laplace transform of derivatives and integrals, Initial Value theorems, Laplace transform of periodic functions, Heaviside unit step function and Dirac delta function.	15
II	Inverse Laplace transforms and their properties, Null functions, shifting theorems, change of scale property, Inverse Laplace transform of derivatives and integrals, Multiplication and division by powers of p, Heaviside expansion theorem, Convolution, Convolution theorem, The Complex Inversion formula.	15
III	Fourier series, Fourier Integral formula, Fourier transform, Inversion Theorem for Complex Fourier transform, Fourier sine and cosine transform, Inversion formula for sine and cosine Fourier transform, Trigonometric Fourier Series and its convergence, Fourier series of even and odd functions, Fourier half-range series, Multiple Fourier Transform, Modulation Theorem, Parseval's identity, Complex form of Fourier series.	15
IV	Finite Fourier Transforms, Finite Fourier sine and cosine transform, Inversion formula for finite Fourier sine and cosine transform, Multiple finite Fourier transforms, Operational properties of finite Fourier transform, Fourier sine and cosine transform, Combined Properties of finite Fourier sine and cosine transform, Convolution.,	15

Essential/ Recommended Readings:

1. E. Kreyszig. Advance Engineering Mathematics, John Wiley & Sons. 2011.
2. R.K. Jain and S.R.K. lyenger, Advanced Engineering Mathematics, Narosa Publishing House, 2009.
3. F. B. Hildebrand, Methods of Applied Mathematics, Courier Dover Publication, 1992.
4. L. Debanth and D. Bhatta, Integral Transforms and their Applications. 2nd Ed. Taylor and Francis Group, 2007.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCS.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Third**
Course Code:	Course Type: MJDSEC-I
Core: **Elective**	Course Title: Introduction to Fuzzy Sets
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

The aim is to equip students with some state-of-the-art fuzzy-logic technology to prepare them in a better way for the rapidly evolving high-tech information-based modern industry and market.

Course outcomes:

- ✓ This theory helps to solve those problems which are described in linguistic terms.
- ✓ This theory provides an excellent tool to handle the vagueness in modern science and technology problems such as computer science, economics and medical science.
- ✓ This theory can be used to make modern systems based on Artificial Intelligence (A.I) and soft computing.
- ✓ On the basis of this theory many real-life based problems can be solved such as robotics, management etc.

Unit	Topic	No. of Hours
I	Introduction: Basics concepts on crisp sets, Fuzzy sets, Representation methods of Fuzzy set, Examples of Fuzzy sets, $\alpha - Cut$ of a fuzzy set, Strong $\alpha - Cut$ of a fuzzy set, Level set, Properties of $\alpha - Cut$ and strong $\alpha - Cut$ of a fuzzy set, The support of a fuzzy sets, Core of a fuzzy set, Height of a fuzzy set, Normal fuzzy set, subnormal fuzzy set, Normalization of fuzzy sets.	15
II	Standard operations of fuzzy sets, The Magnitude of Fuzzy set, Subset of a fuzzy set, Properties of fuzzy sets, Fuzzy point, Subset hood degree of a fuzzy set in another fuzzy set, Hamming distance, Non-specificity of Crisp sets, Non-specificity of fuzzy sets, Fuzziness of fuzzy sets, construction of fuzzy sets.	15
III	Interval Arithmetic: Interval numbers, Classification of intervals, Arithmetic operations on intervals, Fuzzy numbers, Triangular fuzzy Number, Trapezoidal Fuzzy Number, Arithmetic operations of fuzzy number, Interval Fuzzy Arithmetic, Fuzzy Equations.	15
IV	Fuzzy Relations: Introduction to Fuzzy relation, Binary Fuzzy Relation, domain, range and height of a binary fuzzy relation, Inverse of a binary fuzzy relation, Max-Min composition of a binary fuzzy relation, Relational Join, Fuzzy equivalence Relations, Fuzzy Partial Order relations.	15

Suggested Readings:

1. Dubosis Didler and Prade, Henri, Fuzzy Sets and systems Theory and Applications, Academic Press, New York, 1980

2. Klir. Georage. J and Yuan Bo, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India, New Delhi. 2009
3. Lee, Kwang H., First Course on Fuzzy Theory and Applications, Springer International Edition, 2009.
4. Ross, Timothy J., Fuzzy Logic with Engineering Applications, McGraw Hills inc., 2004 New Delhi
5. Roger, Jyh-Shing; Sun, Chuen-Tsai; Mizutani, Eiji, Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, *MATLAB curriculum series,* illustrated, reprint, Prentice Hall, 1997
6. Zimmermann, H.J. Fuzzy Set Theory & its Applications, Allied Publishers Ltd. New Delhi, 2006

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Third**
Course Code:	Course Type: Minor (MNGEC) III
Core: **Elective**	Course Title: **Real Analysis**
Credits (in hours per week): 4	3L-1T-0P
Assessment	

Course Objectives: Real Analysis courses provide a rigorous foundation for calculus by exploring the theoretical underpinnings of limits, continuity, differentiability, and integration. The primary objectives are to transition students from computational math to theoretical proofs, and to build a deep, axiomatic understanding of the real number system.

Course Outcomes:

After completing this course, a student will have:

- ✓ Knowledge of functions, limits with their properties.
- ✓ Ability to analyze the nature of functions.
- ✓ Knowledge of continuity and differentiability with its types. Ability to deal with double and multiple integrals.
- ✓ Knowledge of Laplace transforms. Ability to solve various types of system of differential equations.

Unit	Topic	No. of Hours
I	Introduction of Function, definition, type of functions, composition of functions and invertible function, binary operations, odd and even functions, bounded and unbounded functions, monotonic functions. Limit of a function, one side limit-right hand and left-hand limits, Continuous functions, discontinuity of a function, kinds of continuity, uniform continuity, theorems on continuity.	15

II	Differentiability: definition, meaning of sign of derivative, Rolle's theorem, geometrical interpretation of Rolle's theorem. Lagrange's mean value theorem, Taylor's theorem for expansion of functions with various forms of remainder. Maxima and minima, indeterminate forms, Jacobians.	15
III	Beta and gamma functions. Double and multiple integrals, change of order of integration, Dirichlet's theorem and its Liouville's extension.	15
IV	Laplace transforms and its properties such as additive property, derivative property, limit property, convolution property etc. Inverse Laplace-transform and its properties, Laplace-Stieltjes transform, Mean, Variance and moments by using Laplace transforms. Laplace transforms solution of simple differential equations.	15

Suggested Readings:

Shanti Narayan and M.D. Raisinghania: Elements of Real Analysis. S. Chand, 2023.
Shanti Narayan: A course of mathematical analysis. S. Chand, 2021.
Rudin, W.: Principles of mathematical analysis, McGraw Hills, 2023.
Richardson, C.H.: An Introduction to calculus of finite differences, New York, Van Nostrand, 1954.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Third**
Course Code:	Course Type: Sec-III
Core: **Compulsory (Elective)**	Course Title: MATLAB for Beginners
Credits (in hours per week):2	1L-0T-1P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

- Equip students with foundational knowledge of MATLAB.
- Enhance Proficiency in Programming and Mathematical Visualization.

Course Outcomes:

- ✓ Gain proficiency in MATLAB Interface and Functions.
- ✓ Apply MATLAB for advanced mathematical operations.
- ✓ Achieve expertise in designing and customizing a variety of graphical data representations.

Unit	Topics	No. of Hours
I	**Getting Started with MATLAB** Introduction to MATLAB: Windows, Input & Output, Built-in Functions, Computations, External Interface and Tool boxes, Platform dependence, File Types, General Commands, Printing.	15

	Programming in MATLAB: Creating and working with arrays, Creating and printing simple plots, Scripts and functions, Script files, Executing of function, Working with arrays and matrices, Importing and Exporting Data, Files and Directories.	
II	**Mathematics and Graphics** Mathematical operations, Function properties: domains and ranges, Limit calculations, Differentiation, Finding maxima and minima, Integration. Matrix operations, Polynomial computations, Solving equations. Data visualization: designing and customizing histograms, scatter plots, and bar charts. Fundamental plotting: generating 2D plots, modifying appearance, adding labels and legends. Advanced visualization: creating 3D plots, parametric plotting, interactive visualizations.	15

Essential/ Recommended Readings:

- Gilat, A. (2014). MATLAB: An introduction with Applications (5th ed.). John Wiley & Sons.
- Pratap, R. (2009). Getting started with MATLAB: A quick introduction for scientists and engineers. Oxford University Press, Inc.
- Patel, R. N., & Mittal, A. (2014). Programming in MATLAB®: A Problem-solving Approach. Pearson India.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: First	**Semester: Second**
Course Code:	Course Type: AEC-III
Core: **Compulsory**	Course Title: From the Pool of courses
Credits (in hours per week): 2	2L-0T-0P
Internal Assessment: 30%	External Assessment: 70%
AEC-III	Note: Students have to choose a course from the Pool of courses offered by the University

Semester: IV

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Fourth**
Course Code:	Course Type: MJDSCC-X
Core: **Compulsory**	Course Title: Analysis-II
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The course objective of Analysis-II is to transition students from foundational single-variable calculus to advanced, rigorous mathematical analysis. It focuses on mastering multivariable calculus, infinite series, and Riemann integration while developing the ability to construct formal mathematical proofs

Course Outcomes:

After completing this course, a student will:

- ✓ acquire a thorough understanding of fundamental concepts in Riemann integration, such as partitions, Riemann sums, and the interpretation of integrals as areas under curves.
- ✓ thebe able to apply techniques for evaluating Riemann integrals, including the use of anti-derivatives and the Fundamental Theorems of Calculus, to solve integration problems.
- ✓ develop the ability to distinguish between two types of improper integrals and determine their convergence or divergence using appropriate techniques.
- ✓ have the knowledge of functions of bounded variation with their properties.

