SYLLABI FOR FOUR-YEAR UNDERGRADUATE PROGRAMME

IN

MATHEMATICS

AS PER NATIONAL EDUCATION POLICY (NEP) 2020

Recommended by the 1st meeting of the Board of Studies (BoS), Department of Mathematics, and approved by the 1st meeting of the Academic Council of Lakhimpur Girls' College (A), held on 28 June 2026, vide Resolution No. AC/1/2026/05

LAKHIMPUR GIRLS' COLLEGE (AUTONOMOUS)

NORTH LAKHIMPUR, LAKHIMPUR -787031, ASSAM

Endorsed syllabi of Dibrugarh University as model syllabi for the development of syllabi of the Department of Mathematics, Lakhimpur Girls' College (A), with necessary modifications and additions, keeping in view the context and academic requirements.

STRUCTURE OF FOUR YEAR UNDER GRADUATE PROGRAMMES (FYUGP) IN MATHEMATICS
LAKHIMPUR GIRLS' COLLEGE (AUTONOMOUS)
(AS PER NEP – 2020 GUIDELINES)

PREAMBLE

As recommended by the University Grants Commission (UGC) and proposed for implementation by Lakhimpur Girls' College (autonomous), the Department of Mathematics works to implement the relevant components of New Education Policy (NEP), 2020 for Four Year Under Graduate Programme (FYUGP). The following facts are taken into consideration when designing the basic structure of the Under Graduate (UG) programme:

- Flexibility to switch between disciplines of study,
- Opportunity for learners to select the courses of their interest across all disciplines,
- Flexible entry and exit options with UG certificates, UG diplomas, or UG degrees depending on the number of credits earned,
- Flexibility for students to switch between institutions so they can engage in multi- and/or interdisciplinary learning,
- Flexibility to switch to alternative modes of learning,
- Knowledge required for self-employment initiatives and entrepreneurship mindset,
- Ability for complex critical thinking and real-life problem solving,
- Capability to understand global issues, multicultural competence and digital literacy,
- Capable on research skills, communication skills, community based engagement, environment awareness, responsibility and accountability.

AIM

The UG Programme in mathematics is designed to teach students how to think critically, logically, and analytically, which enables them to employ mathematical reasoning in real-world situations. A UG degree in mathematics will expose students to a variety of intriguing and practical concepts that will help them in their preparation for a variety of mathematics-oriented jobs in industry, government, business, commerce, finance and research.

The programme covers broad range of topics on pure and applied mathematics. Also covers hands-on sessions in Computer Lab using various software, MATLAB, C etc. which enables students to corelate and compare with recent developments in various branches of mathematics in a variety of organisations worldwide.

The programme aims to increase students' skill in mathematics as well as other cross-disciplinary subjects like commerce, physics, computer sciences, economics, and statistics etc. Also aims students' flexibility to move from one discipline to another, to move one institution to another, to switch alternative modes of learning.

Programme Educational Objectives (PEO):

PEO 1: Fundamental Knowledge and Skills Graduates will be well-versed in mathematical theories, concepts, and techniques, enabling them to solve challenging problems and pursue advanced study in mathematics or related fields.

PEO 2: Analytical and Critical Thinking Graduates will acquire the analytical and critical thinking abilities needed to formulate, evaluate, and resolve real-world issues using logical reasoning and mathematical modelling.

PEO 3: Application of Mathematics Graduates will be adept at using computational tools and mathematical concepts to solve problems in a variety of sectors, including science, engineering, technology, and economics.

PEO 4: Communication and Collaboration Graduates will be able to effectively convey mathematical concepts, both orally and in writing, as well as collaborate in multidisciplinary teams to solve challenging problems.

PEO 5: Ethical and Professional Responsibilities Graduates will exhibit a dedication to moral behaviour and professional obligations, which include comprehending how mathematical solutions affect society and maintaining a high standard of professional development.

PEO 6: Lifelong Learning and Adaptability Graduates will pursue lifelong learning in order to keep up with new developments and trends in the mathematics and to adjust to the changing needs of both academia and the workforce.

PEO 7: Research and Innovation Graduates will be equipped with the capacity to carry out autonomous research, enhancing their understanding of mathematics and stimulating their imagination in addressing abstract and practical issues.

PROGRAMME OUTCOMES ARE GRADUATE ATTRIBUTES STATED AS FOLLOWS:

PO1: Disciplinary Knowledge Being able to demonstrate comprehensive knowledge and coherent understanding of both the theoretical and applied components of mathematics as well as chosen interdisciplinary areas of study in a broad multidisciplinary context.

PO2: Communication Skills Capability to express various mathematical ideas clearly through computational methods, graphical methods, examples and their geometrical representations; ability to use mathematics effectively as a precise language of communication in other fields.

PO3: Moral and Ethical Awareness/Reasoning Ability to recognise ethical issues that are pertinent to one's work and pledge not to engage in unethical behaviour such as plagiarism, copyright and infringement of intellectual property rights.

PO4: Multicultural Competence Ability to corelate and compare recent developments in various branches of mathematics in a variety of organisations worldwide; ability to effectively participate in a multicultural group or society and interact politely with diverse groups.

PO5: Information/Digital Literacy Ability to access, asses and utilize Information and Communications Technology (ICT) tools. Ability to understand, read and write programming language/packages/modules (MATLAB; C) for computation, simulation, graphs and solutions.

PO6: Reflective Thinking Ability to formulate appropriate questions pertaining to the ideas in various branches of mathematics in order to propose new solutions using the domain knowledge of mathematics; ability to interpret the findings and use them to solve a variety of problems found in numerous fields of mathematics and real-life.

PO7: Cooperation/Team Work Ability to collaborate with diverse teams in an effective and respectful manner; capacity to cooperate with people from varied backgrounds in the interests of a common goal.

PO8: Research Related Skills The ability to formulate appropriate questions, problems, and hypotheses by analysing and interpreting the ideas from various branches of mathematics; ability to demonstrate the results, theories, techniques and proofs using the concepts of various fields of mathematics.

PO9: Problem Solving Ability to work independently and do in-depth study to find ways that mathematics is used in various industries and in daily life to improve job possibilities in a wide range of fields and

academic study; ability to use innovative, imaginative, lateral thinking, interpersonal skills, and emotional intelligence; ability to tackle various challenges in both familiar and unfamiliar circumstances, then apply what they've learned to actual scenarios.

PO10: Critical Thinking Capability to analyse and synthesise theoretical and applied problems, as well as acquire knowledge and skills through logical reasoning, analytical thinking and evaluations; ability to find gaps and logical faults in arguments; inculcate a healthy attitude to be a lifelong learner.

Programme Specific Outcomes:

The Programme Specific Outcomes of FYUGP programme in Mathematics are listed in the following. After completing the programme the students will be able to

PSO1: Demonstrate the acquisition of comprehensive knowledge and coherent understanding in chosen elective and core subjects in mathematics.

PSO2: Apply mathematical techniques and tools, such as mathematical modeling, computational methods, and statistical analysis, to solve real-world problems in various fields.

PSO3: Possess strong analytical and critical thinking skills, enabling them to construct rigorous logical arguments, develop proofs, and solve complex mathematical problems.

PSO4: Proficient in using modern mathematical software and computational tools such as MATLAB, C, and other relevant technologies to analyze data and solve mathematical problems.

PSO5: Communicate mathematical ideas and solutions to a variety of audiences, including mathematicians, scientists, engineers, and non-specialists, both orally and in writing.

PSO6: Formulate research questions, literature review, methodology, presentation of findings, and demonstrate dedication to lifelong learning and professional development.

PSO7: Utilize the skills that necessary for success in national level competitive exams, pursuing doctoral research degree, teaching and others.

Teaching Learning Process:

The outcome-based approach demands a considerable transition from teacher centric to learner centric pedagogies, as well as from passive to active/participatory pedagogies, especially in the context of undergraduate study. This course promotes the systematic and sequential acquisition of knowledge and skills. It also focuses on practical abilities, as well as an awareness of the link between theory and practice. Teaching strategies involve discussions, presentations, use of required textbooks, e-learning tools, other self-study materials; project, internship, exploring industrial needs and other research activities and so on.

Semester	Course Code	Title of the Paper &Paper Code	Credit	Page
I (FIRST)	**MATH-MAJ-4-101**	Calculus and Classical Algebra	4	9
	MATH-MIN-4-101	Differential Calculus	4	15
	MATH-GEC-3-101	Foundation in Mathematics-I	3	20-21
	AEC	AEC Language: MIL/ Regional Language	4	
	MATH-SEC-3-101	Computer Laboratory-I	3	25-26
	VAC	Value Added Course 1	2	
		Total Credit	**20**	
II (SECOND)	**MATH-MAJ-4-201**	Real Analysis & Differential Equation	4	30
	MATH-MIN-4-201	Real Analysis	4	35
	MATH-GEC-3-201	Foundation in Mathematics-II	3	40
	AEC	AEC: Language and Communication Skills (English) II	4	
	MATH-SEC-3-201	Computer Laboratory-II	3	45-46
	VAC	Value Added Course 2	2	
		Total Credit	**20**	
III (THIRD)	**MATH-MAJ-4-301**	Theory of Real functions	4	50-51
	MATH-MAJ-4-302	Group Theory I	4	55
	MATH-MIN-4-301	Differential Equations	4	60
	MATH-GEC-3-301	Combinatorial Mathematics	3	65
	MATH-SEC-3-301	Mathematical Logic	3	69
	VAC	Value Added Course 3	2	
		Total Credit	**20**	
IV (FOURTH)	**MATH-MAJ-4-401**	Numerical Methods	4	74-75
	MATH-MAJ-4-402	Riemann Integration & Series of Functions	4	80
	MATH-MAJ-4-403	Ring Theory and Linear Algebra I	4	85
	MATH-MAJ-4-404	PDE and Systems of ODE	4	90
	MATH-MIN-4-401	Algebra	4	95
		Total Credit	**20**	

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Calculus and Classical Algebra**
Course Code	**:**	**MATH-MAJ-4-101**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Pre-requisite:

- Ideal of fundamentals of differentiation and integration,
- Trigonometric and logarithmic functions,
- Arithmetic.

Course Objectives:

The course introduces learners to the applications of De Moivre's theorem and expansions of trigonometric and hyperbolic functions. Students will learn techniques of successive differentiation, Leibnitz theorem, and L'Hospital's rule for solving problems in differential calculus. The course also explains reduction formulae for various trigonometric and logarithmic integrals and their applications. Further, it develops foundational understanding of functions, mathematical induction, divisibility, congruence relations, and elementary number theory. The course introduces systems of linear equations, row reduction methods, vector equations, and concepts of linear dependence and independence. In addition, the course familiarizes students with contributions of Classical Indian Mathematics, including trigonometric methods, algebraic rules, and works of ancient Indian mathematicians.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Apply De Moivre's theorem to solve problems involving complex numbers.

- ILO 1.1: Demonstrate the use of De Moivre's theorem in finding powers and roots of complex numbers.
- ILO 1.2: Solve problems involving rational indices using trigonometric form of complex numbers.

CO2: Discuss expansions of trigonometric and hyperbolic functions.

- ILO 2.1: Derive the expansions of sine, cosine, hyperbolic sine, and hyperbolic cosine functions.
- ILO 2.2: Apply Gregory's series in solving related mathematical problems.

CO3: Apply successive differentiation and Leibnitz theorem in differential calculus.

- ILO 3.1: Find higher-order derivatives using successive differentiation techniques.
- ILO 3.2: Apply Leibnitz theorem to evaluate derivatives of product functions.

CO4: Utilize L'Hospital's rule in evaluating limits.

- ILO 4.1: Evaluate limits involving indeterminate forms using L'Hospital's rule.
- ILO 4.2: Analyze problems where L'Hospital's rule is applicable.

CO5: Derive and apply reduction formulae for integration problems.