Unit	Topics	No. of Hours
I	Riemann integration: Partitions of closed and bounded interval, refinement of partitions, Darboux integral, basic properties of upper and lower sums, definition of Riemann integration, necessary and sufficient condition for Riemann integrability, examples, Riemann sum, definition of Riemann integration as a limit of sum and equivalence of two definitions, Riemann integrability of monotone and continuous functions, properties of Riemann integration.	15
II	Fundamental theorems: Definitions of piecewise continuous and piecewise monotone functions and their Riemann integrability, intermediate value theorem for integrals, Fundamental theorems of calculus, Mean value theorem of integral calculus, integration by parts, change of variable in an integral, average value of a function.	15
III	Improper integrals: Definition of improper integrals, improper integrals over an unbounded interval, improper integrals of unbounded functions, convergence of Beta and Gamma functions, comparison tests, general test for convergence, absolute convergence.	15

IV	Functions of bounded variation: Definition and examples, total variation, additive property of total variation, total variation on [a, x] as a function of x, functions of bounded variation expressed as the difference of increasing functions, continuous functions of bounded variation, curves and paths, rectifiable paths and arc length, additive and continuity properties of arc length, equivalence of paths, change of parameter.	15

Essential/Recommended Readings:

1. S. C. Malik, S. Arora (2018): Mathematical Analysis, New Age Publications.
2. R. G. Bartle, D. R. Sherbert (2015): Introduction to Real Analysis (4th ed.). Wiley India Edition. New Delhi.
3. T. M. Apostol (1985): Mathematical Analysis, Narosa Publishing, New Delhi.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Fourth**
Course Code:	Course Type: MJDSCC-XI
Core: **Compulsory**	Course Title: Mechanics-I
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

- To develop a systematic understanding of the statics of particles and rigid bodies using vector and analytical methods in two and three dimensions.
- To introduce the principles of equilibrium, moments, couples, virtual work, and friction for the analysis of mechanical systems and constrained bodies.
- To study the concepts of centre of gravity and stability of equilibrium using potential energy and work-based criteria.
- To familiarize students with flexible strings and chains, rotating frames of reference, and apparent forces, thereby providing a smooth conceptual transition from statics to dynamics.
- To enhance analytical reasoning and problem-solving skills through the application of fundamental principles of mechanics to standard physical and engineering systems.

Course Outcomes: On successful completion of the course, students will be able to

- ✓ Explain the fundamental concepts of mechanics including force, moment, couple, equilibrium, and constraints for particles and rigid bodies in two and three dimensions.
- ✓ Apply the conditions of equilibrium to analyse coplanar and concurrent force systems involving particles, strings, pulleys, and constrained rigid bodies.
- ✓ Analyse rigid body systems using moments, couples, reduction of force systems, and centre of gravity to determine equilibrium configurations. Use the principle of virtual work and laws of friction to solve equilibrium problems involving inclined planes, ladders, strings, rods,

and rigid bodies.

- ✓ Evaluate the stability of equilibrium of mechanical systems using potential energy methods and work function tests. Explain the behaviour of flexible strings and chains, including the catenary, and apply elementary concepts of rotating frames and apparent forces in mechanical systems.
- ✓ Integrate concepts of statics, equilibrium, and rotating frames to develop a foundational understanding for the study of dynamics and advanced mechanics.

Unit	Topics	No. of Hours
I	**STATICS OF A PARTICLE – FORCE SYSTEMS** Introduction to mechanics; Force: definition, representation, and line of action; Composition and resolution of forces; Parallelogram law of forces; Resultant of coplanar forces; Equilibrium of a particle under coplanar forces; Forces in three dimensions: Equilibrium of a particle under concurrent forces in three dimensions; Simple applications including hanging bodies, strings, and pulleys.	15
II	**STATICS OF RIGID BODIES – FORCE SYSTEMS** Rigid body: definition and constraints; Moment of a force about a point and an axis; Varignon's theorem; Couple and its properties; Reduction of a force system to force-couple system; Invariance of a force system; Equilibrium of rigid bodies, Bodies with one fixed point and two fixed points; Centre of gravity of discrete bodies, continuous bodies and composite bodies.	15
III	**VIRTUAL WORK, FRICTION AND STABILITY OF EQUILIBRIUM** Virtual Work: Virtual displacement; Principle of virtual work; Applications to smooth inclined plane, coplanar force systems, strings and rods, rigid body equilibrium with one point fixed and two bodies in contact with smooth surfaces. Friction: limiting friction, angle of friction, and cone of friction; Applications to ladder problems and a block on a rough plane. Stability of equilibrium: stable, unstable, and neutral equilibrium; Potential energy test for stability; Work function test for stability; Simple applications.	15
IV	**ADVANCED STATICS AND TRANSITION TO DYNAMICS** Flexible strings and chains: Uniform string under gravity, Catenary (basic derivation and properties only); Frames of reference: Inertial and non-inertial frames; Rotating frame and angular velocity of the frame (elementary); Transformation of velocity and acceleration in rotating frames; Centrifugal and Coriolis forces; Modified Newton's second law in a rotating frame; Simple applications (motion on a rotating platform, motion relative to the Earth).	15

Essential/ Recommended Readings:

1. Singh, S. (2013): Engineering Mechanics. Khanna Publishers.
2. Synge, J. L., & Griffith, B. A. (2017): *Principles of Mechanics* (3rd ed.). McGraw-Hill Education, Indian Reprint.
3. Meriam, J. L., Kraige, L. G. and Bolton, J. N. (2020): *Engineering Mechanics: Statics* (9th ed.), Wiley.
4. Shames, Irving H., & Rao, G. Krishna Mohan (2009): *Engineering Mechanics: Statics and Dynamics* (4th ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
5. Ramsey, A. S. (1985): *Statics* (2nd ed.), Cambridge University Press.
6. Hibbeler, R. C. (2016): *Engineering Mechanics: Statics & Dynamics* (14th ed.), Pearson Prentice Hall (Pearson Education), New Jersey.
7. Rana, N. C. and Joag, P. S. (2017) *Classical Mechanics*, McGraw Hill Education (India).
8. Rajasekaran S. and Sankarasubramanian G. (2011): Engineering Mechanics: Statics and Dynamics. Vikas Publishing House.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Fourth**
Course Code:	Course Type: MJDSCC-XII
Core: **Compulsory**	Course Title: Numerical Analysis
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: he primary objective of Numerical Analysis is to equip students with mathematical and computational tools to find **approximate but highly accurate solutions** to complex problems where exact analytical solutions do not exist or are too difficult to compute.

Course Outcomes:

- ✓ Employ the concept of errors and apply various numerical methods to find the roots of non-linear equations and solution of system of equations.
- ✓ Solve differentiation and integration for complex functions and apply interpolation formulas to find approximate polynomials and missing values.
- ✓ Solve ordinary differential equations using different numerical methods.
- ✓ Solve system of linear and nonlinear equations by numerical methods.

Unit	Topics	No. of Hours
I	**Interpolation:** Error, Finite Difference Operator, Newton's Forward and Backward Interpolation, Lagrange's Interpolation, Newton's Divided Difference Interpolation, Inverse Interpolation. Derivatives from Difference Tables, Higher Order Derivatives, Newton – Cotes quadrature formula, Trapezoidal Rule, Simpson's 1/3 and 3/8 Rule, Boole's Rule, Weddle's Rule, Romberg's Method.	15

II	**Solution of Transcendental Equations:** Bisection Method, False Position Method, Method of Iteration, Newton-Raphson Method, Secant Method, Rate and Order of Convergence of Iterative Methods, Existence of the Solution of Iterative Methods.	15
III	**Solution of System of Linear and Non-linear Equations:** Pivoting, Gauss Elimination Method, Gauss-Jacobi Method, Gauss – Seidel Method, Computation of Eigen Values of a Matrix by Power Method, Inverse Power Method, Scaled Power Method, Newton's Method for Non-linear Equations.	15
IV	**Numerical solution to Ordinary Differential Equations:** Picard's Method, Tayler's Method, Euler Method and Modified Euler Method, Runge-Kutta Method, Milne's Method.	15

Essential/ Recommended Readings:

1. Jain, M. K. (1997): Numerical Solution of Differential Equations, John Wiley.
2. Gerald, C. F. and Wheatly P. O. (2002): Applied Numerical Analysis, 6th Ed., Addison-Wesley Publishing.
3. Balagurusamy, E. (1999): Numerical Methods, Tata McGraw Hill Publication.
4. Bradie, B. (2006): A Friendly Introduction to Numerical Analysis. Pearson Education, India, Dorling Kindersley (India) Pvt. Ltd. Third impression 2011.
5. Sastry, S.S. (2012): Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Fourth**
Course Code:	Course Type: MJDSEC-II
Core: **Elective**	Course Title: Linear Programming and Applications
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The primary course objective of **Linear Programming and Applications** is to equip students with the mathematical and computational skills required to formulate and solve complex optimization problems. It teaches how to maximize or minimize a linear objective function subject to defined constraints to achieve optimal resource allocation.

Course Outcomes:

- ✓ Learn about the basic feasible solutions of linear programming problems.
- ✓ Understand the theory of the Simplex method to solve linear programming problems. Learn about the relationship between the primal and dual problems.
- ✓ Solve transportation and assignment problems.
- ✓ Understand two-person zero sum game, game with mixed strategies and formulation of game to primal and dual linear programming problems to solve using duality.

Unit	**Topics**	**No. of Hours**

I	**Introduction to Linear Programming** Linear programming problem: Standard, Canonical and matrix forms, Geometric solution; Convex and polyhedral sets, Hyperplanes, Extreme points; Basic solutions, Basic feasible solutions, Reduction of feasible solution to a basic feasible solution, Correspondence between basic feasible solutions and extreme points.	15
II	**Optimality of Linear Programming Problem** Simplex method: Optimal solution, Termination criteria for optimal solution of the linear programming problem, Unique and alternate optimal solutions, Unboundedness; Simplex, Algorithm and its tableau format; Artificial Variables, Two Phase method, Big-M method.	15
III	**Duality Theory of Linear Programming and Game Theory** Motivation and formulation of dual problem, Primal-Dual relationships, Fundamental theorem of duality, Complimentary slackness, Game Theory, two-person zero sum game, Game with mixed strategies, Formulation of game to primal and dual linear programming problems, Solution of game using duality.	15
IV	**Applications: Transportation and Assignment Problem** Necessity of transportation Problem, Definition and formulation, Methods of finding initial basic feasible solutions, Northwest-corner rule. Least- cost method; Vogel's approximation method, Algorithm for solving transportation problem, Necessity of assignment problem, Introduction to Assignment Problem, Mathematical formulation of Assignment problems. Hungarian method of solving Assignment Problems.	15

Essential/ Recommended Readings:

1. Bazaraa, Mokhtar S., Jarvis, John J., and Sherali, Hanif D. (2010). Linear Programming and Network Flows (4th ed.). John Wiley and Sons.
2. Hadley, G. (1997). Linear Programming, Narosa Publishing House, New Delhi
3. Taha, Hamdy A. (2010). Operations Research: An Introduction (9th ed.), Pearson.
4. Hillier, Frederick S. and Lieberman, Gerald J. (2021). Introduction to Operations Research (11th ed.), McGraw-Hill Education (India) Pvt. Ltd.
5. Thie, Paul R., & Keough, G. E. (2014). An Introduction to Linear Programming and Game Theory, (3rd ed.), Wiley India Pvt. Ltd.
5. Suggested digital platform: NPTEL/SWAYAM/MOOCs

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: **Mathematics**
Year: Second	Semester: **Fourth**
Course Code:	Course Type: MJDSEC-II
Core: Elective	Course Title: Biomathematics
Credits (in hours per week): 4	3L-1T-0P

AKBm.

Internal Assessment: 30%	External Assessment: 70%
Credits: 04	Core:

Course Objectives

The objectives of this course are:

1. Develop and analyse the models of the biological phenomenon with emphasis on population growth and predator-prey models.
2. Interpret first-order autonomous systems of nonlinear differential equations using the Poincaré phase plane.
3. Apply the basic concepts of probability to understand molecular evolution and genetics.

Course Outcomes:

- ✓ Get a better comprehension of mathematical models, utilized in biology.
- ✓ To identify and explain the findings from models of population studies, species communication, adaptation, and dynamics of disorder.
- ✓ Create a basic model of molecular evolution by making use of probability and matrices.

Core:	Topics	No. of Hours
I	Formulation a model through data, A continuous population growth model, Long-term behavior and equilibrium states, The Verhulst model for discrete population growth, Administration of drugs, Differential equation of chemical process and predator-prey model (Function response: Types I, II and III).	15
II	Introduction to infectious disease, The SIS, SIR and SEIR models of the spread of an epidemic, Analyzing equilibrium states, Phase plane analysis, Stability of equilibrium points.	15
III	Classifying the equilibrium state; Local stability, Limit cycles, Poincaré-Bendixson theorem, Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation and period-doubling.	15
IV	Chaos, Stability of limit cycles, Introduction of the Poincaré plane; Modeling molecular evolution: Matrix models of base substitutions for DNA sequences, Jukes-Cantor and Kimura models, Phylogenetic distances.	15

Suggested Readings:

1. Robeva, Raina S., et al. (2008). An Invitation to Biomathematics. Academic press.
2. Jones, D. S., Plank, M. J., & Sleeman, B. D. (2009). Differential Equations and Mathematical Biology (2nd ed.). CRC Press, Taylor & Francis Group.
3. Allman, Elizabeth S., & Rhodes, John A. (2004). Mathematical Models in Biology: An Introduction. Cambridge University Press.
4. Linda J. S. Allen (2007). An Introduction to Mathematical Biology. Pearson Education.
5. Murray, J. D. (2002). Mathematical Biology: An Introduction (3rd ed.). Springer.
6. Shonkwiler, Ronald W., & Herod, James. (2009). Mathematical Biology: An Introduction with Maple and MATLAB (2nd ed.). Springer.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: **Mathematics**
Year: Second	Semester: **Fourth**
Course Code:	Course Type: MJDSEC-II
Core: Elective	Course Title: Mathematical Data Science
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

To provide a comprehensive understanding of the data science lifecycle, from data procurement to exploratory analysis. To develop a solid mathematical foundation in probability, linear algebra, and distance metrics essential for data analysis. To introduce fundamental optimization techniques and their application in solving data science problems. To equip students with the skills to implement essential regression, dimensionality reduction, clustering, and classification algorithms.

Course Outcomes:

Upon successful completion of the course, the student will:

- ✓ Be able to identify and classify various data types and apply appropriate preprocessing techniques to clean and prepare the dirty data.
- ✓ Demonstrate a working knowledge of statistical and mathematical measures, including distance metrics and probability foundations, to analyze data characteristics.
- ✓ Be able to apply optimization methods like gradient descent to solve regression problems and evaluate model accuracy using cross-validation.
- ✓ Implement dimensionality reduction techniques, specifically PCA, to simplify and extract meaningful information from high-dimensional datasets.
- ✓ Select and apply appropriate clustering and classification algorithms to solve real-world pattern recognition tasks.

Unit	Topic	No. of Hours
I	What is Data, Types of Data: Nominal, Ordinal, Interval, Ratio, Structured, and Unstructured, Steps in Data Science Case-study: Question, Procurement, Exploration, Modeling and Presentation, Scale and Source of Data, Problems with Data: Dirty and Missing Data in Tabular Formats, Anomaly Detection, Data Quality, Rectification and Creation Methods, Data Hygiene.	15
II	Probability foundations, Random Variables, Expectation, Variance, Sampling, Norms in Vector Spaces: Euclidean, and metric choices, Types of Distances: Manhattan, Hamming, Mahalanobis, Cosine and angular distances.	15
III	Linear Regression: Simple, Multiple Explanatory Variables, Cross-Validation, Gradient Descent, Problem of Dimensionality: Dimensionality Reduction, Principal Component Analysis (PCA), geometric interpretation of PCA, calculation of principal components.	15

IV	Clustering, Partitional Clustering, k-means Clustering, Lloyd's algorithm, Hierarchical Clustering, Classification: Introduction to Linear Classifiers, Support Vector Machines (SVM), k-nearest neighbors (k-NN) Classifier.	15

Suggested Readings:

1. Mertz, David. (2021). Cleaning Data for Effective Data Science, Published by Packt Publishing Ltd. Livery Place 35 Livery Street Birmingham B3 2PB, UK.
2. Ozdemir, Sinan. (2016). Principles of Data Science, Packt Publishing Ltd. Livery Place 35 Livery Street Birmingham B3 2PB, UK.
3. Phillips, Jeff M. (2021). Mathematical Foundations for Data Analysis, Springer. (https://mathfordata.github.io/).
4. Frank Emmert-Streib, et al. (2022). Mathematical Foundations of Data Science Using R. (2nd ed.).
5. De Gruyter Oldenbourg. Wes McKinney. (2022). Python for Data Analysis (3rd ed.).
6. O'Reilly. Wickham, Hadley, et al. (2023). R for Data Science (2nd ed.).

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Fourth**
Course Code:	Course Type: MNGEC
Core: **Elective**	Course Title: **Numerical Methods**
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The core objective of a **Numerical Methods** course is to teach students how to formulate and apply mathematical algorithms for solving complex engineering and scientific problems that cannot be solved analytically.