- ILO 5.1: Develop reduction formulae involving trigonometric integrals.
- ILO 5.2: Apply reduction formulae to evaluate logarithmic and mixed trigonometric integrals.

CO6: Explain concepts related to functions and mathematical induction.

- ILO 6.1: Describe composite and invertible functions with suitable examples.
- ILO 6.2: Apply the principle of mathematical induction to prove mathematical statements.

CO7: Describe divisibility properties and elementary number theory concepts.

- ILO 7.1: Explain the well-ordering property, division algorithm, and Euclidean algorithm.
- ILO 7.2: State the Fundamental Theorem of Arithmetic and apply divisibility concepts in problem solving.

CO8: Apply congruence relations in modular arithmetic.

- ILO 8.1: Explain congruence relations and their algebraic properties.
- ILO 8.2: Solve problems involving modular arithmetic and congruences.

CO9: Demonstrate row reduction and echelon form of matrices.

- ILO 9.1: Perform elementary row operations to obtain row echelon form.
- ILO 9.2: Reduce matrices to reduced row echelon form for solving systems.

CO10: Solve systems of linear equations using matrix methods.

- ILO 10.1: Solve linear systems using matrix equation Ax=bAx=bAx=b.
- ILO 10.2: Interpret the solution set of a linear system using row reduction techniques.

CO11: Explain vector equations and linear dependence of vectors.

- ILO 11.1: Represent systems using vector equations and matrix equations.
- ILO 11.2: Determine linear dependence and independence of vectors.

CO12: Discuss contributions of Classical Indian Mathematics.

- ILO 12.1: Explain ancient Indian approaches to trigonometry, sine tables, and approximation methods.
- ILO 12.2: Describe Bhaskaracharya's contributions and apply traditional algebraic rules in solving equations.

Mapping of CO's with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO7, CO12	CO2	X	X	CO5	X
Conceptual	CO6, CO8	CO11	CO3, CO9, CO10	X	CO4	X
Procedural	X	CO1	CO5, CO10	X	CO9	X
Metacognitive	X	X	X	X	X	X

Mapping of Course outcome to Programme outcome:

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓				
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				
CO5	✓	✓	✓	✓				
CO6	✓	✓	✓	✓		✓		

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO7	✓	✓	✓	✓				
CO8	✓	✓	✓	✓				
CO9	✓	✓	✓	✓	✓			
CO10	✓	✓	✓	✓	✓	✓		
CO11	✓	✓	✓	✓	✓	✓		
CO12	✓		✓	✓		✓	✓	✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (10 Marks)	De Moivre's Theorem with rational indices and its application to various problems, Expansion of sinx, cosx, sinhx and coshx and related problems, Gregory's series and its application Trignometry in Classical India: Sine table, value of sin (x+ Ɛ) and approximate to first and second derivative of sin x. Derivation of Rsine, first and second order differences for Rsines	09	03	-	12
II (10 Marks)	Successive Differentiation, Leibnitz Theorem and its application, L'Hospital's Rule.	09	03	-	12
III (10 Marks)	Derivation of reduction formulae of the types $\int \sin^n x\,dx$, $\int_0^{\frac{\pi}{2}} sin^n\, xdx$, $\int \cos^n x\,dx$, $\int_0^{\frac{\pi}{2}} cos^n\, xdx$, $\int \tan^n x\,dx$, $\int_0^{\frac{\pi}{2}} tan^n\, xdx$,$\int (\log x)^n dx$ and $\int \sin^m x \cos^n x\,dx$ and applicatioins.	09	03	-	12
IV (16 Marks)	Composite and invertible functions, Principle of Mathematical Induction and its application, well ordering property of positive integers, Division algorithm, Divisibility & Euclidean algorithm, Congruence relation between integers, Fundamental Theorem of Arithmetic.	09	03	-	12
V (14 Marks)	System of Linear Equations, Row Reduction and Echelon Form, Vector Equation and matrix equation Ax=b. Solution set of a linear system, Linear Dependence and Independence of vectors. A brief history of Bhaskaracharaya. The Six rules for positive and negative numbers, The Six rules for Zero, The Six rules for algebraic numbers, Equation of the form Ax+c=by, Equation with one unknown. The ten questions.	09	03	-	12
	Total	**45**	**15**	**-**	**60**

Where L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Das, B.C. & Mukherjee, B.N., *Higher Trigonometry*, U N Dhur & Sons, 1933.
2. Thomas, G.B. & Finney, R.L., *Calculus*, Pearson Education, 2007.
3. Burton, D.M., *Elementary Number Theory*, McGraw Hill, 7th Ed., 2023.
4. Lay, David C., Lay, S.R. & McDonald, J.J., *Linear Algebra and Its Application*, Pearson, 2015.

REFERENCE BOOKS:

1. Arumugam, S., Somasundaram, A. & Isaac, A.T., *Differential Calculus*, CBS Publishers, 2021.
2. Greenhill, A.G., *Differential and Integral Calculus*, Alpha Edition, 2020.
3. Khanna, V.K. & Bhambri, S.K., *Abstract Algebra*, Vikash Publishing, 2017.
4. Bressoud, D., "Was Calculus Invented in India?", *The College Mathematics Journal*, Vol. 33, No. 1, 2002, pp. 2–13.
5. Sarma, K.V., Ramasubramanian, K., Srinivas, M.D. & Sriram, M.S., *Yuktibhāṣā of Jyeṣṭhadeva: Ganita (Volume I – Mathematics)*, Hindustan Book Agency, 2008.
6. Datta, B. & Singh, A.N., *Hindu Mathematics*, Asia Publishing House, New Delhi.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Calculus and Classical Algebra**
Course Code	**:**	**MATH-MIN-4-101**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites:

1. Basic knowledge of algebra, trigonometry, functions, and coordinate geometry.
2. Introductory understanding of differential calculus, matrices, and determinants at the Higher Secondary (10+2) level.
3. Ability to apply logical reasoning and basic mathematical problem-solving techniques.

Course Objectives:

The course introduces learners to the applications of De Moivre's theorem and expansions of trigonometric and hyperbolic functions. It develops the concepts of systems of linear equations, matrices, vector equations, and linear dependence and independence of vectors. The course also provides foundational understanding of functions, mathematical induction, divisibility, congruence relations, and elementary number theory. Further, the course introduces Rolle's theorem, Mean Value theorems, Taylor's theorem, Taylor and Maclaurin series, maxima and minima, and indeterminate forms to strengthen students' understanding of differential calculus and analytical methods.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Apply De Moivre's theorem to solve problems involving complex numbers.

- ILO 1.1: Demonstrate the use of De Moivre's theorem in finding powers and roots of complex numbers.
- ILO 1.2: Solve problems involving rational indices using trigonometric form of complex numbers.

CO2: Discuss expansions of trigonometric and hyperbolic functions.

- ILO 2.1: Derive the expansions of sine, cosine, hyperbolic sine, and hyperbolic cosine functions.
- ILO 2.2: Apply Gregory's series in solving related mathematical problems.

CO3: Demonstrate row reduction and echelon form of matrices.

- ILO 3.1: Perform elementary row operations to obtain row echelon form.
- ILO 3.2: Reduce matrices to reduced row echelon form for solving systems.

CO4: Solve systems of linear equations using matrix methods.

- ILO 4.1: Solve linear systems using matrix equation Ax=bAx=bAx=b.
- ILO 4.2: Interpret the solution set of a linear system using row reduction techniques.

CO5: Explain vector equations and linear dependence of vectors.

- ILO 5.1: Represent systems using vector equations and matrix equations.
- ILO 5.2: Determine linear dependence and independence of vectors.

CO6: Explain concepts related to functions and mathematical induction.

- ILO 6.1: Describe composite and invertible functions with suitable examples.
- ILO 6.2: Apply the principle of mathematical induction to prove mathematical statements.

CO7: Describe divisibility properties and elementary number theory concepts.

- ILO 7.1: Explain the well-ordering property, division algorithm, and Euclidean algorithm.
- ILO 7.2: State the Fundamental Theorem of Arithmetic and apply divisibility concepts in problem solving.

CO8: Apply congruence relations in modular arithmetic.

- ILO 8.1: Explain congruence relations and their algebraic properties.
- ILO 8.2: Solve problems involving modular arithmetic and congruences.

CO9: Apply Rolle's theorem and Mean Value theorems in differential calculus.

- ILO 9.1: State and explain Rolle's theorem and Lagrange's Mean Value theorem.
- ILO 9.2: Apply Mean Value theorems to solve analytical problems.

CO10: Utilize Taylor's theorem and series expansions.

- ILO 10.1: Derive Taylor's and Maclaurin's series for standard functions.
- ILO 10.2: Apply Taylor's theorem with Lagrange's and Cauchy's forms of remainder in problem solving.

CO11: Evaluate maxima, minima, and indeterminate forms.

- ILO 11.1: Determine maxima and minima of functions using derivative tests.
- ILO 11.2: Evaluate indeterminate forms using appropriate analytical methods.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	**Remembering**	**Understanding**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual	CO7	CO2	X	X	CO10	X
Conceptual	CO6, CO8	CO5	CO3, CO4	X	CO9	X
Procedural	X	CO1	CO10, CO11	X	CO3	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	**PO1 Knowledge**	**PO2 Problem Analysis**	**PO3 Critical Thinking**	**PO4 Mathematical Skills**	**PO5 Modern Tools**	**PO6 Communication**	**PO7 Ethics & Values**	**PO8 Lifelong Learning**
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓				
CO3	✓	✓	✓	✓	✓			
CO4	✓	✓	✓	✓	✓	✓		
CO5	✓	✓	✓	✓	✓	✓		
CO6	✓	✓	✓	✓		✓		
CO7	✓	✓	✓	✓				
CO8	✓	✓	✓	✓				

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO9	✓	✓	✓	✓				
CO10	✓	✓	✓	✓				✓
CO11	✓	✓	✓	✓				✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	De Moivre's Theorem with rational indices and its application to various problems, Expansion of sinx, cosx, sinhx and coshx and related problems, Gregory's series and its application Trignometry in Classical India: Sine table, value of sin (x+ Ɛ) and approximate to first and second derivative of sin x. Derivation of Rsine, first and second order differences for Rsines.	09	03	-	12
II (14 Marks)	System of Linear Equations, Row Reduction and Echelon Form, Vector Equation and matrix equation Ax=b. Solution set of a linear system, Linear Dependence and Independence of vectors.	09	03	-	12
III (18 Marks)	Composite and invertible functions, Principle of Mathematical Induction and its application, well ordering property of positive integers, Division algorithm, Divisibility & Euclidean algorithm, Congruence relation between integers, Fundamental Theorem of Arithmetic.	12	04	-	16
IV (16 Marks)	Rolle's theorem, Mean Value theorems, Taylor's theorem with Lagrange's and Cauchy's forms of remainder, Taylor's series, Maclaurin's series of sin x, cos x, e^x, log(l+x), $(l+x)^m$, Maxima and Minima, Indeterminate forms. A brief history of Bhaskaracharaya. The Six rules for positive and negative numbers, The Six rules for Zero, The Six rules for algebraic numbers, Equation of the form Ax+c=by, Equation with one unknown. The ten questions.	15	05	-	20
	Total	**45**	**15**	**-**	**60**

Where L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

5. Das, B.C. & Mukherjee, B.N., *Higher Trigonometry*, U N Dhur & Sons, 1933.
6. Thomas, G.B. & Finney, R.L., *Calculus*, Pearson Education, 2007.
7. Burton, D.M., *Elementary Number Theory*, McGraw Hill, 7th Ed., 2023.
8. Lay, David C., Lay, S.R. & McDonald, J.J., *Linear Algebra and Its Application*, Pearson, 2015.