Course outcomes:

After completing this course, a student will have:

- ✓ Knowledge of types of errors.
- ✓ Ability to solve non-linear equations using iterative methods.
- ✓ Ability to interpolate value of dependent variable using past data.
- ✓ Ability to differentiate complex functions numerically. Ability to numerically solve complex integrals.

Unit	Topic	No. of Hours
I	**Errors in Computation-** Floating point representation of numbers, Significant Digits, Rounding and chopping, Absolute and relative errors, computation of errors using differentials, Truncation error. **Solution of non-linear equations:** Bisection method, Newton Raphson's	15

	method, Successive iteration method.	
II	**Interpolation-**Some operators and their properties, Finite difference table, Error in approximating a function by polynomial, Newton forward and backward Difference formulae, Gauss forward and backward formulae, Stirling's and Bessel's formulae, Lagrange's method, Divided differences and Newton's divided difference formula.	**15**
III	**Numerical Differentiation** - Differentiation methods based on Newton's forward and backward formulae, Differentiation by central difference formula.	**15**
IV	**Numerical Integration:** Trapezoidal, Weddle, Simpson's Newton Cotes Formulas, Gaussian Quadrature Formulas.	**15**

Suggested Readings:

R. K. Gupta (2019), Numerical methods: Fundamental and Applications, 1st Edition, Cambridge University Press.

M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6th edition). New Age International Publishers.

Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson.

C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition), Pearson Education, India.

F. B. Hildebrand (2013). Introduction to Numerical Analysis: (2nd edition). Dover Publications.

Robert J. Schilling & Sandra L. Harris (1999). Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/ Cole.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	**Semester: Fourth**
Course Code:	Course Type: SEC-IV
Core: **Compulsory (Elective)**	Course Title: Computer Algebra System
Credits (in hours per week): 2	1L-0T-1P
Internal Assessment: 40%	External Assessment: 60%

Course Objectives:

Equip students with the ability to proficiently use Computer Algebra Systems (CAS) for a variety of mathematical operations. Provide comprehensive knowledge and practical skills in advanced matrix operations and systems solving.

Course Outcomes:

- ✓ Students will be able to effectively use Computer Algebra Systems for calculations.
- ✓ Students will gain insights into matrix theory and linear algebra.
- ✓ Students will be adept at solving algebraic and trigonometric equations.
- ✓ Students will have the practical skills of matrix and system solving operations.

Unit	Topics	No. of Hours
I	**Introduction to CAS and Applications in Algebra:** Computer Algebra Systems (CAS), Use of CAS as a calculator, Simple programming in CAS, Computing and plotting functions in 2D, Customizing and animating plots, Producing tables of values, Working with piecewise-defined functions, Combining graphics, Factoring and expanding polynomials, Finding roots of polynomials, Working with rational and trigonometric functions, Solving general equations.	15
II	**Advanced Applications in Matrices and System Solving:** Performing Gaussian elimination, Matrix operations: transpose, determinant, inverse, Minors and cofactors, Solving systems of linear equations, Rank and nullity of a matrix, Eigenvalues and eigenvectors, Diagonalization.	15

Essential/ Recommended Readings:

1.Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.

2.Torrence, Bruce F., & Torrence, Eve A. (2009). The Student's Introduction to Mathematica®: A Handbook for Precalculus, Calculus, and Linear Algebra (2nd ed.). Cambridge University Press.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: **Mathematics**
Year: Second	Semester: **Fourth**
Course Code:	Course Type: AEC-IV
Core: Compulsory	Course Title: From the pool of courses offered by the University
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Second	Semester: **Fourth**
Course Code:	Course Type: VAC -IV (From the pool of courses offered by the University)
Core: **Compulsory (Elective)**	From the pool of courses offered by the university
Credits (in hours per week): 2	Assessment: Through MOOCS

Semester: V

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Fifth**
Course Code:	Course Type: MJDSCC-XIII
Core: **Compulsory**	Course Title: Metric Space
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: A Metric Space course introduces the abstract concept of distance and formalizes topological properties, transitioning from concrete Euclidean spaces to generalized sets. It builds the foundational language required for advanced mathematical analysis.

Course outcomes:

After completing this course, a student will have:

- ✓ Learn various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces.
- ✓ Analyse how a theory advances from a particular frame to a general frame.
- ✓ Appreciate the mathematical understanding of various geometrical concepts, viz. Balls or connected sets etc. in an abstract setting.
- ✓ Apply the Banach Fixed Point Theorem to prove the existence and uniqueness of solutions for various mathematical problems.

Unit	Topic	No. of Hours
I	Metric spaces: Definition and examples, Distance between sets, Diameters in Metric spaces, Bounded and Unbounded Metric spaces	15
II	Open and Closed ball, Neighborhood, Open set, Interior points, Limit points, Isolated points, Boundary points, Interior of a set, Derived set, Closed set, Closure of a set, Subspaces, Dense sets, Definition and examples of separable metric spaces.	15
III	Convergence in metric spaces, Cauchy sequences, and the relationship between convergent and Cauchy sequences, Complete Metric Spaces: Definition and examples, Cantor's intersection theorem, Banach fixed point theorem.	15
IV	Continuous Functions: Sequential criterion for continuity, (ϵ, δ) definition, and the characterization of continuity via open/closed sets, Uniform Continuity: Definition, properties, and the difference between continuity and uniform continuity, Homeomorphisms: Definition of homeomorphic spaces and topological properties.	15

Recommended Texts:

1. Shirali, Satish & Vasudeva, H. L., *Metric Spaces*, Springer, First Indian Print. 2009.

2. Kumaresan, S., *Topology of Metric Spaces* Narosa Publishing House, 2014.
3. Simmons, G. F. *Introduction to Topology and Modern Analysis*, Tata McGraw Hill. 2004.
4. M K Singal and A R Singal, *Topics in Analysis II*, 2017.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Fifth**
Course Code:	Course Type: MJDSCC-XIV
Core: **Compulsory**	Course Title: Group & Ring Theory-II
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives

To apply conjugacy, class equations, normalizers, and Cauchy's theorem in studying finite groups. To use group homomorphisms and subgroup series in the classification of groups. To study solvable groups and related theorems such as the Jordan–Hölder theorem. To apply factorization and field-theoretic concepts in solving problems related to rings and fields.

Course Outcomes: This course will enable the students to:

- ✓ Use class equations, direct products, and homomorphism theorems to analyze group structures.
- ✓ Determine and classify solvable and non-solvable groups.
- ✓ Develop abstract reasoning and rigorous proof-writing skills in group and ring theory.
- ✓ Understand polynomial rings, division algorithms, and unique factorization in UFDs, fields, and Euclidean rings.

Unit	Topic	No. of Hours
I	Conjugate elements of a group, Normalizer (Centralizer) of an element of a group, Centre of a group, Class equation of a group, Conjugate subgroups, Invariant subgroups. Cauchy's theorem for finite abelian group, Cauchy's theorem for an arbitrary finite group.	15
II	Fundamental theorem on homomorphism of groups, Second and third law of isomorphism of groups, Maximal subgroup, Composition series, Jordan Holder's theorem, Subnormal and normal series, Solvable groups and properties, Characteristic property of solvable groups.	15
III	Imbedding of rings, Field of quotients of an integral domain, Gauss lemma, Unique Factorization Theorem for polynomial rings over a UFD, Eisenstein's criterion of irreducibility and its applications, Krull's theorem.	15
IV	Prime field, Properties of prime field, Remainder theorem and factor theorem in a field, Remainder theorem and factor theorem for polynomials over a field, Unique Factorization Theorem for polynomials over a field, Unique Factorization Theorem for Euclidean rings.	15

	Factorization Theorem for Euclidean rings.	

Recommended Texts:

- I. N. Herstein: Topics in Algebra, Wiley, 2nd Edition, 2006.
- Vijay K. Khanna, S K Bhambri , A Course in Abstract Algebra, Vikas Publishing 5E, January 2017
- Joseph A. Gallian, Contemporary Abstract Algebra, Brooks/Cole Cengage Learning, 2016
- Surjit Singh and Quazi Zameeruddin: Modern Algebra, Vikas Publishing House, 2021.
- Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
- Cohn, P. M. Basic Algebra, Springer International Edition, .2003.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Fifth**
Course Code:	Course Type: MJDSCC-XV
Core: **Compulsory**	Course Title: Partial Differential Equations
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The primary objective of a Partial Differential Equations (PDE) course is to teach students how to formulate, classify, and solve mathematical models that describe continuous phenomena (like heat, fluid flow, and waves) in physics and engineering. It equips learners with analytical and numerical techniques to solve multivariate problems.

Course outcomes:

After completing this course, a student will have:

- ✓ The main objective of this course is to introduce:
- ✓ Basic concepts of first and second-order linear/nonlinear partial differential equations.
- ✓ Methods to solve first-order nonlinear PDEs and determine integral surfaces.
- ✓ Linear PDEs with constant coefficients, and finding their solutions using complimentary functions and particular integral.

Unit	Topic	No. of Hours
I	**First Order Partial Differential Equations** Formation and classification of first-order PDEs, Linear and Quasilinear first-order PDEs, Cauchy's problem for first order PDEs, The Cauchy Kowalevski Theorem, Integral surfaces passing through a given curve, Nonlinear first-order PDEs, The method of characteristics, Compatible systems, Charpit's method, Jacobi's method for nonlinear PDEs.	15

II	**Second-order Partial Differential Equations** Origins of second-order PDEs, and solving linear PDEs with constant coefficients using methods of finding the complementary function and particular integral; Monge's method of integrating nonlinear second-order PDE of type Rr + Ss + Tt = V with variable coefficients.	15
III	**The Fourier Transform Methods for PDEs** Fourier transform, Fourier sine and cosine transform, Heat flow problem in an infinite and semi-infinite rod, Infinite string problem, Laplace equation in a half-plane.	15
IV	**Applications of Partial Differential Equations** Mathematical models: The vibrating string, vibrating membrane, conduction of heat in solids, the gravitational potential, conservation laws and the Burgers equation, Traffic flow; Cauchy problem homogeneous wave equations with initial boundary-value problems, and non-homogeneous boundary conditions, Cauchy problem for non-homogeneous wave equations.	15

Recommended Texts:

1. Myint-U, Tyn & Debnath, Lokenath. (2007). Linear Partial Differential Equations for Scientists and Engineers (4th ed.). Birkhäuser. Indian Reprint.
2. Sneddon, Ian N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint.
3. Abell, Martha & Braselton, J.P. (2004) Differential Equations with Mathematica, Elsevier, Academic Press, Third Edition.
4. Stavroulakis, Ioannis P & Tersian, Stepan A. (2004). Partial Differential Equations: An Introduction with Mathematica and MAPLE (2nd ed.). World Scientific.
5. Amaranath T. (2023). An Elementary Course in Partial Differential Equations (3rd ed.). Narosa Publishing House.
6. Arrigo, Daniel (2023). An Introduction to Partial Differential Equations (2nd ed.). Springer.
7. Kapoor, N. M. (2023). A Text Book of Differential Equations. Pitambar Publishing Company.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Fifth**
Course Code:	Course Type: MJDSEC-III
Core: **Elective**	Course Title: Mechanics-II
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

To develop a rigorous understanding of the dynamics of particles and systems of particles using vector and analytical methods. To introduce the fundamental principles of Newtonian mechanics, including momentum, angular momentum, work, and energy, for the analysis of mechanical systems. To analyse special motions of particles such as simple harmonic motion, constrained motion, and motion under central forces. To familiarize students with rigid body dynamics, central orbits, and introductory analytical mechanics, including generalized coordinates and Lagrange's equations. To develop critical thinking and problem-solving abilities through the application of fundamental principles of mechanics to standard physical systems and dynamical situations.

Course Outcomes: On successful completion of the course, students will be able to demonstrate the following learning outcomes:

- ✓ Explain the concepts of velocity, acceleration, angular velocity, angular acceleration, and the relations between linear and angular motion for particles moving in straight lines and plane curves. Apply Newton's laws of motion to solve problems involving rectilinear motion, projectile motion, vertical motion under gravity, and motion under Earth's attraction.
- ✓ Apply principles of momentum, angular momentum, work, and energy, including conservation laws, to analyse particle motion in standard mechanical systems. Analyse simple harmonic motion, elastic string and spring systems, pendulum motion, and constrained motions in circles and cycloids. Apply D'Alembert's principle and general equations of motion to simple dynamical systems.
- ✓ Analyse central force motion and planetary motion, including orbit equations, inverse square law motion, apses, elliptic orbits, and Kepler's laws. Apply concepts of rigid body dynamics including moment of inertia, radius of gyration, angular momentum, and product of inertia to standard rigid body systems.
- ✓ Explain constraints, generalized coordinates, and the basic formulation of Lagrangian mechanics for systems with one degree of freedom.

Unit	Topic	No. of Hours
I	**DYNAMICS OF A PARTICLE** Velocity and acceleration of a particle moving along a straight line and a plane curve; Angular velocity and angular acceleration; Relation between angular and linear velocities; Rate of change of a unit vector in a plane; Radial and transverse velocities and accelerations; Tangential and normal velocities and accelerations. Linear and angular momentum of a particle; Principle of angular momentum for a particle; Kinetic energy; Conservative and non-conservative forces; Principle of energy for a particle, Potential energy; Principle of conservation of energy for a particle; Conservation of linear and angular momentum with selected standard applications. Rectilinear motion: Newton's laws of motion; Rectilinear particle motion with constant acceleration and vertical motion under gravity, Motion of a particle under the attraction of the Earth. Uniplanar motion: Projectiles including trajectory, time of flight, horizontal range, greatest height and velocity (with air resistance neglected).	15

II	**SPECIAL MOTIONS OF A PARTICLE** Motion of a particle under acceleration varying as distance: Simple harmonic motion; Elastic strings and spiral springs: Hooke's law; Motion of a particle attached to the one end of a horizontal elastic string; Motion of a particle suspended by a vertical elastic string or spiral spring. Constrained Motion: Motion in a smooth vertical circle (motion on the inside and outside), Motion of a simple pendulum, Constrained motion in a smooth horizontal circle with uniform speed, Constrained motion on a smooth cycloid. D'Alembert's principle; General equations of motion; Simple applications.	15
III	**CENTRAL FORCES AND RIGID BODY DYNAMICS** Central force and central orbits; Differential equation of an orbit in polar coordinates; Differential equation of a central orbit in polar form; Rate of description of sectorial area (Areal velocity), Different forms of velocity at a point under central forces; Elliptic orbit, Apses of an orbit, Motion under Inverse Square Law; Simple examples of orbits under Inverse Square Law. Planetary motion: Newton's law of gravitation, Kepler's Laws. Some Aspects of Rigid Body Dynamics: Kinetic energy and angular momentum; Moment of inertia and radius of gyration; Theorems of parallel and perpendicular axes; Moments of inertia of a rod, rectangular lamina, circular disc, solid sphere, and hollow sphere. Product of inertia; Moment and product of inertia of a plane lamina about a line; Moment of inertia of a body about a given line.	15
IV	**SYSTEM OF PARTICLES AND ANALYTICAL MECHANICS** Dynamics of a System of Particles: Principle of linear momentum for a system of particles, Motion of the center of mass; Principle of angular momentum for a system of particles; Principle of conservation of energy for a system of particles; Constraints and Generalized Coordinates: Holonomic and non-holonomic constraints; Degrees of freedom; Generalized coordinates. Introductory analytical mechanics: Lagrangian function and Lagrange's equations of motion (outline only); Simple examples involving one degree of freedom (simple pendulum, particle in one dimension, mass-spring system).	15

Recommended Texts: Essential/ Recommended Readings:

1. Synge, J. L., & Griffith, B. A. (2017): *Principles of Mechanics* (3rd ed.). McGraw-Hil Education, Indian Reprint.
2. F. Charlton (2002), *Textbook of Dynamics*, 2nd Edition, CBS Publishers & Distributors, Nev Delhi.
3. Raisinghania, M. D. (2022): Dynamics. S. Chand and Company Limited.
4. Ray, M., & Sharma, G. C. (2018). *A Textbook on Dynamics*. S. Chand Publishing.
5. Ray, M., & Sharma, H. S. (1995). *Dynamics of a Rigid Body*. Student's Friends & Company.
6. Goldstein, H., Poole, C. and Safko, J. (2014): *Classical Mechanics*, Pearson.
7. Rana, N. C. and Joag, P. S. (2017) *Classical Mechanics*, McGraw Hill Education (India).

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Fifth**
Course Code:	Course Type: MJDSEC-III
Core: **Elective**	Course Title: Introduction to Graph Theory
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

To provide a foundational understanding of graphs, subgraphs, and their matrix representations. To explore the theory of trees, connectivity, and planarity as key structural components of graphs. To demonstrate the versatility of graph theory in solving complex real-world problems in computing and social sciences. To foster analytical thinking and the ability to construct logical mathematical.

Course Outcomes:

Upon successful completion of the course, the student will:

- ✓ Be able to categorize graphs and describe their properties.
- ✓ Understand and apply the basic concepts of graph theory.
- ✓ Be able to write rigorous mathematical proofs involving graphs.
- ✓ Be able to recognize the numerical application of graph theory and solve real-world problems.