REFERENCE BOOKS:

7. Arumugam, S., Somasundaram, A. & Isaac, A.T., *Differential Calculus*, CBS Publishers, 2021.
8. Greenhill, A.G., *Differential and Integral Calculus*, Alpha Edition, 2020.
9. Khanna, V.K. & Bhambri, S.K., *Abstract Algebra*, Vikash Publishing, 2017.
10. Bressoud, D., "Was Calculus Invented in India?", *The College Mathematics Journal*, Vol. 33, No. 1, 2002, pp. 2–13.
11. Sarma, K.V., Ramasubramanian, K., Srinivas, M.D. & Sriram, M.S., *Yuktibhāṣā of Jyeṣṭhadeva: Ganita (Volume I – Mathematics)*, Hindustan Book Agency, 2008.
12. Datta, B. & Singh, A.N., *Hindu Mathematics*, Asia Publishing House, New Delhi.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Foundation in Mathematics-I**
Course Code	**:**	**MATH-GEC-3-101**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of algebra, trigonometry, and coordinate geometry.
2. Familiarity with functions, graphs, and elementary calculus concepts at the Higher Secondary (10+2) level.
3. Ability to apply logical reasoning and basic mathematical problem-solving techniques.

Course Objectives:

The course introduces learners to the fundamental concepts of sets, logic, relations, and functions. It develops understanding of propositional logic, quantifiers, and logical reasoning techniques. The course also provides foundational knowledge of limits, continuity, differentiability, derivatives, maxima and minima, and introductory integration. Further, it introduces ordinary differential equations, methods of solving first-order differential equations, and homogeneous and non-homogeneous linear differential equations of second order with constant coefficients.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the fundamental concepts of sets and logic.

- ILO 1.1: Describe sets, subsets, Cartesian products, and operations on sets.
- ILO 1.2: Analyze logical statements using truth tables, quantifiers, tautologies, and contradictions.

CO2: Apply propositional logic in mathematical reasoning.

- ILO 2.1: Differentiate between converse, contrapositive, and inverse propositions.
- ILO 2.2: Establish propositional equivalence using logical laws.

CO3: Describe relations and functions and their properties.

- ILO 3.1: Explain different types of relations and functions with suitable examples.
- ILO 3.2: Represent functions graphically and analyze their properties.

CO4: Apply compositions and inverses of functions and binary operations.

- ILO 4.1: Determine compositions and inverses of functions.
- ILO 4.2: Explain binary operations and their algebraic properties.

CO5: Apply concepts of limits, continuity, and differentiability.

- ILO 5.1: Evaluate limits and determine continuity of functions.
- ILO 5.2: Analyze differentiability of functions using derivative concepts.

CO6: Utilize derivatives in problem solving.

- ILO 6.1: Compute derivatives and second-order derivatives of functions.
- ILO 6.2: Solve problems involving rate of change, maxima, and minima.

CO7: Explain basic concepts of integration and applications.

- ILO 7.1: Describe the concept of integration and fundamental integration techniques.
- ILO 7.2: Apply integrals in solving elementary application-based problems.

CO8: Solve first-order differential equations using standard methods.

- ILO 8.1: Solve differential equations using separation of variables.
- ILO 8.2: Solve homogeneous and linear differential equations of first order.

CO9: Solve second-order linear differential equations with constant coefficients.

- ILO 9.1: Obtain general and particular solutions of homogeneous differential equations.
- ILO 9.2: Solve non-homogeneous linear differential equations with constant coefficients.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO3	X	X	CO7	X
Conceptual	CO2	CO4	CO5	X	CO6	X
Procedural	X	CO5, CO8	CO6, CO9	X	CO8	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓			✓		
CO2	✓	✓	✓			✓		
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				
CO5	✓	✓	✓	✓				
CO6	✓	✓	✓	✓				
CO7	✓	✓	✓	✓				✓
CO8	✓	✓	✓	✓				✓
CO9	✓	✓	✓	✓				✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I **(11 Marks)**	**Sets and Logic** Sets, subsets, types of set, operations on sets, Cartesian product, Statements, truth values and truth table, negation, conjunction and disjunction, Statements with quantifiers, compound statements, implications, biconditional proposition, converse, contrapositive and inverse proposition, propositional equivalence, predicates and quantifier, tautology and contradiction. Philosophical foundation of set theory in Indian logic.	06	03	-	9
II **(19 Marks)**	**Relation and Functions** Relation and functions, types of relation and functions, graphs of functions, compositions of functions and invertible function, Binary operations. Nyāya and Vaiśeṣika Systems, Discussion of sambandha (relation) - samavāya (inherence), saṃyoga (contact), and samaveta-samavāya .	08	04	-	12
III **(15 Marks)**	**Calculus** Limits, continuity, Differentiability of function, Derivatives of different types of functions, second order derivatives, rate of change of quantities, increasing and decreasing function, Maxima and Minima, introduction to Integrals, Applications of integrals. Historical Foundations of Calculus in India, Explanations involving infinitesimal increments and	08	04	-	12

	convergence in Yuktibhasa, Siddhānta Shiromani by Bhāskara II, Mādhava's Series for π, sin(x), cos(x), and arctan(x).				
IV (15 Marks)	General and particular solutions of differential equations, separation of variables, Homogeneous equations, Linear Differential Equations of first order, General and particular solutions of homogeneous and non-homogeneous linear differential equations of second order with constant coefficients. Bhāskara's treatment of changing quantities; Concept of Tatkalika Gati, Madhava's iterative corrections intrigonometric series.	08	04	-	12
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Kumar, A., Kumaresan, S. & Sarma, B.K., *A Foundation Course in Mathematics*, Narosa Publishing House, 2018.
2. Stewart, I. & Tall, D., *The Foundations of Mathematics*, Oxford University Press, 2nd Ed., 2015.

REFERENCE BOOKS:

1. Sarma, K.V., *A History of the Kerala School of Hindu Astronomy*, Vishveshvarananda Institute of Sanskrit and Indological Studies, Panjab University, Hoshiarpur.
2. Matilal, B.K., *Navya–Nyaya Doctrine of Negation – Semantics & Ontology of Negative Statements: The Semantics and Ontology of Negative Statements in Navya-Nyaya Philosophy (Harvard Oriental Series)*, Harvard University Press, 1990.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Computer Laboratory-I**
Course Code	**:**	**MATH-SEC-3-101**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=0, T=0, P=3)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of algebra, trigonometry, matrices, and coordinate geometry.
2. Familiarity with elementary calculus concepts including functions, derivatives, and integration.
3. Basic computer handling skills and logical problem-solving ability.

Course Objectives:

The course introduces learners to the use of mathematical software such as MATLAB or Mathematica for solving algebraic and graphical problems. It develops practical skills in evaluating mathematical expressions, solving equations, and visualizing functions and curves. The course also familiarizes students with parametric curves, surfaces of revolution, conic sections, and matrix operations through computational techniques and graphical representation.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Demonstrate the use of basic commands in MATLAB or Mathematica.

- ILO 1.1: Execute basic computational commands and mathematical operations using software tools.
- ILO 1.2: Utilize built-in functions for algebraic, trigonometric, logarithmic, and graphical computations.

CO2: Evaluate mathematical expressions and solve algebraic equations computationally.

- ILO 2.1: Compute arithmetic, exponential, logarithmic, and trigonometric expressions using software.
- ILO 2.2: Solve algebraic and simultaneous linear equations using computational methods.

CO3: Plot and analyze graphs of elementary functions.

- ILO 3.1: Plot graphs of exponential, logarithmic, trigonometric, and rational functions.
- ILO 3.2: Analyze the effect of parameters on the graphical behavior of functions.

CO4: Visualize polynomial functions and their derivatives.

- ILO 4.1: Plot polynomial functions of higher degree and their derivatives.
- ILO 4.2: Compare graphs of functions, first derivatives, and second derivatives.

CO5: Apply computational techniques to parametric curves and arc length.

- ILO 5.1: Sketch parametric curves such as cycloids and epicycloids.
- ILO 5.2: Compute arc lengths and areas of surfaces of revolution.

CO6: Sketch and analyze conic sections and quadric surfaces.

- ILO 6.1: Trace conics in Cartesian and polar coordinates.
- ILO 6.2: Visualize quadric surfaces such as ellipsoids and hyperboloids using software tools.

CO7: Perform matrix operations using computational software.

- ILO 7.1: Carry out matrix operations including addition, multiplication, transpose, and inverse.
- ILO 7.2: Apply matrix operations in solving mathematical problems computationally.

Mapping of COs with Bloom's Taxonomy:

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO3	X	X	CO6	X
Conceptual	CO2	CO5	CO4	X	CO7	X
Procedural	X	CO1, CO2	CO5, CO7	X	CO4	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs):

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓		✓	✓			
CO2	✓	✓	✓	✓	✓			
CO3	✓	✓	✓	✓	✓			
CO4	✓	✓	✓	✓	✓			
CO5	✓	✓	✓	✓	✓			✓
CO6	✓	✓	✓	✓	✓			✓
CO7	✓	✓	✓	✓	✓			✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (19 Marks)	Basic commands of Matlab or Mathematica, Evaluation of different mathematical Expressions, Solutions of algebraic equation. **List of Practicals** 1. Basic commands of Matlab or Mathematica: clc, help, clear, format, exit, line space, zeros, ones, meshgrid, eye, rand, real, imag, angle, conj, commands for trigonometric and inverse trigonometric function, abs, exp, sqrt, log, log2, log10, mod, plot, title, legend, hold on, axis, grid on, figure, clf, close all. 2. Evaluation of arithmetic expression, exponential and logarithms, trigonometric functions, computation of complex numbers. 3. Solution of algebraic equation, simultaneous linear equations.	-	00	15x2	30
II (11 Marks)	Parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution. **List of Practicals** 1. Plotting of graphs of function e^ax+b , log(ax + b), 1/(ax + b), sin(ax + b), cos(ax +b), |ax + b| and to illustrate the effect of a and b on the graph. 2. Plotting the graphs of polynomials of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.	-	00	07x2	14
III (11 Marks)	Techniques of sketching conics, polar equation of conics **List of Practicals** 1. Sketching parametric curves (E.g., Trochoid, cycloid, epicycloids, hypocycloid). 2. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic paraboloid, hyperbolic paraboloid using cartesian coordinates.	-	00	08x2	16

IV (19 Marks)	Surface and volume of revolution, polar equation of conics, Matrix operations. **List of Practicals** 1. Obtaining surface of revolution of curves. 2. Tracing of conics in Cartesian coordinates/ polar coordinates. 3. Matrix operations (addition, multiplication, inverse, transpose).	-	00	15x2	30
	Total			**45X2**	**90**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Pratap Rudra, *Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers*, Oxford University Press, 2010.
2. Wolfram, S., *The Mathematica*, Cambridge University Press, 2003.
3. Thomas, G.B. & Finney, R.L., *Calculus*, 9th Ed., Pearson Education, Delhi, 2005

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Real Analysis and Differential Equations**
Course Code	**:**	**MATH-MAJ-4-201**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks:		**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of algebra, functions, sequences, and elementary calculus.
2. Familiarity with differentiation, integration, and introductory differential equations.
3. Ability to apply logical reasoning and mathematical proof techniques.

Course Objectives:

The course introduces learners to the foundational concepts of Real Analysis, including properties of real numbers, sequences, convergence, and infinite series. It develops rigorous understanding of boundedness, completeness, limit points, and convergence criteria. The course also provides knowledge of ordinary differential equations, methods of solving first-order and higher-order differential equations, and applications of Wronskian, variation of parameters, and related analytical techniques.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain algebraic and order properties of the real number system.

- ILO 1.1: Describe boundedness, supremum, infimum, and completeness properties of R\mathbb{R}R.
- ILO 1.2: Explain Archimedean property, density of rational and irrational numbers, and intervals in R\mathbb{R}R.

CO2: Analyze countability and topological properties of subsets of real numbers.

- ILO 2.1: Differentiate between countable and uncountable sets with examples.
- ILO 2.2: Identify limit points, isolated points, and apply Bolzano-Weierstrass theorem for sets.

CO3: Apply concepts of sequences and convergence.

- ILO 3.1: Determine convergence and boundedness of sequences.
- ILO 3.2: Apply limit theorems and Monotone Convergence Theorem in sequence analysis.

CO4: Explain subsequences, Cauchy sequences, and infinite series.

- ILO 4.1: Analyze subsequences and apply Bolzano-Weierstrass theorem for sequences.
- ILO 4.2: Test convergence and divergence of infinite series using Cauchy criterion.

CO5: Solve first-order differential equations using standard techniques.

- ILO 5.1: Solve separable, homogeneous, and exact differential equations.
- ILO 5.2: Apply integrating factors and Bernoulli's method to solve linear differential equations.

CO6: Solve higher-order linear differential equations with constant coefficients.

- ILO 6.1: Obtain general solutions of homogeneous differential equations of higher order.
- ILO 6.2: Solve non-homogeneous linear differential equations using standard methods.

CO7: Apply advanced methods for solving differential equations.

- ILO 7.1: Solve Euler's equations and apply the method of undetermined coefficients.
- ILO 7.2: Apply variation of parameters and Wronskian in solving differential equations.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	**Remembering**	**Understanding**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual	CO1	CO2	X	X	CO4	X
Conceptual	CO3	CO5	CO6	X	CO7	X
Procedural	X	CO3, CO5	CO6, CO7	X	CO5	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓		✓		
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				✓
CO5	✓	✓	✓	✓				
CO6	✓	✓	✓	✓				✓
CO7	✓	✓	✓	✓		✓		✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	Algebraic and Order Properties of R, neighborhood of a point in R, Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of R, The Archimedean Property, Density of Rational (and Irrational) numbers in R, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets. Summation of series: Sum of natural numbers; Summation of squares; Summation of third and fourth powers; General principle of summation; Repeated summations.	12	04	-	16
II (15 Marks)	Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion. Statements of Infinite series, convergence and divergence of infinite series, Cauchy Criterion.	12	04	-	16
III (10 Marks)	Review of Differential equation, definition, formation of differential equation, separation of variables, homogeneous equation, Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations. Approximate to first and second derivative of sin x.	09	03	-	12
IV (20 Marks)	Linear differential equation with constant coefficients, General solution of homogeneous equation of second order, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters, Wronskian: its properties and applications.	12	04	-	16
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Bartle, R.G. & Sherbert, D.R., *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Malik, S.C. & Arora, S., *Mathematical Analysis*, New Age International Publishers, New Delhi, 1992.
3. Ross, S.L., *Differential Equations*, 3rd Ed., John Wiley and Sons, India, 2004.

REFERENCE BOOKS:

1. Raisinghania, M.D., *Ordinary and Partial Differential Equations*, S. Chand Publishing, New Delhi, 2013.
2. Sarma, K.V. (Trans.), *Yuktibhāṣā of Jyeṣṭhadeva: Ganita (Volume I – Mathematics)*, with notes by K. Ramasubramanian, M.D. Srinivas & M.S. Sriram, Hindustan Book Agency, 2008.
3. Bressoud, D., "Was Calculus Invented in India?", *The College Mathematics Journal*, Vol. 33, No. 1, 2002, pp. 2–13.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Real Analysis**
Course Code	**:**	**MATH-MIN-4-201**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks:		**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of algebra, functions, and elementary set theory.
2. Familiarity with sequences, limits, and introductory calculus concepts.
3. Ability to apply logical reasoning and mathematical proof techniques.

Course Objectives:

The course introduces learners to the foundational concepts of Real Analysis, including finite and infinite sets, countability, properties of real numbers, and boundedness. It develops understanding of real sequences, convergence criteria, monotone sequences, and infinite series. The course also familiarizes students with convergence tests for series and concepts of absolute and conditional convergence.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the fundamental properties of the real number system.

- ILO 1.1: Describe finite, infinite, countable, and uncountable sets with examples.
- ILO 1.2: Explain bounded sets, supremum, infimum, completeness property, and Archimedean property of R\mathbb{R}R.

CO2: Analyze topological properties of subsets of real numbers.

- ILO 2.1: Identify intervals and cluster points in subsets of real numbers.
- ILO 2.2: State and apply the Bolzano-Weierstrass theorem in relevant problems.

CO3: Apply concepts of sequences and convergence.

- ILO 3.1: Determine boundedness and convergence of real sequences.
- ILO 3.2: Apply Cauchy convergence criterion and limit theorems for sequences.

CO4: Explain monotone sequences and their convergence properties.

- ILO 4.1: Analyze monotone sequences and their boundedness.
- ILO 4.2: Apply the Monotone Convergence Theorem to determine convergence.

CO5: Explain convergence and divergence of infinite series.

- ILO 5.1: Apply Cauchy convergence criterion for infinite series.
- ILO 5.2: Analyze convergence of geometric series, p-series, and alternating series.

CO6: Apply standard tests of convergence for infinite series.

- ILO 6.1: Use comparison, root, and ratio tests to determine convergence of series.
- ILO 6.2: Apply Leibnitz's test for alternating series.

CO7: Differentiate between absolute and conditional convergence.

- ILO 7.1: Define absolute and conditional convergence with suitable examples.
- ILO 7.2: Analyze convergence behavior of series using appropriate convergence tests.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO2	X	X	CO7	X
Conceptual	CO3	CO4	CO5	X	CO6	X
Procedural	X	CO3, CO5	CO6, CO7	X	CO5	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓		✓		
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				✓
CO5	✓	✓	✓	✓				
CO6	✓	✓	✓	✓				✓
CO7	✓	✓	✓	✓		✓		✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (15 Marks)	Finite and infinite sets, examples of countable and uncountable sets, Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.	09	03	-	12
II (19 Marks)	Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences, Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof). From Zero to Infinity: Mathematics in Jain and Buddhist Literature; The Ten Questions and Answers; Arithmetics of Fractions; Progression (series), AP series, GP series	15	05	-	20
III (11 Marks)	Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, convergence of pseries, alternating series,	09	03	-	12
IV (15 Marks)	Comparison test, Root test, Ratio test, Leibnitz's test (Tests of Convergence without proof). Definition and examples of absolute and conditional convergence.	12	04	-	16
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Bartle, R.G. & Sherbert, D.R., *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Malik, S.C. & Arora, S., *Mathematical Analysis*, New Age International Publishers, New Delhi, 1992.

REFERENCE BOOKS:

1. Patwardhan, K. S., Naimpally, S. A., & Singh, S. N. (Eds./Trans.). *Lilavati of Bhaskaracharya*. Motilal Banarsidass.
2. Sarma, K. V. (Trans.). (2008). *Yuktibhāṣā of Jyeṣṭhadeva: Ganita (Volume I – Mathematics)* (K. Ramasubramanian, M. D. Srinivas, & M. S. Sriram, Notes). Hindustan Book Agency.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Foundation in Mathematics-II**
Course Code	**:**	**MATH-GEC-3-201**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of algebra, sets, and functions.
2. Familiarity with elementary probability and mathematical reasoning.
3. Ability to apply logical thinking and basic computational techniques in problem solving.

Course Objectives:

The course introduces learners to fundamental counting principles and combinatorial techniques including permutations, combinations, multinomial theorem, and inclusion-exclusion principle. It develops understanding of finite differences and interpolation methods for numerical approximation. The course also provides foundational knowledge of probability theory, random variables, and probability distributions. Further, it introduces basic statistical concepts and measures of central tendency.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Apply counting principles in combinatorial problems.

- ILO 1.1: Use sum and product rules in counting problems.
- ILO 1.2: Solve problems involving permutations, combinations, and multinomial theorem.

CO2: Explain advanced combinatorial techniques.

- ILO 2.1: Apply Pigeonhole Principle in mathematical problems.

- ILO 2.2: Use inclusion-exclusion principle and set partitions in counting problems.

CO3: Apply finite difference operators and interpolation methods.

- ILO 3.1: Compute forward, backward, and central differences using finite difference operators.
- ILO 3.2: Explain the role of operators EEE and DDD in finite differences.

CO4: Utilize interpolation formulae for numerical approximation.

- ILO 4.1: Apply Newton's forward and backward interpolation formulae.
- ILO 4.2: Use Lagrange's interpolation formula for estimating unknown values.

CO5: Explain the fundamental concepts of probability.

- ILO 5.1: Define random experiments, events, and axiomatic probability.
- ILO 5.2: Apply conditional probability and multiplication theorem in problem solving.

CO6: Apply Bayes' theorem and probability distributions.

- ILO 6.1: Explain Bayes' theorem and its applications.
- ILO 6.2: Describe random variables and probability distributions with examples.

CO7: Explain basic concepts of statistics and measures of central tendency.

- ILO 7.1: Describe the scope and importance of statistics.
- ILO 7.2: Compute and interpret measures of central tendency.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO7	CO5	X	X	CO6	X
Conceptual	CO2	CO3	CO1, CO4	X	CO5	X
Procedural	X	CO1	CO4, CO6	X	CO7	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓				
CO3	✓	✓	✓	✓	✓			
CO4	✓	✓	✓	✓	✓			
CO5	✓	✓	✓	✓				
CO6	✓	✓	✓	✓		✓		
CO7	✓	✓	✓	✓		✓		✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (18 Marks)	**Counting Principles** Sum and Product rule of counting, permutation and combination, multinomial theorem, Pigeon hole principle, inclusion-exclusion principle, set partitions.	08	04	-	12
II (18 Marks)	**Finite Differences and Interpolation** Introduction, forward difference operator, Operators E & D, backward differences, central differences, Newton' forward and backward interpolation formulae, Lagrange's interpolation formula.	10	05	-	15
III (15 Marks)	**Probability** Introduction to probability, Random experiment, event, axiomatic approach to probability, conditional probability, Multiple theorem on probability, Bayes' theorem (Statement Only with Applications), random variables and distributions.	08	04	-	12
IV (9 Marks)	**Statistics** Introduction to statistics, Measure of Central Tendency.	04	02	-	06
	Total	**30**	**15**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Rao, G.S., *Numerical Analysis*, New Age International Publishers, 2003.
2. Berge, C., *Principles of Combinatorics*, New York, 1971.
3. Stewart, I. & Tall, D., *The Foundations of Mathematics*, Oxford University Press, 2015.
4. Shastry, S.S., *Introductory Methods of Numerical Analysis*, PHI, 2012.
5. Ross, S.M., *Introduction to Probability and Statistics for Engineers and Scientists*, Elsevier, 2021.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Computer Laboratory-II**
Course Code	**:**	**MATH-SEC-3-201**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=0, T=0, P=3)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of differential equations, sequences, and infinite series.
2. Familiarity with elementary calculus and mathematical modeling concepts.
3. Basic understanding of graph plotting and computational techniques.

Course Objectives:

The course introduces learners to mathematical modeling using differential equations in population growth, decay processes, pollution studies, epidemiology, and battle strategies. It develops practical skills in plotting and analyzing solution families, recursive sequences, and convergence behavior through computational methods. The course also familiarizes students with predator-prey systems, epidemic models, and graphical interpretation of convergence and divergence of sequences and infinite series.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain compartmental and exponential growth models.

- ILO 1.1: Describe compartmental models and exponential population growth.
- ILO 1.2: Analyze exponential decay models and their applications.

CO2: Apply mathematical models to environmental problems.

- ILO 2.1: Formulate and analyze lake pollution models with constant and seasonal flow.
- ILO 2.2: Interpret graphical solutions of environmental models computationally.

CO3: Analyze drug assimilation and limited population growth models.

- ILO 3.1: Model drug assimilation into the bloodstream for single and repeated doses.
- ILO 3.2: Explain limited population growth models with and without harvesting.

CO4: Apply predator-prey and epidemic models in biological systems.