Unit	Topic	No. of Hours
I	Graph: Definition, Model, Matrices, Isomorphism, Special Graphs (K_n, K_{mn}), Paths, Cycles, Trails, Eulerian Circuit, Bipartite Graphs, Finite and Infinite Graphs, Incidence and Degree, Isolated vertex, Pendant vertex, Null graph, Vertex, Degree and their counting.	15
II	Operations on Graphs, Subgraphs, Directed Graphs, Eulerian Graph, Hamiltonian Graph, Tree: Definition, properties, Spanning Trees, Enumeration of Trees, Walks, Paths, Circuits.	15
III	Matchings: Maximum Matchings, Min-Max Theorems, Independent Set, Covers: Algorithms and Applications, Maximum Bipartite Matching, Network Flows, Circuit Matrix, Cut-set Matrix, Path Matrix.	15
IV	Cuts, Connectivity, Edge-connectivity, Blocks, Coloring: Vertex, Edge, Chromatic Number and Chromatic Index, Planar Graphs, Dual Graph, Detection of Planarity.	15

Suggested Readings:

1. D.B. West: Introduction to Graph Theory, 2nd Edition, Pearson, 2017
2. N: Deo: Graph Theory with Applications to Engineering and Computer Science, 2016
3. J.A. Bondy & U.S.R. Murty: Graph theory, Springer, 1982
4. J. Clark, & D.A. Holton: A First Look at Graph Theory, World Scientific, 1991

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Fifth**
Course Code:	Course Type: MJDSEC-III
Core: **Elective**	Course Title: Differential Geometry
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives

The objectives of this course are this course introduces the fundamentals of Differential Geometry primarily by focusing on the theory of curves and surfaces in three spaces. Introducing the concepts: Regular curves, arc length, and natural parametrization.

Course Outcomes:

- ✓ Explain the geometry of different types of curves and spaces.
- ✓ Understand the basic concepts and results related to space curves, tangents, normal and surfaces.
- ✓ Understand principal directions and curvatures, asymptotic lines and then apply their important theorems and results to study various properties of curves and surfaces.
- ✓ Explain the physical properties of different curves and spaces.

Unit	Topic	No. of Hours
I	Theory of space curves, arc length, Tangent and normal, Curvature and torsion of curve given as the intersection of two surfaces, Involute and evolute.	15
II	Metric: The first and second fundamental form, Weingarten equation, Orthogonal trajectories, Mensurier theorem, Gaussian curvature, Euler's theorem	15
III	Spherical Indicatrix, Bertrand Curve, Surfaces, Envelopes, Edge of Regression, Developable Surfaces, Two Fundamental Form.	15
IV	Asymptotic lines, Fundamental equations of surface theory, Gauss's formulae, Gauss characteristics equations, Mainardi Codazzi equations, Weingarten equations, Bonnet's theorem on parallel surface.	15

Recommended Texts:

1. Carmo, M. Do: Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
2. Millman, R.S. and Parker, G.D. Elements of Differential Geometry, Prentice Hall, 1977.
3. Neil, B.O.: Elementary Differential Geometry, Academic Press, 1966.
4. Thorpe, J.A: Elementary Topics in Differential Geometry, Springer-Verlag, 1979.
5. Willmore, T.J.: An Introduction to Differential Geometry and Riemannian Geometry, Oxford University Press, 1965.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Fifth**
Course Code:	Course Type: MNGEC
Core: **Elective**	Course Title: Mathematical Python
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives

The objectives of this course are to be able to model and solve mathematical problems using Python Programs. To experience utility of open-source resources for numerical and symbolic mathematical software systems.

Course Outcomes:

After completing this course, a student will be able

- ✓ For numerical and symbolic computation in mathematical problems from calculus, algebra, and geometry.
- ✓ To tabulate and plot diverse graphs of functions and understand tracing of shapes, geometries, and fractals.
- ✓ To prepare smart documents with LaTeX interface.

Unit	Topic	No. of Hours
I	Drawing diverse shapes using code and Turtle; Using matplotlib and NumPy for data organization, structuring and plotting lines, bars, markers, contours and fields, managing subplots and axes; Pyplot and subplots, Animations of decay, Bayes update, Random Walk.	15
II	NumPy for scalars and linear algebra on n-dimensional arrays; Computing eigenspace, Solving dynamical systems on coupled ordinary differential equations, Functional programming fundamentals using NumPy; Symbolic computation and SymPy: Differentiation and integration of functions, Limits, Solution of ordinary differential equations.	15
III	Computation of eigenvalues, Solution of expressions at multiple points (lambdify), Simplification of expressions, Factorization, Collecting and canceling terms, Partial fraction decomposition, Trigonometric simplification, Exponential and logarithms, Series expansion and finite differences, Solvers, Recursive equations.	15
IV	Pretty printing using SymPy; Pandas API for IO tools: interfacing Python with text/csv, HTML, LaTeX, XML, MS Excel, OpenDocument, and other such formats; Pylatex and writing document files from Python with auto-computed values, Plots and visualizations.	15

Recommended Texts:

6. Farrell, Peter (2019). Math Adventures with Python. No Starch Press. ISBN Number: 978-1-59327-867-0.

7. Farrell, Peter and et al. (2020). The Statistics and Calculus with Python Workshop. Packet Publishing Ltd. ISBN: 978-1-80020-976-3.
8. Saha, Amit (2015). Doing Math with Python. No Starch Press. ISBN: 978-1-59327-640-9.
9. Morley, Sam (2022). Applying Math with Python (2nd ed.). Packet Publishing Ltd. ISBN: 978-1-80461-837-0.

Online resources and documentation on the libraries, such as:

- https://matplotlib.org
- https://sympy.org
- https://pandas.pydata.org
- https://numpy.org
- https://pypi.org
- https://patrickwalls.github.io/mathematicalpython/

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Fifth**
Course Code:	Course Type: MNGEC
Core: **Elective**	Course Title: Introduction to Reliability Theory
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives

The objectives of this course are this course presents some fundamental knowledge of Reliability Theory and Fuzzy Set Theory. It includes general techniques to formulate reliability engineering problems. It deals with assurance and failure testing in design and production of products or services to meet customer demand.

Course Outcomes:

After completing this course, a student will

- ✓ Understand basic knowledge of Reliability and Maintainability.
- ✓ Evaluate these aspects for complex systems.
- ✓ Appreciate the role of human and mathematical evidences.
- ✓ Have the knowledge of various methods to control the quality of a product and to increase the reliability of a device/system and fundamental tools/methods in various industrial plants.

Unit	**Topic**	**No. of Hours**
I	Basic Concepts of Reliability: General Reliability Function, Failure and Failure modes, Hazard Rate, Bath-tub curve, Memory-less Property, MTTF, MTTR and repair rate, Error, State of Error, Common Cause error, Circumstantial error.	15

II	System Reliability and Evaluation Techniques: Series, Parallel, Standby Redundancy, k-out-of-n Configuration, Series-Parallel, Parallel-Series configurations and Bridge Structure.	15
III	Reliability Evaluation Techniques: Binomial Theorem to evaluate Network Reliability, State Space Approach, Minimal Cut Set Method, Successive disjoint method, active and passive redundant systems, Human failure and Software Reliability.	15
IV	Maintainability and Availability Concepts: Maintainability Function, Availability Function, Frequency of Failures, Two Unit Parallel System with Repair.	15

Recommended Texts:

1. C. E. Ebeling, Reliability and Maintainability Engineering, Tata McGraw Hill, 2004.
2. B. S. Dhillon and C. Singh: Engineering Reliability, John Wiley & Sons, 2000.
3. R. F. Barlow and F. Proschan: Mathematical Theory of Reliability, John Wiley & Sons, 1996.
4. L. S. Sri Nath: Mathematical Theory of Reliability, Affiliated East West Press Pvt. Ltd, 2009
5. E. Balagurusamy: Reliability Engineering, Tata McGraw Hill Publications, New Delhi, 2010.
6. Kai-Yuan Cai: Introduction to Fuzzy Reliability, Kluwer Academic Publishers, Boston/Dordrecht/London, 1996.

Semester: VI

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Sixth**
Course Code:	Course Type: MJDSEC-IV
Core: ~~Elective~~ Compulsory	Course Title: Operations Research
Credits (in hours per week): 4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: The primary course objective of Operations Research is to equip students with mathematical modeling and quantitative techniques to optimize decision-making and efficiently allocate limited resources (like capital, materials, and labor) in complex business or industrial scenarios.

Course Outcomes

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

- ✓ Analyse LP duality (primal-dual relations, sensitivity analysis, key theorems) and apply it to real-world problems.
- ✓ Apply various replacement models to determine the optimal replacement policy for items that deteriorate with time, fail suddenly, and under group replacement policy; and solve job sequencing problems for n jobs on 2 machines, n jobs on m machines, and 2 jobs on m machines to minimize total processing time.
- ✓ Solve transportation problems using North-West Corner, Vogel's, and MODI methods; handle unbalanced/ degenerate cases, transshipment, and TSP applications.
- ✓ Apply CPM and PERT techniques to construct project networks, identify the critical path, calculate floats, and analyse project completion time and probability under uncertainty.