- ILO 4.1: Analyze predator-prey interactions using Volterra-type models.
- ILO 4.2: Apply epidemic models to study the spread of infectious diseases.

CO5: Explain mathematical battle models and their applications.

- ILO 5.1: Describe basic battle models and warfare strategies mathematically.
- ILO 5.2: Analyze the effects of factors such as jungle warfare and long-range weapons.

CO6: Utilize computational techniques for graphical analysis of differential equations.

- ILO 6.1: Plot second-order and third-order solution families of differential equations.
- ILO 6.2: Interpret graphical behavior of mathematical models computationally.

CO7: Analyze recursive sequences and convergence graphically.

- ILO 7.1: Plot recursive sequences and study their convergence behavior.
- ILO 7.2: Identify convergent subsequences using graphical verification of Bolzano-Weierstrass theorem.

CO8: Examine convergence and divergence of infinite series through graphical methods.

- ILO 8.1: Plot sequences of partial sums for infinite series.
- ILO 8.2: Analyze convergence and divergence of series using graphical interpretation.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO3	X	X	CO5	X
Conceptual	CO2	CO4	CO6	X	CO7	X
Procedural	X	CO1, CO6	CO3, CO8	X	CO4	X

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓	✓		✓	
CO3	✓	✓	✓	✓	✓			
CO4	✓	✓	✓	✓	✓		✓	
CO5	✓	✓	✓	✓	✓		✓	
CO6	✓	✓	✓	✓	✓			✓
CO7	✓	✓	✓	✓	✓			✓
CO8	✓	✓	✓	✓	✓	✓		

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I **(18 Marks)**	Introduction to compartmental model, exponential growth of population, exponential decay model, lake pollution model (case study of Lake Burley Griffin). **List of Practicals** 1. Plotting of second order solution family of differential equation. 2. Plotting of third order solution family of differential equation. 3. Growth model (exponential case only). 4. Decay model (exponential case only). 5. Lake pollution model (with constant/seasonal flow and pollution concentration).	-	00	15x2	30
II **(9 Marks)**	Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), limited growth of population, limited growth with harvesting. **List of Practicals** 1. Case of single cold pill and a course of coldpills. 2. Limited growth of population (with and without harvesting). 1.	-	00	5x2	10
III **(15 Marks)**	Predatory-prey model, epidemic model of influenza, battle model. **List of Practicals** 2. Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two preyone predator). 3. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers). 4. Battle model (basic battle model, jungle warfare, long range weapons).	-	00	10x2	20

IV **(18 Marks)**	Plotting recursive sequences, convergence sequences, convergent subsequences, divergent sequences and infinite series 1. Plotting of recursive sequences. 2. Study the convergence of sequences through plotting. 3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot. 4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.	-	00	15x2	30
	Total			**45X2**	**90**

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Barnes, B. & Fulford, Glenn R., *Mathematical Modeling with Case Studies: A Differential Equation Approach using Maple and MATLAB*, 2nd Ed., Taylor and Francis Group, London and New York, 2009.
2. Abell, Martha L. & Braselton, James P., *Differential Equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004.

FOUR YEARS UNDER GRADUATE PROGRAMME In MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Theory of Real Functions**
Course Code	**:**	**MATH-MAJ-4-301**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of functions, sequences, and elementary calculus.
2. Familiarity with limits, continuity, and differentiation at the Higher Secondary (10+2) level.
3. Ability to apply logical reasoning and mathematical proof techniques.

Course Objectives:

The course introduces learners to rigorous concepts of limits, continuity, and differentiability of real-valued functions. It develops understanding of sequential criteria, convergence theorems, continuity on intervals, and uniform continuity. The course also provides knowledge of Rolle's theorem, Mean Value theorems, Taylor's theorem, Taylor and Maclaurin series, and their applications in mathematical analysis.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the concept of limits and related convergence criteria.

- ILO 1.1: Evaluate limits of functions using sequential criterion and limit theorems.
- ILO 1.2: Analyze one-sided limits, infinite limits, and limits at infinity.

CO2: Apply concepts of continuity and discontinuity of functions.

- ILO 2.1: Determine continuity and discontinuity using sequential criterion.

- ILO 2.2: Apply algebra of continuous functions in solving analytical problems.

CO3: Explain continuity on intervals and uniform continuity.

- ILO 3.1: Apply Intermediate Value Theorem, Location Root Theorem, and Preservation of Interval Theorem.
- ILO 3.2: Differentiate between continuity and uniform continuity using relevant criteria.

CO4: Analyze differentiability of functions.

- ILO 4.1: Explain differentiability at a point and on an interval.
- ILO 4.2: Apply Caratheodory's theorem and algebra of differentiable functions.

CO5: Apply Rolle's theorem and Mean Value theorems.

- ILO 5.1: Determine relative extrema using Interior Extremum Theorem.
- ILO 5.2: Apply Rolle's theorem and Mean Value Theorem in analytical problems.

CO6: Explain properties of derivatives and related theorems.

- ILO 6.1: Analyze the intermediate value property of derivatives.
- ILO 6.2: Explain Darboux's theorem and its significance.

CO7: Apply Cauchy's Mean Value Theorem and Taylor's theorem.

- ILO 7.1: Use Cauchy's Mean Value Theorem in problem solving.
- ILO 7.2: Apply Taylor's theorem with Lagrange's and Cauchy's forms of remainder.

CO8: Utilize Taylor and Maclaurin series expansions.

- ILO 8.1: Derive Taylor and Maclaurin series for standard functions.
- ILO 8.2: Apply series expansions to solve analytical and approximation problems.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO2	X	X	CO6	X
Conceptual	CO3	CO4	CO5	X	CO7	X
Procedural	X	CO1, CO5	CO7, CO8	X	CO4	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓		✓		
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				
CO5	✓	✓	✓	✓				✓
CO6	✓	✓	✓	✓		✓		
CO7	✓	✓	✓	✓				✓
CO8	✓	✓	✓	✓				✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (11 Marks)	Limit of a function, Sequential Criterion of limits, Divergence criteria, Statement of Limit theorems & their applications. Statements of the theorems of one sided limits, Infinite Limits and limits at infinity and statements of the related theorems. Historical Roots of the Concept of Limit in Ancient India, Bhāskara II's concept of infinitesimals, Vedāntic concept of the Ananta (Infinite) and Parimita (Finite).	06	02	-	08
II (14 Marks)	Continuous Functions and sequential criterion of continuity and discontinuity. Algebra of continuous functions (statements only) & their application to problems, Continuity on an interval, intermediate value theorem, Location Root Theorem, Preservation of interval theorem. Uniform Continuity, Statement of Non uniformity criteria, Uniform Continuity Theorem. Concept of Continuity in Ancient Indian Sciences and in Nyāya Philosophy.	09	03	-	12
III (16 Marks)	Differentiability of a function at a point and in an interval, Caratheodory's Theorem, Algebra of differentiable functions and their applications. Relative Extrema, Interior Extremum Theorem. Rolle's Theorem, Mean Value Theorem, Intermediate Value property of derivatives, Darboux's Theorem. Concept of infinitesimal increments and convergence in Yuktibhasa, Siddhānta Shiromani by Bhāskara II, Bhāskara's treatment of changing quantities; Concept of Tatkalika Gati.	15	05	-	20
IV (19 Marks)	Cauchy's Mean Value Theorem, Taylor's Theorem with Lagrange's form of remainder & Cauchy's form of remainder, Application of Taylor's theorem to convex function. Taylor & Maclaurin series and their applications to simple problems.	15	05	-	20

	Taylor series for sine and cosine functions by Madhaba of Sangamagrama, Derivation of power series of sine and cosine by Madhaba.				
	Total	**45**	**15**	**-**	**60**

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Bartle, R.G. & Sherbert, D.R., *Introduction to Real Analysis*, 4th Ed., Wiley, 2021.
2. Kumar, A. & Kumaresan, S., *A Basic Course in Real Analysis*, Taylor & Francis Group, 2014.
3. Malik, S.C. & Arora, S., *Mathematical Analysis*, New Age International Publishers, New Delhi, 1992.

REFERENCE BOOKS:

1. Sarma, K.V., *A History of the Kerala School of Hindu Astronomy*, Vishveshvarananda Institute, Hoshiarpur, 1972.

FOUR YEARS UNDER GRADUATE PROGRAMME In MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Group Theory**
Course Code	**:**	**MATH-MAJ-4-302**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of sets, functions, and binary operations.
2. Familiarity with matrices, permutations, and elementary algebraic structures.
3. Ability to apply logical reasoning and mathematical proof techniques.

Course Objectives:

The course introduces learners to the fundamental concepts of group theory and abstract algebra. It develops understanding of groups, subgroups, cyclic groups, permutations, and cosets. The course also provides knowledge of normal subgroups, factor groups, direct products, and homomorphisms. Further, it familiarizes students with important algebraic results including Lagrange's theorem, Cayley's theorem, Cauchy's theorem, and isomorphism theorems.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the fundamental concepts and properties of groups.

- ILO 1.1: Describe groups through examples such as symmetry groups, dihedral groups, and quaternion groups.
- ILO 1.2: Verify elementary properties of groups and binary operations.

CO2: Analyze subgroups and related concepts.

- ILO 2.1: Identify and determine subgroups of a given group.
- ILO 2.2: Explain centralizers, normalizers, centers, and products of subgroups.

CO3: Apply properties of cyclic groups and permutations.

- ILO 3.1: Classify subgroups of cyclic groups.
- ILO 3.2: Represent and analyze permutations using cycle notation.

CO4: Explain cosets and Lagrange's theorem.

- ILO 4.1: Analyze properties of cosets in groups.
- ILO 4.2: Apply Lagrange's theorem to finite groups.

CO5: Explain alternating groups and parity of permutations.

- ILO 5.1: Differentiate between even and odd permutations.
- ILO 5.2: Describe properties of alternating groups.

CO6: Analyze normal subgroups, factor groups, and direct products.

- ILO 6.1: Explain external direct products and factor groups.
- ILO 6.2: Identify normal subgroups and apply Cauchy's theorem for finite abelian groups.

CO7: Apply homomorphisms and isomorphism theorems in group theory.

- ILO 7.1: Explain properties of group homomorphisms and isomorphisms.
- ILO 7.2: Apply Cayley's theorem and the First, Second, and Third Isomorphism Theorems.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO2	X	X	CO5	X
Conceptual	CO3	CO4	CO6	X	CO7	X
Procedural	X	CO1, CO3	CO4, CO7	X	CO6	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓		✓		
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				
CO5	✓	✓	✓	✓		✓		
CO6	✓	✓	✓	✓				✓
CO7	✓	✓	✓	✓		✓		✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (11 Marks)	Symmetries of a square, Dihedral groups, definition and examples of groups, Quaternion groups (illustration through matrices), elementary properties of groups. Symmetry in Indian art, architecture, and geometry – examples from Śrī Yantra, Kolam/Rangoli patterns and temple layouts (e.g., Konark, Khajuraho) illustrating rotational and reflectional symmetries. Concepts of transformation and structural preservation in the Śulbasūtras. Cyclic rhythmic patterns (Tāla) as analogues of abelian groups; sub-patterns in Mandala designs as subgroups; central Bindu in Yantrarepresenting the group center and invariance.	09	03	-	12
II (11 Marks)	Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.	09	03	-	12
III (15 Marks)	Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem.	09	03	-	12
Unit IV (11 Marks)	External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.	09	03		12
Unit V (12 Marks)	Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.	09	03		12
60 MARKS	**Total**	**45**	**15**	**-**	**60**

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Gallian, J.A., *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.
2. Fraleigh, J.B., *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.

REFERENCE BOOKS:

1. Dummit, D.S. & Foote, R.M., *Abstract Algebra*, 3rd Ed., Wiley, 2011.
2. Rotman, J.J., *An Introduction to the Theory of Groups*, 4th Ed., Springer Verlag, 1995.
3. Herstein, I.N., *Topics in Algebra*, Wiley, India, 2006.
4. Prabakaran, R., *Mathematics in Indian Knowledge System*, 2025.
5. Datta, Bibhutibhushan, *Ancient Indian Geometry: The Science of the Śulbasūtras*.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Differential Equations**
Course Code	**:**	**MATH-MIN-4-301**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of calculus, differentiation, and integration.
2. Familiarity with ordinary differential equations and elementary algebra.
3. Ability to apply logical reasoning and mathematical problem-solving techniques.

Course Objectives:

The course introduces learners to ordinary and partial differential equations and their methods of solution. It develops understanding of exact differential equations, integrating factors, higher-order differential equations, and Wronskian theory. The course also provides knowledge of linear differential equations with constant coefficients, variation of parameters, and Cauchy-Euler equations. Further, it introduces first-order and second-order partial differential equations, Lagrange's and Charpit's methods, and classification of partial differential equations.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the formation and basic theory of differential equations.

- ILO 1.1: Form differential equations from given conditions.
- ILO 1.2: Describe homogeneous and exact differential equations.

CO2: Apply integrating factors in solving differential equations.

- ILO 2.1: Determine suitable integrating factors for non-exact differential equations.
- ILO 2.2: Solve exact and reducible differential equations using integrating factors.

CO3: Solve first-order higher-degree differential equations.

- ILO 3.1: Solve equations solvable for xxx, yyy, and ppp.
- ILO 3.2: Apply methods for solving higher-order differential equations.

CO4: Explain the role of Wronskian in differential equations.

- ILO 4.1: Compute Wronskians of functions.
- ILO 4.2: Analyze linear dependence and independence of solutions using Wronskian properties.

CO5: Solve linear differential equations with constant coefficients.

- ILO 5.1: Obtain solutions of linear homogeneous differential equations.
- ILO 5.2: Solve linear non-homogeneous differential equations using standard methods.

CO6: Apply advanced methods for solving differential equations.

- ILO 6.1: Solve differential equations using variation of parameters.
- ILO 6.2: Solve Cauchy-Euler differential equations.

CO7: Explain concepts related to partial differential equations.

- ILO 7.1: Define order, degree, and types of partial differential equations.
- ILO 7.2: Form first-order partial differential equations from given conditions.

CO8: Solve first-order partial differential equations using standard methods.

- ILO 8.1: Apply Lagrange's method for solving linear partial differential equations.
- ILO 8.2: Apply Charpit's method for solving non-linear partial differential equations.

CO9: Classify second-order partial differential equations.

- ILO 9.1: Differentiate elliptic, parabolic, and hyperbolic equations.
- ILO 9.2: Classify second-order partial differential equations through examples.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO4	X	X	CO9	X

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Conceptual	CO2	CO7	CO3, CO5	X	CO6	X
Procedural	X	CO1, CO3	CO5, CO8	X	CO2	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓				
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓		✓		
CO5	✓	✓	✓	✓				✓
CO6	✓	✓	✓	✓				✓
CO7	✓	✓	✓	✓		✓		
CO8	✓	✓	✓	✓				✓
CO9	✓	✓	✓	✓				✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Review of formation of differential equation, basic theory of linear DE, homogeneous DE. Exact differential equations. Integrating factors, rules to find an integrating factor.	09	03	-	12
II (15 Marks)	First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations, Wronskian, and its properties. Concept of infinitesimal increments and convergence in Yuktibhasa, SiddhāntaShiromani by Bhāskara II Bhāskara's treatment of changing quantities; Concept of Tatkalika Gati. Approximate to first and second derivative of sin x.	09	03	-	12
III (11 Marks)	Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation.	09	03	-	12
IV (12 Marks)	Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.	09	03		12
V (10 Marks)	Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.	09	03		12
	Total	**45**	**15**	**-**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Ross, S.L., *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. Raisinghania, M.D., *Ordinary and Partial Differential Equations*, 19th Ed., S. Chand and Company, 2020.

REFERENCE BOOKS:

1. Sarma, K.V., *A History of the Kerala School of Hindu Astronomy*, Vishveshvaranand Institute, Hoshiarpur, 1972.
2. Bressoud, D., "Was Calculus Invented in India?", *The College Mathematics Journal*, Vol. 33, No. 1, 2002, pp. 2–13.

FOUR YEARS UNDER GRADUATE PROGRAMME In MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Combinatorial Mathematics**
Course Code	**:**	**MATH-GEC-3-301**
Nature of the Course	**:**	**Generic Elective Course (GEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of algebra, sets, and functions.
2. Familiarity with permutations, combinations, and elementary probability concepts.
3. Ability to apply logical reasoning and mathematical problem-solving techniques.

Course Objectives:

The course introduces learners to fundamental principles of combinatorics and discrete mathematics. It develops understanding of permutations, combinations, counting principles, generating functions, and recurrence relations. The course also provides knowledge of inclusion-exclusion principle, derangements, integer partitions, and systems of distinct representatives. Further, it familiarizes students with Polya counting theory, Burnside's lemma, and their applications in counting problems.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Apply basic counting principles in combinatorial problems.

- ILO 1.1: Solve problems involving permutations and combinations with and without repetitions.
- ILO 1.2: Apply binomial and multinomial theorems in counting problems.

CO2: Analyze counting methods involving subsets and partitions.

- ILO 2.1: Count subsets and set partitions using combinatorial techniques.
- ILO 2.2: Explain Stirling numbers and their applications.

CO3: Apply inclusion-exclusion principle and derangement concepts.

- ILO 3.1: Solve counting problems using the Principle of Inclusion and Exclusion.
- ILO 3.2: Analyze derangements and inversion formulae in combinatorics.

CO4: Explain generating functions and their algebraic properties.

- ILO 4.1: Describe algebra of formal power series and generating function models.
- ILO 4.2: Compute ordinary and exponential generating functions.

CO5: Apply recurrence relations in mathematical problem solving.

- ILO 5.1: Formulate recurrence relation models for combinatorial problems.
- ILO 5.2: Solve recurrence relations using standard techniques and generating functions.

CO6: Explain integer partitions and systems of distinct representatives.

- ILO 6.1: Analyze integer partition problems using combinatorial methods.
- ILO 6.2: Describe systems of distinct representatives with examples.

CO7: Apply Polya theory and Burnside’s lemma in counting problems.

- ILO 7.1: Solve necklace and symmetry-related counting problems using Burnside’s lemma.
- ILO 7.2: Apply Polya’s theorem in combinatorial enumeration problems.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO2	X	X	CO6	X
Conceptual	CO3	CO4	CO5	X	CO7	X
Procedural	X	CO1, CO3	CO5, CO7	X	CO4	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓				
CO3	✓	✓	✓	✓		✓		
CO4	✓	✓	✓	✓	✓			
CO5	✓	✓	✓	✓	✓			✓
CO6	✓	✓	✓	✓		✓		
CO7	✓	✓	✓	✓	✓	✓		✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (12 Marks)	Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers	06	03	-	09
II (12 Marks)	Principle of Inclusion and Exclusion, Derangements, Inversion formulae	06	03	-	09
III (12 Marks)	Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions.	06	03	-	09
IV (12 Marks)	Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions.	06	03	-	09
V (12 Marks)	Integer partitions, Systems of distinct representatives. Polya theory of counting: Necklace problem and Burnside's lemma, Polya's theorems and their immediate applications	06	03	-	09
	Total	**30**	**15**	**-**	**45**

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Balakrishnan, V.K., *Introductory Discrete Mathematics*, Dover Publications Inc., 2000.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Mathematical Logic**
Course Code	**:**	**MATH-SEC-3-301**
Nature of the Course	**:**	**Skill Enhancement Course (SEC)**
Total Credits	**:**	**03 (L=2, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of sets, functions, and elementary algebra.
2. Familiarity with logical reasoning and mathematical statements.
3. Ability to apply analytical thinking and problem-solving techniques.

Course Objectives:

The course introduces learners to the fundamental concepts of mathematical logic, set theory, and relations. It develops understanding of propositions, logical equivalences, predicates, and quantifiers. The course also provides knowledge of set operations, counting principles, classes of sets, and generalized set operations. Further, it familiarizes students with relations, equivalence relations, partial orderings, and composition of relations.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the basic concepts of mathematical logic.

- ILO 1.1: Construct truth tables for logical propositions.
- ILO 1.2: Analyze implications, biconditional propositions, converse, contrapositive, and inverse statements.

CO2: Apply logical equivalences and quantifiers in reasoning.

- ILO 2.1: Establish propositional equivalences using logical laws.
- ILO 2.2: Apply predicates and quantifiers in mathematical statements and their negations.

CO3: Explain the fundamental concepts of set theory.

- ILO 3.1: Describe sets, subsets, finite and infinite sets with examples.
- ILO 3.2: Apply set operations and laws of set theory using Venn diagrams.

CO4: Analyze advanced set operations and identities.

- ILO 4.1: Explain power sets, symmetric difference, and generalized unions and intersections.
- ILO 4.2: Verify set identities using algebraic methods.

CO5: Apply counting principles in finite sets.

- ILO 5.1: Solve problems involving finite sets and counting principles.
- ILO 5.2: Explain properties and applications of the empty set.

CO6: Explain relations and their properties.

- ILO 6.1: Describe product sets, compositions, and types of relations.
- ILO 6.2: Analyze partitions and equivalence relations with suitable examples.

CO7: Apply partial ordering relations and n-ary relations.

- ILO 7.1: Explain partial ordering relations and their applications.
- ILO 7.2: Describe n-ary relations and related structures.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO3	X	X	CO5	X
Conceptual	CO2	CO4	CO6	X	CO7	X
Procedural	X	CO1, CO3	CO5, CO6	X	CO2	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓		✓		
CO2	✓	✓	✓	✓		✓		
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				
CO5	✓	✓	✓	✓				
CO6	✓	✓	✓	✓		✓		
CO7	✓	✓	✓	✓				✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (19 Marks)	Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations. Philosophical foundation of set theory in Indian logic. Nyāya and Vaiśeṣika Systems, Discussion of sambandha (relation)- samavāya (inherence), saṃyoga (contact), and samaveta-samavāya.	10	05	-	15
II (15 Marks)	Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set.	08	04	-	12
III (11 Marks)	Standard set operations. Classes of sets. Power set of a set. Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections.	04	02	-	06
IV (15 Marks)	Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-array relations.	08	04	-	12
	Total	**30**	**15**	**-**	**45**

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Kumar, A., Kumaresan, S. & Sarma, B.K., *A Foundation Course in Mathematics*, Alpha Science International, 2017.
2. Srivastava, S.M., *A Course on Mathematical Logic*, Springer, 2012.

REFERENCE BOOKS:

1. Sarma, K.V., *A History of the Kerala School of Hindu Astronomy*, Vishveshvarananda Institute of Sanskrit and Indological Studies, Panjab University, Hoshiarpur.
2. Matilal, B.K., *Navya–Nyaya Doctrine of Negation – Semantics & Ontology of Negative Statements: The Semantics and Ontology of Negative Statements in Navya-Nyaya Philosophy (Harvard Oriental Series)*, Harvard University Press, 1990.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Numerical Methods**
Course Code	**:**	**MATH-MAJ-4-401**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=0, P=1)**
Distribution of Marks	**:**	**45 (End Sem) +15 (Practical) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of algebra, matrices, and differential calculus.
2. Familiarity with equations, functions, and elementary numerical computations.
3. Basic understanding of programming concepts and computational problem solving.

Course Objectives:

The course introduces learners to numerical methods for solving algebraic equations, systems of linear equations, interpolation problems, numerical integration, and ordinary differential equations. It develops understanding of computational errors, convergence analysis, and approximation techniques. The course also provides practical experience in implementing numerical algorithms using computer-aided software and programming tools.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain algorithms, convergence, and computational errors.