Unit	Topic	No. of Hours
I	**Duality** Definition of the dual of an LPP and its significance. Primal-dual relationships. Weak and strong duality theorems (statements only), with illustrations through examples. Dual simplex and revised simplex methods. Sensitivity analysis: Concepts and applications. Resolution of degeneracy in duality contexts.	15
II	**Network Analysis** Project Scheduling using **CPM** (Critical Path Method) and **PERT** (Program Evaluation and Review Technique). Network construction and representation. Determination of Critical Path, Floats and Slacks (Total Float, Free Float, Independent Float). Probability considerations and time estimates in PERT, Calculation of project completion time and its variance.	15

III	**Replacement and Job Sequencing** **Replacement**: Introduction to Replacement Problems., Types/ Classification of Replacement Problems: (i) Replacement of items that deteriorate with time. (ii) Replacement of items that fail suddenly. (iii) Group replacement policy. **Job Sequencing**: Introduction, processing of n jobs on 2 machines, n jobs on m machines, and two jobs on m machines.	15
IV	**Transportation** Introduction, Basic Feasible Solution of a Transportation Problem, Modified Distribution (MODI) method and Stepping Stone method, Unbalanced Transportation Problem, Degenerate Transportation Problem, transshipment, and traveling salesman applications.	15

Recommended Texts:

1. G. Hadley, Linear Programming, Narosa Publishing House (1995).
2. F.S. Hillier, and G.J. Lieberman, Introduction to Operations Research (SIE) (2021). Tata McGraw Hill, New Delhi (2021).
3. P.K. Gupta and D.S. Hira, Operations Research, S. Chand & Co. 7th Edition (2021).
4. S.D. Sharma, Operation Research, Kedar Nath Ram Nath Publications (2010).
5. P. R. Thie., & Keough, G. E. An introduction to linear programming and game theory (3rd ed.) New Jersey: John Wiley & Sons (2008).
6. M. J. Osborne, An introduction to game theory. New York: Oxford University Press (2009).
7. Hillier, F.S., Lieberman, G. J., Nag, B., & Basu, P. Introduction to operations research-concepts and cases (10th ed.). New Delhi: Tata McGraw Hill (Indian print) (2017).
8. H. A. Taha, Operations research-an introduction (10th ed.). New Delhi: Pearson Prentice Hall (Indian print) (2019).
9. S. Mokhtar, Bazaraa, J. John, Jarvis and D. Hanif, Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, (2004).

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Sixth**
Course Code:	Course Type: MJDSCC-XVII
Core: **Compulsory**	Course Title: Linear Algebra
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives

The objectives of this course are to develop understanding of vector spaces and linear transformations. Learn matrix representations of linear transformations, inner product spaces and their applications. Learn canonical forms including rational and Jordan forms. Analyze bilinear forms and their classifications.

Course Outcomes

This course will enable the students to:

- ✓ Determine the range, null space, rank, and nullity of linear transformations.
- ✓ Analyze inner product spaces and apply Bessel's inequality.

- ✓ Determine minimal and annihilating polynomials.
- ✓ Construct cyclic subspaces and cyclic decompositions.
- ✓ Represent bilinear forms using matrices and reduce bilinear forms to canonical form.

Unit	Topic	No. of Hours
I	Linear Transformations: Linear Transformations, Isomorphism, Range and null space, The matrix representation of a linear transformations, Linear functionals, Double dual.	15
II	Invertibility and Isomorphisms, The change of Coordinate matrix, The transpose of a linear transformations, Polynomial ideals, Prime factorization of polynomials, Inner product spaces, Bessel's inequality, Normal and unitary operators, Eigen values and eigenvectors, Cayley-Hamilton Theorem.	15
III	Elementary Canonical forms: Annihilating Polynomials, The minimal polynomial, Invariant subspaces, Simultaneous Triangulation, Simultaneous diagonalization, Direct-sum decomposition, Invariant direct sums, The primary decomposition theorem.	15
IV	The Rational and Jordan Forms: Cyclic subspaces and annihilators, Cyclic decomposition and the rational form, The Jordan form. Bilinear Forms: Bilinear forms, The matrix of a bilinear form, Classification of bilinear forms: Symmetric bilinear forms, Skew-symmetric bilinear forms.	15

Recommended Texts:

1. K. Hoffman, R. Kunze, Linear Algebra. 2nd Edition, Pearson, 2017.
2. S.H. Friedberg, A.J. Insel, L.E. Spence: Linear Algebra, Pearson Education India; 4th Edition, 2015.
3. G. Strang, Linear Algebra and its applications, Cengage Learning, 4th Edition, 2007.
4. Vivek Sahai, Vikas Bist, Linear Algebra, Narosa Publishing House, 2nd Edition, 2013.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Sixth**
Course Code:	Course Type: MJDSCC-XVIII
Core: **Compulsory**	Course Title: Complex Analysis
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

To develop basic understanding of functions of a complex variable, limits, continuity, differentiability, and the Cauchy–Riemann equations. To study analytic and harmonic functions, and to apply methods such as Milne–Thomson's method for constructing analytic functions. To understand some elementary transformations and their role in mapping regions of the complex plane. To explore elementary transcendental functions of a complex variable, and to introduce contour integration, branch cuts, antiderivatives.

Course outcomes:

- ✓ Analyze functions of a complex variable and verify analyticity using the Cauchy–Riemann equations and related concepts.
- ✓ Evaluate and interpret complex elementary functions, including logarithmic, exponential, trigonometric, and hyperbolic.
- ✓ Compute contour integrals, apply properties of analytic functions, and estimate upper bounds of contour integrals.
- ✓ Apply concepts of complex analysis in advanced mathematical studies and related scientific disciplines.

Unit	Topic	No. of Hours
I	Functions of complex variable, Mappings, Mappings by the exponential function, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulae, Cauchy-Riemann equations, Sufficient conditions for differentiability.	15
II	Analytic functions and their examples, Harmonic functions, Method of constructing a regular function (Milne-Thomson's method), Reflection Principle, Elementary transformations, Linear transformation, The transformation $w = {}^{1}/_{z}$, Mappings by ${}^{1}/_{z}$. Isogonal mapping, Conformal mapping, necessary and sufficient conditions of conformal mapping, Examples of conformal mappings.	15
III	Exponential function, Logarithmic function, Branches and derivatives of logarithms, Identities involving logarithms, Complex exponents, Trigonometric functions, Hyperbolic functions, Inverse trigonometric functions, Inverse hyperbolic functions.	15
IV	Derivatives of functions, Definite integrals of functions, Contours, Contour integrals and its examples, Examples with branch cuts, Upper bounds for moduli of contour integrals, Antiderivatives.	15

RECOMMENDED BOOKS

- J. Brown, R.V. Churchill: Complex Variable and Applications, McGraw-Hill Education; 9th Edition, 2013.
- Shanti Narain, Function of Complex Variable, S Chand, 2005.
- Joseph Bak & Donald J. Newman: Complex Analysis (3rd ed.). Undergraduate Texts in Mathematics, Springer, 2010.
- Dennis G. Zills & Patrick D. Shanahan: A First Course in Complex Analysis with Applications. Jones & Bartlett Publishers, 2003.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Sixth**
Course Code:	Course Type: MJDSCC-XVI
Core: **Elective**	Course Title: Basics of Control Theory
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:
This course is designed to introduce students to the fundamental concepts and mathematical foundations of control theory. The course aims to develop an understanding of mathematical modeling, state space representation, controllability, observability, and feedback control of dynamical systems. It also provides exposure to discrete and continuous control systems, realization theory, and optimal control techniques.

Course Outcomes: This course will enable the students to:
- ✓ Develop mathematical models and state space representations for continuous and discrete control systems.
- ✓ Analyze dynamical systems using transfer functions, block diagrams, and state transition matrices.
- ✓ Examine controllability, observability, realization, and feedback properties of linear control systems.
- ✓ Design and analyze feedback controllers, state observers, and multivariable control systems.
- ✓ Apply optimal control techniques, including Riccati equations and calculus of variations, to linear and nonlinear systems.

Unit	Topic	No. of Hours
I	Mathematical models of control systems, State space representation, Autonomous and non-autonomous systems, State variables and state trajectories, State transition matrix, Peano series solution of linear dynamical systems.	15
II	Block diagrams, Transfer functions, Realization of control systems, Controllability of linear systems, Kalman controllability theorem, Controllability Grammian, Control computation using Grammian matrix.	15
III	Observability of control systems, Duality theorems, Discrete control systems, Controllability results for discrete systems, Observability results for discrete systems, Companion form, Feedback control, State observer, Realization theory.	15
IV	State feedback of multivariable systems, Riccati equation, Introduction to calculus of variations, Euler–Hamiltonian equations, Optimal control for nonlinear control systems, Computation of optimal controls for linear systems.	15

Recommended Texts:

1. Barnett, S. *Introduction to Mathematical Control Theory*, Clarendon Press, Oxford, 1975.
2. Nagrath, I. J. and Gopal, M., *Control System Engineering*, New Age International, 2007.
3. Datta, B., *Numerical Methods for Linear Control Systems*, Academic Press, Elsevier, 2004.
4. Golnaraghi, F. and Kuo, B. C. *Automatic Control Systems*, McGraw Hill Education, 2017.

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Sixth**
Course Code:	Course Type: MJDSEC-IV
Core: **Elective**	Course Title: Mathematical Modelling
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

The main objectives of this course are to make students to understand the basic concepts of modelling and simulation. Use mathematical techniques to simulate the models. Apply mathematical models to the problems of practical interest. Analyze and validate the solutions obtained from models.

Course Outcomes:

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

- ✓ Understand the principles and types of mathematical models used in real-world systems.
- ✓ Formulate linear, nonlinear, deterministic, and stochastic models for practical problems.
- ✓ Apply approximation, validation, and error analysis techniques in modelling.
- ✓ Use regression and least squares methods for data fitting and analysis.
- ✓ Perform simulations and data analysis using computational tools such as MATLAB/Scilab.
- ✓ Analyze applications of mathematical modelling in population dynamics, traffic flow, finance, communication, and queuing systems.

Unit	Topic	No. of Hours
I	**Mathematical Modelling**: Modelling and its principles, problem definition, dimensional homogeneity and consistency, abstraction and scaling, conservation and balance principles, system characterization, constructing linear models, discrete versus continuous modelling, deterministic versus stochastic. Model Assumptions and Simplifications – Understanding scope and limitations of models.	15
II	**Approximating and Validating Models**: Review of Taylor's formula and various trigonometric expansions, validating the model, error analysis, fitting curves to the data. Least Squares Method (Linear and Nonlinear Regression).	15

III	**Simulation Approaches**: Methods for simulation and data analysis using MATLAB/ SciLab/ Maxima/ Maple/ Mathematica, etc., statistics for simulations and analysis, random variates generation, sensitivity analysis. Monte Carlo Simulation Techniques – Applications in finance, risk analysis, physics.	15
IV	**Model and its Different Types**: Linear and nonlinear population models, traffic flow models, transport phenomena, diffusion and air pollution models, statistical models, Poisson process, stochastic models, computer data communications, stock market, option pricing, Black-Scholes model. Queuing Theory and Network Models – Applications in communication and service systems.	15

Recommended Texts:

1. C. L. Dym, Principles of Mathematical Modelling, Elsevier Press, Second Edition (2004).
2. E. A. Bender, An Introduction to Mathematical Modelling, Dover (2000).
3. D Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, Third Edition, American Mathematical Society (2009).
4. J. N. Kutz: Data-Driven Modelling & Scientific Computation: Methods for Complex Systems & Big Data, Oxford University Press (2013).
5. J. N. Kapur, Mathematical Modelling, New Age International Pvt. Ltd. (2021).

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Sixth**
Course Code:	Course Type: MJDSEC-IV
Core: **Elective**	Course Title: Soft Computing Techniques
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives:

To introduce the fundamental concepts of Soft Computing, specifically focusing on Artificial Neural Networks and Fuzzy Logic. To provide an understanding of neural network architectures, learning paradigms, and the mathematical foundations of fuzzy systems.

Course Outcomes:

Upon successful completion of the course, the student will:

- ✓ Be able to learn basic soft computing techniques and their potential applications.
- ✓ Analyze various neural network architectures, including perceptron and backpropagation networks.
- ✓ Understand the fuzzy sets and their operations using membership functions.
- ✓ Be able to identify suitable neural or fuzzy techniques to model and represent data-driven problems.

Unit	Topic	No. of Hours

I	Introduction to Soft Computing, Artificial Neural Networks: Biological Neurons, Basic models of Artificial Neural Networks: Connections, Learning, Activation Functions, McCulloch and Pitts Neuron, Hebb Network.	15
II	Perceptron Networks, Learning rule, Training and testing algorithm, Adaptive Linear Neuron, Back propagation Network: Architecture, Training algorithm.	15
III	Adaptive networks, Supervised Learning Neural Networks, Learning from Reinforcement, Unsupervised Learning Neural Networks.	15
IV	Fuzzy logic: Fuzzy Sets and their Properties, Operations on Fuzzy Sets, Fuzzy Membership Functions, Fuzzification, Methods of Membership Value Assignments.	15

Suggested Readings:

1. Ross, Timothy J.: Fuzzy Logic with Engineering Applications, John Wiley & Sons, (2016).
2. Sivanandam, S. N. & Deepa, S. N.: Principles of soft computing, John Wiley & Sons, (2007).
3. Simon Haykin: Neural Network- A Comprehensive Foundation, Prentice Hall International, Inc., (1998).
4. Bart Kosko: Neural Network and Fuzzy Systems, Prentice Hall, Inc., Englewood Cliffs, (1992).
5. Driankov D., Hellendoorn H. & Reinfrank M.: An Introduction to Fuzzy Control, Narosa Pub., (2001).
6. Shing, Jyh, Jang Roger, Mizutani Eiji, Sun, Chuen-Tsai: Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall, Inc., (2007).

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Sixth**
Course Code:	Course Type: MNGEC
Core: **Elective**	Course Title: Mathematical Statistics
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives: To establish a strong mathematical understanding of probability theory, including set-theoretic approaches and the properties of random variables, including moments and generating functions. To analyze various standard probability distributions and their practical applications. To introduce the fundamental principles of sampling methods and the theory of statistical inference. To provide the skills to formulate hypotheses and execute parametric tests of significance for empirical data analysis.

Course Outcomes:

Upon successful completion of the course, the student will:

- ✓ Be able to apply set-theoretic probability and Bayes' Theorem to solve complex probabilistic events.
- ✓ Calculate and interpret expectations, moments, and MGFs for various univariate and multivariate distributions.
- ✓ Be able to apply suitable discrete and continuous distributions to model real-world problems.
- ✓ Distinguish between various sampling techniques and determine their suitability for specific research designs.

Unit	Topic	No. of Hours
I	Probability: Definition, Set theoretic approach, Sample spaces, Events, Addison and Multiplication rules of probability; Dependent and Independent events, Conditional probability, Total probability and Bayes' theorem, Probability mass and density functions,	15
II	Random variables, Distribution functions, Joint probability distribution function, Conditional distribution function, Probability density function, Mathematical Expectation: Definition, Properties, Expectation of sum and product of random variables, Moments, Moment Generating Function (MGF) Covariance, Variance of variables, standard discrete and continuous univariate distributions, standard errors, marginal and conditional distributions.	15
III	Basics concept of Moment generating function, Probability generating function and Universal generating function, Discrete distributions: Geometric, Binomial, and Poisson distributions, Continuous distributions: Normal, Exponential, Gamma and Beta distributions.	15
IV	Sampling Methods: Random Sampling Methods, Simple Random sampling, Stratified Sampling, Systematic Sampling, Probability Proportional to size sampling, Test of Hypothesis and significance: Statistical Hypothesis (Simple and composite), Null and alternative hypotheses.	15

Suggested Readings:

1. Gupta, S.C., Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi. (2016)
2. Rohatgi, V.K., Saleh, A.K. Md. Ehsanes: An Introduction to Probability and Statistics, Second Edition Wiley Publication(2008)
3. Kennedy and Gentle: Statistics Computing, Published by CRC Press. (2021)
4. Mayer, P.L.: Introductory Probability and Statistical Applications, IBH. 2nd Edition (1970)
5. Mood, A.M. and Graybill, F.: Introduction to the Theory of Statistics, McGraw Hill Education; 3rd edition (2017).
6. Hogg, R.V., Craig, A. and McKean, Joseph W.: Introduction to Mathematical Statistics, Pearson Education, .8th Edition New Delhi (2019).

Program: **B.Sc. (Honours/ Honours with Research)**	Subject: Mathematics
Year: Third	**Semester: Sixth**

Course Code:	Course Type: MNGEC
Core: **Elective**	Course Title: Machine Learning
Credits (in hours per week):4	3L-1T-0P
Internal Assessment: 30%	External Assessment: 70%

Course Objectives

The course aims at introducing the basic concepts and techniques of machine learning so that a student can apply machine learning techniques to a problem at hand.

Course Outcomes

- ✓ Differentiate between supervised and unsupervised learning tasks.
- ✓ State the need of preprocessing, feature scaling and feature selection.
- ✓ Formulate classification, regression and clustering problems as optimization problems.
- ✓ Implement various machine learning algorithms learnt in the course

Unit	Topic	No. of Hours
I	**Introduction:** Basic definitions and concepts, key elements, supervised and unsupervised learning, introduction to reinforcement learning, applications of ML.	15
II	**Preprocessing:** Feature scaling, feature selection methods, dimensionality reduction (Principal Component Analysis). **Regression:** Linear regression with one variable, linear regression with multiple variables, gradient descent, over-fitting, regularization. Regression evaluation metrics.	15
III	**Classification:** Decision trees, Naive Bayes classifier, logistic regression, k-nearest neighbor classifier, perceptron, multilayer perceptron, neural networks, back-propagation algorithm, Support Vector Machine (SVM). Classification evaluation metrics.	15
IV	**Clustering:** Approaches for clustering, distance metrics, K-means clustering, hierarchical clustering.	15

Suggested Readings:

1. Mitchell, T.M. Machine Learning, McGraw Hill Education, 2017.
2. James, G., Witten. D., Hastie. T., Tibshirani. R. An Introduction to Statistical Learning with Applications in R, Springer, 2014.
3. Alpaydin, E. Introduction to Machine Learning, MIT press, 2009.
4. Flach, P., Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Cambridge University Press, 2015.
5. Christopher & Bishop, M., Pattern Recognition and Machine Learning, New York: Springer-Verlag, 2016.
6. Sebastian Raschka, Python Machine Learning, Published by Packt Publishing Ltd. Livery Place 35 Livery Street Birmingham B3 2PB, UK. ISBN 978-1-78995-575-0, 2019.