- ILO 1.1: Differentiate between absolute, relative, round-off, and truncation errors.
- ILO 1.2: Analyze convergence behavior of numerical algorithms.

CO2: Apply numerical methods for solving algebraic and transcendental equations.

- ILO 2.1: Solve equations using Bisection, Newton-Raphson, and Secant methods.
- ILO 2.2: Compare efficiency and convergence of different root-finding methods.

CO3: Solve systems of linear algebraic equations numerically.

- ILO 3.1: Apply Gaussian Elimination and Gauss-Jordan methods.
- ILO 3.2: Solve systems using Gauss-Jacobi and Gauss-Seidel iterative methods and analyze convergence.

CO4: Apply interpolation techniques and finite difference methods.

- ILO 4.1: Construct interpolation polynomials using Lagrange and Newton interpolation methods.
- ILO 4.2: Apply finite difference operators and Newton-Gregory interpolation formulae.

CO5: Utilize numerical integration techniques.

- ILO 5.1: Approximate definite integrals using Trapezoidal and Simpson's rules.
- ILO 5.2: Apply composite numerical integration methods for improved accuracy.

CO6: Solve ordinary differential equations numerically.

- ILO 6.1: Apply Euler's method for numerical solutions of differential equations.
- ILO 6.2: Solve ordinary differential equations using Runge-Kutta methods of different orders.

CO7: Implement numerical algorithms using computational software.

- ILO 7.1: Develop programs for numerical methods using computer-aided software.
- ILO 7.2: Apply programming concepts such as arrays, loops, operators, and control statements in numerical computations.

CO8: Analyze and interpret computational results.

- ILO 8.1: Evaluate accuracy and efficiency of numerical methods through practical applications.
- ILO 8.2: Interpret graphical and numerical outputs generated from computational techniques.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO3	X	X	CO8	X
Conceptual	CO2	CO4	CO5	X	CO6	X
Procedural	X	CO1, CO7	CO2, CO6	X	CO5	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓	✓			
CO3	✓	✓	✓	✓	✓			
CO4	✓	✓	✓	✓	✓			
CO5	✓	✓	✓	✓	✓			✓
CO6	✓	✓	✓	✓	✓			✓
CO7	✓	✓	✓	✓	✓	✓		✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (10 Marks)	Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Square root, Cube root, Some technical terms and definitions, Computation of Rsines, Desired Rsines and Rversines from Jya-sankalita, First, second, etc. repeated summations; Successive corrections to Jya and Sara; Accurate computation of Rsines and Rversines, without using tables; Accurate circumference from an approximate value.	09	00	00	09
II (7 Marks)	System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.	06	00	00	06
III (7 Marks)	Interpolation: Lagrange and Newton's methods. Finite difference operators. Newton Gregory forward and backward difference interpolation and its application.	06	00	00	06
IV (10 Marks)	Numerical Integration: Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Boole's Rule, Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.	09	00	00	09
V (6 Marks)	Ordinary Differential Equations: Euler's method, RungeKutta methods of orders two and four.	06	00	00	06

VI (20 Marks)	**List of Practicals (using any software)** (i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ---+ 1/N. (ii) To find the absolute value of an integer. (iii) Enter 100 integers into an array and sort them in an ascending order. (iv) Bisection Method. (v) Newton Raphson Method. (vi) Secant Method. (vii) Regula Falsi Method. (viii) LU decomposition Method. (ix) Gauss-Jacobi Method. (x) Gauss-Siedel Method. (xi) Lagrange Interpolation or Newton Interpolation. (xii) Simpson's rule. Note: For any of the CAS (Computer aided software) Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.	-	-	24	24
	Total	**36**	**00**	**24**	**60**

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Jain, M.K., Iyengar, S.R.K. & Jain, R.K., *Numerical Methods for Scientific and Engineering Computation*, 6th Ed., New Age International Publisher, India, 2007.
2. Atkinson, K., *An Introduction to Numerical Analysis*, 2nd Ed., Wiley Publications, 1978.

REFERENCE BOOKS:

1. Gerald, C.F. & Wheatley, P.O., *Applied Numerical Analysis*, Pearson Education, India, 2008.
2. Ascher, U.M. & Greif, C., *A First Course in Numerical Methods*, 7th Ed., PHI Learning Private Limited, 2013.
3. Mathews, J.H. & Fink, Kurtis D., *Numerical Methods using MATLAB*, 4th Ed., PHI Learning Private Limited, 2012.
4. *Lilavati of Bhaskaracharya*, translated by Patwardhan, Naimpally & Singh, Motilal Banarsidass Publishers, Delhi, 2001.
5. Sarma, K.V. (Trans.), *Yuktibhāṣā of Jyeṣṭhadeva: Ganita (Volume I – Mathematics)*, with notes by K. Ramasubramanian, M.D. Srinivas & M.S. Sriram, Hindustan Book Agency, 2008.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Riemann Integration & Series of Functions**
Course Code	**:**	**MATH-MAJ-4-402**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of limits, continuity, differentiation, and sequences of real numbers.
2. Familiarity with elementary real analysis and infinite series.
3. Ability to apply logical reasoning and mathematical proof techniques.

Course Objectives:

The course introduces learners to the theory of Riemann integration and conditions of integrability. It develops understanding of upper and lower sums, improper integrals, Beta and Gamma functions, and the Fundamental Theorem of Calculus. The course also provides knowledge of pointwise and uniform convergence of sequences and series of functions, continuity and differentiability of limit functions, and convergence tests. Further, it introduces power series, radius of convergence, Abel's theorem, and Weierstrass Approximation Theorem.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the concepts of Riemann integration and integrability.

- ILO 1.1: Define upper sums, lower sums, and Riemann sums.
- ILO 1.2: Apply Riemann conditions to determine integrability of functions.

CO2: Apply properties and theorems of Riemann integrals.

- ILO 2.1: Analyze integrability of monotone and piecewise continuous functions.
- ILO 2.2: Apply Intermediate Value Theorem for Integrals and the Fundamental Theorem of Calculus.

CO3: Evaluate improper integrals and special functions.

- ILO 3.1: Determine convergence of improper integrals.
- ILO 3.2: Analyze Beta and Gamma functions and their convergence properties.

CO4: Explain pointwise and uniform convergence of sequences of functions.

- ILO 4.1: Differentiate between pointwise and uniform convergence.
- ILO 4.2: Apply convergence theorems to continuity, differentiability, and integrability of limit functions.

CO5: Analyze convergence properties of series of functions.

- ILO 5.1: Apply theorems related to continuity and differentiability of series of functions.
- ILO 5.2: Use Cauchy criterion and Weierstrass M-Test for uniform convergence.

CO6: Explain limit superior, limit inferior, and power series.

- ILO 6.1: Determine limit superior and limit inferior of sequences.
- ILO 6.2: Compute radius of convergence of power series using Cauchy-Hadamard theorem.

CO7: Apply analytical properties of power series.

- ILO 7.1: Differentiate and integrate power series within the interval of convergence.
- ILO 7.2: Apply Abel's theorem in the study of power series.

CO8: Explain approximation theorems in analysis.

- ILO 8.1: State and interpret Weierstrass Approximation Theorem.
- ILO 8.2: Apply approximation concepts in analysis-related problems.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO3	X	X	CO8	X
Conceptual	CO2	CO4	CO5	X	CO6	X
Procedural	X	CO1, CO5	CO2, CO7	X	CO4	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓		✓		
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				✓
CO5	✓	✓	✓	✓		✓		✓
CO6	✓	✓	✓	✓				
CO7	✓	✓	✓	✓				✓
CO8	✓	✓	✓	✓		✓		✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (19 Marks)	Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorem of Calculus.	18	06	-	24
II (11 Marks)	Improper integrals; Convergence of Beta and Gamma functions.	06	02	-	08
III (19 Marks)	Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.	15	05	-	20
IV (11 Marks)	Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem.	06	02	-	08
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Bartle, R. & Sherbert, D.R., *Introduction to Real Analysis*, John Wiley and Sons, 2003.
2. Kumar, A. & Kumaresan, S., *A Basic Course in Analysis*, CRC Press, 2014.

REFERENCE BOOKS:

1. Ghorpade, S.R. & Limaye, B.V., *A Course in Calculus and Real Analysis*, Springer, 2006.
2. Ross, K.A., *Elementary Analysis: The Theory of Calculus*, Undergraduate Texts in Mathematics, Springer (SIE), Indian Reprint, 2004.
3. Denlinger, C.G., *Elements of Real Analysis*, Jones & Bartlett (Student Edition), 2011.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Ring Theory and Linear Algebra I**
Course Code	**:**	**MATH-MAJ-4-403**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of sets, functions, matrices, and elementary algebraic structures.
2. Familiarity with groups, binary operations, and systems of linear equations.
3. Ability to apply logical reasoning and mathematical proof techniques.

Course Objectives:

The course introduces learners to the fundamental concepts of ring theory and linear algebra. It develops understanding of rings, ideals, integral domains, fields, and ring homomorphisms. The course also provides knowledge of vector spaces, subspaces, quotient spaces, linear independence, basis, and dimension. Further, it familiarizes students with linear transformations, matrix representations, rank-nullity theorem, and isomorphism theorems.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the fundamental concepts and properties of rings.

- ILO 1.1: Describe rings, subrings, integral domains, and fields with examples.
- ILO 1.2: Analyze properties and characteristics of rings.

CO2: Apply concepts of ideals and factor rings.

- ILO 2.1: Determine ideals generated by subsets of rings.
- ILO 2.2: Explain operations on ideals, factor rings, prime ideals, and maximal ideals.

CO3: Explain ring homomorphisms and isomorphism theorems.

- ILO 3.1: Analyze properties of ring homomorphisms.
- ILO 3.2: Apply the First, Second, and Third Isomorphism Theorems for rings.

CO4: Explain vector spaces and subspaces.

- ILO 4.1: Describe vector spaces, subspaces, and quotient spaces with examples.
- ILO 4.2: Apply algebraic operations on subspaces.

CO5: Analyze linear combinations, span, and linear independence.

- ILO 5.1: Determine linear combinations and linear spans of vectors.
- ILO 5.2: Test vectors for linear independence and dependence.

CO6: Apply concepts of basis and dimension in vector spaces.

- ILO 6.1: Determine bases and dimensions of vector spaces and subspaces.
- ILO 6.2: Analyze dimension relations in quotient spaces.

CO7: Explain linear transformations and their algebraic properties.

- ILO 7.1: Determine null space, range, rank, and nullity of linear transformations.
- ILO 7.2: Apply algebraic operations on linear transformations.

CO8: Analyze matrix representations and isomorphisms.

- ILO 8.1: Represent linear transformations using matrices.
- ILO 8.2: Apply isomorphism theorems in vector spaces and linear transformations.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO4	X	X	CO6	X
Conceptual	CO2	CO3	CO5	X	CO8	X
Procedural	X	CO1, CO5	CO6, CO7	X	CO3	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓		✓		
CO3	✓	✓	✓	✓		✓		✓
CO4	✓	✓	✓	✓				
CO5	✓	✓	✓	✓				
CO6	✓	✓	✓	✓		✓		✓
CO7	✓	✓	✓	✓	✓			
CO8	✓	✓	✓	✓	✓	✓		✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (11 Marks)	Definition and examples of rings, Properties of rings, Subrings, Integral domains and fields, characteristic of a ring. Ideals, Ideal generated by a subset of a ring, Factor rings, Operations on ideals, Prime and maximal ideals.	09	03	-	12
II (19 Marks)	Ring homomorphisms, Properties of ring homomorphisms, First, Second and Third Isomorphism theorems for rings. The Indian conception of algebra. The treatment of unknown (avyakta), their powers (varga, ghana), and operations with them. Brahmagupta's rules for zero (śūnya) and negative numbers (ṛṇa). ĀryabhaṭasKuttaka,	12	04	-	16
III (11 Marks)	Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of vectors, Linear span, Linear independence, Basis and dimension, Dimension of subspaces.	12	04	-	16
IV (19 Marks)	Linear transformations, Null space, Range, Rank and nullity of a linear transformation, Matrix representation of a linear transformation, Algebra of linear transformations. Isomorphisms, Isomorphism theorems. Linear Combinations in the Bakhshali Manuscript, coordinate systems used in Indian planetary models (deśāntara calculations for longitudinal difference).	12	04	-	16
	Total	45	15	-	60

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Gallian, J.A., *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, New Delhi, 1999.
2. Friedberg, S.H., Insel, A.J. & Spence, L.E., *Linear Algebra*, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
3. Hoffman, K. & Kunze, R.A., *Linear Algebra*, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.

REFERENCE BOOKS:

1. Fraleigh, J.B., *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.
2. Strang, G., *Linear Algebra and its Applications*, Thomson, 2007.
3. Artin, M., *Abstract Algebra*, 2nd Ed., Pearson, 2011.
4. Lang, S., *Introduction to Linear Algebra*, 2nd Ed., Springer, 2005.
5. Kumaresan, S., *Linear Algebra – A Geometric Approach*, Prentice Hall of India, 1999.
6. Datta, B. & Singh, A.N., *History of Hindu Mathematics* (Part II: Chapter II – Algebra), Motilal Banarsidass, 1938.
7. Bhāskara II, *Bījagaṇita*, edited by K.S. Shukla, Indian National Science Academy (INSA), 1976.
8. Krishnamurthy, E.V., "The Kuttaka and Its Applications", *Indian Journal of History of Science*, 2010.
9. Sarma, K.V., *The Bakhshali Manuscript*, 2015.
10. Van der Waerden, B.L., *Geometry and Algebra in Ancient Civilizations* (Chapters on Indian Algebra), Springer, 1983.

FOUR YEARS UNDER GRADUATE PROGRAMME In MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**PDE and Systems of ODE**
Course Code	**:**	**MATH-MAJ-4-404**
Nature of the Course	**:**	**MAJOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of ordinary differential equations, partial derivatives, and multivariable calculus.
2. Familiarity with linear algebra, matrices, and differential operators.
3. Ability to apply logical reasoning and mathematical problem-solving techniques.

Course Objectives:

The course introduces learners to the theory and applications of partial differential equations and systems of linear differential equations. It develops understanding of first-order and second-order partial differential equations, classification methods, canonical forms, and methods of characteristics. The course also provides knowledge of heat, wave, and Laplace equations along with separation of variables techniques. Further, it familiarizes students with systems of linear differential equations and operator methods for solving linear systems with constant coefficients.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the basic concepts and classifications of partial differential equations.

- ILO 1.1: Define partial differential equations and formulate mathematical models.
- ILO 1.2: Classify first-order partial differential equations.

CO2: Apply methods for solving first-order partial differential equations.

- ILO 2.1: Solve quasi-linear equations using the method of characteristics.
- ILO 2.2: Apply Charpit's and Jacobi's methods to solve non-linear partial differential equations.

CO3: Analyze canonical forms and separation of variables techniques.

- ILO 3.1: Reduce first-order linear equations into canonical forms.
- ILO 3.2: Apply separation of variables to solve first-order partial differential equations.

CO4: Explain classifications of second-order linear partial differential equations.

- ILO 4.1: Differentiate hyperbolic, parabolic, and elliptic equations.
- ILO 4.2: Reduce second-order linear equations into canonical forms.

CO5: Derive and solve classical partial differential equations.

- ILO 5.1: Derive Heat, Wave, and Laplace equations from physical problems.
- ILO 5.2: Solve classical partial differential equations using standard methods.

CO6: Apply separation of variables in boundary value problems.

- ILO 6.1: Solve the vibrating string problem using separation of variables.
- ILO 6.2: Solve heat conduction problems analytically.

CO7: Explain systems of linear differential equations and their properties.

- ILO 7.1: Describe different types of linear systems and differential operators.
- ILO 7.2: Apply operator methods for solving systems with constant coefficients.

CO8: Analyze homogeneous linear systems with constant coefficients.

- ILO 8.1: Solve homogeneous linear systems in normal form.
- ILO 8.2: Interpret solutions of systems of linear differential equations.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO4	X	X	CO8	X
Conceptual	CO2	CO3	CO5	X	CO7	X
Procedural	X	CO1, CO5	CO2, CO6	X	CO4	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓				
CO3	✓	✓	✓	✓		✓		
CO4	✓	✓	✓	✓				
CO5	✓	✓	✓	✓				✓
CO6	✓	✓	✓	✓				✓
CO7	✓	✓	✓	✓	✓	✓		
CO8	✓	✓	✓	✓	✓			✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (20 Marks)	Partial Differential Equations – Basic concepts and Definitions, Mathematical Problems. First- Order Equations: Classification. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Non-linear partial differential equations, Charpit's method & Jacobi's method Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.	12	04	-	16
II (15 Marks)	Classifications of second order linear equations as hyperbolic, parabolic or elliptic. Derivations of Heat, Wave and Laplace equation and their solutions. Reduction of second order Linear Equations to canonical forms.	12	04	-	16
III (10 Marks)	Method of separation of variables, Solving the Vibrating String Problem, Solving the Heat Conduction problem	09	03	-	12
IV (15 Marks)	Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients.	12	04	-	16
	Total	45	15	-	60

Where, L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Ross, S.L., *Differential Equations*, 3rd Ed., John Wiley and Sons, India, 2004.
2. Myint-U, T. & Debnath, L., *Linear Partial Differential Equations for Scientists and Engineers*, 4th Ed., Springer, Indian Reprint, 2006.

REFERENCE BOOKS:

1. Sneddon, I.N., *Elements of Partial Differential Equations*, Dover Publications, 2006.
2. Boyce, W.E. & DiPrima, R.C., *Elementary Differential Equations and Boundary Value Problems*, 9th Ed., Wiley, 2009.

FOUR YEARS UNDER GRADUATE PROGRAMME IN MATHEMATICS

DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Algebra**
Course Code	**:**	**MATH-MIN-4-401**
Nature of the Course	**:**	**MINOR**
Total Credits	**:**	**04 (L=3, T=1, P=0)**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

Prerequisites

1. Basic knowledge of sets, functions, and binary operations.
2. Familiarity with elementary algebra and modular arithmetic.
3. Ability to apply logical reasoning and mathematical proof techniques.

Course Objectives:

The course introduces learners to the fundamental concepts of group theory and ring theory. It develops understanding of finite groups, cyclic groups, quotient groups, and symmetry groups. The course also provides knowledge of subgroups, cosets, Lagrange's theorem, and normal subgroups. Further, it familiarizes students with rings, ideals, integral domains, fields, and examples of algebraic structures arising from number systems, matrices, quaternions, and polynomial rings.

Course Outcomes:

After completing the course, a learner will be able to:

CO1: Explain the basic concepts and properties of groups.

- ILO 1.1: Differentiate between abelian and non-abelian groups with examples.
- ILO 1.2: Describe groups such as Zn\mathbb{Z}_nZn, U(n)U(n)U(n), circle groups, and quaternion groups.

CO2: Analyze symmetry groups and matrix groups.

- ILO 2.1: Describe symmetry groups of geometric figures such as triangles, rectangles, and squares.
- ILO 2.2: Explain properties of the general linear group GL(n,R)GL(n,\mathbb{R})GL(n,R).

CO3: Apply subgroup concepts in group theory.

- ILO 3.1: Identify cyclic subgroups and subgroups generated by elements.
- ILO 3.2: Determine order of elements and analyze subgroup structures.

CO4: Explain cosets and Lagrange's theorem.

- ILO 4.1: Analyze left and right cosets and determine index of subgroups.
- ILO 4.2: Apply Lagrange's theorem to finite groups.

CO5: Analyze normal subgroups and quotient groups.

- ILO 5.1: Identify and characterize normal subgroups.
- ILO 5.2: Construct and analyze quotient groups.

CO6: Explain the basic concepts and examples of rings.

- ILO 6.1: Differentiate between commutative and non-commutative rings.
- ILO 6.2: Describe rings arising from matrices, quaternions, polynomials, and continuous functions.

CO7: Apply concepts of subrings and ideals.

- ILO 7.1: Identify subrings and ideals in algebraic structures.
- ILO 7.2: Analyze operations and properties of ideals.

CO8: Explain integral domains and fields.

- ILO 8.1: Differentiate between rings, integral domains, and fields.
- ILO 8.2: Describe examples of fields such as Zp\mathbb{Z}_pZp, Q\mathbb{Q}Q, R\mathbb{R}R, and C\mathbb{C}C.

Mapping of COs with Bloom's Taxonomy

Cognitive Knowledge Dimension	Remembering	Understanding	Apply	Analyze	Evaluate	Create
Factual	CO1	CO2	X	X	CO8	X
Conceptual	CO3	CO4	CO5	X	CO7	X
Procedural	X	CO1, CO6	CO3, CO5	X	CO4	X
Metacognitive	X	X	X	X	X	X

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)

COs \ POs	PO1 Knowledge	PO2 Problem Analysis	PO3 Critical Thinking	PO4 Mathematical Skills	PO5 Modern Tools	PO6 Communication	PO7 Ethics & Values	PO8 Lifelong Learning
CO1	✓	✓	✓	✓				
CO2	✓	✓	✓	✓		✓		
CO3	✓	✓	✓	✓				
CO4	✓	✓	✓	✓				
CO5	✓	✓	✓	✓		✓		✓
CO6	✓	✓	✓	✓				
CO7	✓	✓	✓	✓		✓		✓
CO8	✓	✓	✓	✓				✓

Unit-wise Distribution of Course Contents

UNITS	CONTENTS	L	T	P	Total Hours
I (19 Marks)	Definition and examples of groups: abelian and non-abelian groups, the group Zn of integers modulo n under addition modulo n and the group U(n) of units under multiplication modulo n. Complex roots of unity, circle group, the general linear group $GL(n, R)$, groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, Group of quaternions, elementary properties of groups. Foundation and History of Algebra. The Six rules for positive and negative numbers, The Six rules for Zero, The Six rules for algebraic numbers, Equation of the form Ax+c=by, Equation with one unknown. The ten questions.	12	04	-	16
II (11 Marks)	Subgroups, cyclic subgroups, order of an element, the concept of a subgroup generated by an element, examples of subgroups including the center of a group, cosets, Index of subgroup.	09	03	-	12
III (11 Marks)	Lagrange's theorem, Normal subgroups: their definition, examples, and characterizations, Quotient groups.	09	03		12
IV (19 Marks)	Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, Z_n the ring of integers modulo n, ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions. Subrings and ideals, Integral domains and fields, examples of fields: Z_p, Q, R, and C.	15	05	-	20
	Total	45	15	-	60

Where, **L: Lectures** **T: Tutorials** **P: Practicals**

MODES OF IN-SEMESTER ASSESSMENT (40 Marks):

- Two Internal Examination **20 Marks**
- Others (any two or more) - **20 Marks**
  - Seminar presentation on any of the relevant topics
  - Assignment
  - Group Discussion
  - Quiz
  - Viva-Voce
  - Attendance

TEXTBOOKS:

1. Gallian, J.A., *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.
2. Fraleigh, J.B., *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002.

REFERENCE BOOKS:

1. Abhyankar, S.K., *Bhaskaracharya's Bījagaṇita and Its English Translation*, Bhaskaracharya Pratishthana, Pune, India.
2. Sarma, K.V. (Trans.), *Yuktibhāṣā of Jyeṣṭhadeva: Ganita (Volume I – Mathematics)*, with notes by K. Ramasubramanian, M.D. Srinivas & M.S. Sriram, Hindustan Book Agency, 2008.
3. Datta, B. & Singh, A.N., *Hindu Mathematics*, Asia Publishing House, New Delhi.