FYUGP SYLLABUS IN MATHEMATICS
GAUHATI UNIVERSITY

(Recommended by the meeting of the CCS in Mathematics held on 30.03.2026, the joint Faculty meeting held on 20.05.2026 and the Academic Council held on 26.05.2026)

DEPARTMENT OF MATHEMATICS

GAUHATI UNIVERSITY

GUWAHATI-781014, ASSAM

INDIA

Programme Objectives

The Four-Year Undergraduate Programme in Mathematics aims to:

PO1: Develop a strong foundation in pure and applied mathematics through rigorous theoretical and practical training.

PO2: Enhance analytical, logical reasoning, and problem-solving abilities required for advanced mathematical studies and real-world applications.

PO3: Equip students with computational and quantitative skills for modeling, data analysis, and scientific computing.

PO4: Foster research aptitude and innovation by encouraging independent learning, critical thinking, and mathematical investigation.

PO5: Enable students to apply mathematical concepts to interdisciplinary fields such as science, engineering, economics, finance, artificial intelligence, and data science.

PO6: Prepare graduates for higher studies, research careers, and professional opportunities in academia, industry, and government sectors.

Programme Specific Outcomes:

PSO1: Demonstrate mathematical ability effectively by oral, written, computational and graphical means.

PSO2: Measure the hypothesis, theories, techniques and proofs provisionally through analytic ability.

PSO3: Utilize mathematics to solve theoretical and applied/ real world problems by critical understanding, analysis and synthesis.

PSO4: Develop a spirit of lifelong learning through continued education and research.

GAUHATI UNIVERSITY
FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP)
SUBJECT: MATHEMATICS
Syllabus: Version-II

With effect from 2026-2027 academic session

Programme Code: MAT027

Programme name	Eligibility Criteria of the programme, if any	Semester/ Course Level	Course name	Course code	credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks	External Marks
						Lecture	Tutorial	Practical			
FYUGP in Mathematics	Mathematics in 10+2	I	**Classical Algebra (Major)**	MAT0100104 MJ	4	3	1	0	Mathematics in 10+2	40	60
			Classical Algebra (Minor)	MAT0100104 MN	4	3	1	0	Mathematics in 10+2	40	60
			C Programming	SEC0100103	3	2	0	1	Do	Practical 25+Internal 20	30
		II	**Calculus (with practical) (Major)**	MAT0200104 MJ	4	3	0	1	Do	Practical 25+Internal 30	45
			Calculus (with practical) (Minor)	MAT0200104 MN	4	3	0	1	Do	Practical 25+Internal 30	45

			LaTeX	SEC0206803	3	2	0	1	Do	Practical 25+Internal 20	30
		III	**Ordinary Differential Equations (with practical) (Major)**	MAT0300104 MJ	4	3	0	1	MAT020104MJ	Practical 25+Internal 30	45
			Real Analysis-I (Major)	MAT0300204 MJ	4	3	1	0	Mathematics in 10+2	40	60
			Computer Algebra Systems and Related Software	SEC0316303	3	2	0	1	Do	Practical 25+Internal 20	30
			Choose any one paper for other Major students and one or both paper for only minor students								
			Ordinary Differential Equations (with practical) (Minor)	MAT0300104 MN	4	3	0	1	MAT020104MN	Practical 25+Internal 30	45
			Real Analysis-I (Minor)	MAT0300204 MN	4	3	1	0	Mathematics in 10+2	40	60
		IV	**Abstract Algebra (Major)**	MAT0400104 MJ	4	3	1	0	Mathematics in 10+2	40	60
			Elementary Number Theory (Major)	MAT0400204 MJ	4	3	0	1	Mathematics in 10+2	40	60

			Analytical Geometry (Major)	MAT0400304 MJ	4	3	1	0	Do	40	60
			Real Analysis-II (Major)	MAT0400404 MJ	4	3	1	0	MAT0300204MJ	40	60
			Choose any one paper for other Major students and any two or three paper for only minor students								
			Abstract Algebra (Minor)	MAT0400104 MN	4	3	1	0	Mathematics in 10+2	40	60
			Elementary Number Theory (Minor)	MAT0400204 MN	4	3	0	1	Mathematics in 10+2	40	60
			Analytical Geometry (Minor)	MAT0400304 MN	4	3	1	0	Do	40	60
			Real Analysis-II (Minor)	MAT0400404 MN	4	3	1	0	MATMN0300204	40	60
		V	**Multivariate Calculus (Major)**	MAT0500104 MJ	4	3	1	0	MAT0200104MJ & MAT0400404MJ	40	60
			Linear Algebra (Major)	MAT0500204 MJ	4	3	1	0	MATMJ0400104	40	60
			Numerical Analysis-I (with practical) (Major)	MAT0500304 MJ	4	3	0	1	Mathematics in 10+2	Practical 25+Internal 30	45
			Internship	MAT0500404 MJ	4	4	0	0	Nil	40	60
			Choose any one paper for other Major students and any two or three paper for only minor students								

			Multivariate Calculus (Minor)	MAT0500104 MN	4	3	1	0	MAT0200104MN & MAT0400404MN	40	60
			Linear Algebra (Minor)	MAT0500204 MN	4	3	1	0	MAT0400104MN	40	60
			Numerical Analysis-I (with practical) (Minor)	MAT0500304 MN	4	3	0	1	Mathematics in 10+2	Practical 25+Internal 30	45
		VI	**Complex Analysis-I (with practical) (Major)**	MAT0600104 MJ	4	3	1	0	MAT0300204MJ	Practical 25+Internal 30	45
			Partial Differential Equations (with practical) (Major)	MAT0600204 MJ	4	3	0	1	MAT0300104MJ	Practical 25+Internal 30	45
			Metric Spaces (Major)	MAT0600304 MJ	4	3	1	0	MAT0300204MJ	40	60
			Mechanics (Major)	MAT0600404 MJ	4	3	1	0	Mathematics in 10+2	40	60
			Choose any one paper for other Major students and any two or three paper for only minor students								
			Complex Analysis-I (with practical) (Minor)	MAT0600104 MN	4	3	1	0	MAT0300204MN	Practical 25+Internal 30	45

			Partial Differential Equations (with practical) (Minor)	MAT0600204 MN	4	3	0	1	MAT0300104MN	Practical 25+Internal 30	45
			Metric Spaces (Minor)	MAT0600304 MN	4	3	1	0	MAT0300204MN	40	60
			Mechanics (Minor)	MAT0600404 MN	4	3	1	0	Mathematics in 10+2	40	60
		OPTION-I: HONOURS / OPTION-II: HONOURS WITH RESEARCH									
		VII	**Algebra**	MAT4700104 MJ	4	3	1	0	MAT0500104MJ	40	60
			Real Analysis and Lebesgue Measure	MAT4700204 MJ	4	3	1	0	MAT0300204MJ & MAT0400404MJ	40	60
			Complex Analysis-II	MAT4700304 MJ	4	3	1	0	MAT0600104MJ	40	60
			Research Methodology	MAT4700504 MJ	4	3	1	0	Nil	40	60
			Choose any one paper for other Major students								
			Differential Equations	MAT4700404 MN	4	3	1	0	MAT0300104MN & MAT0600204MN	40	60
			Biomathematics	MAT4700604 MN	4	3	1	0	MAT0300104MN	40	60

			History of Mathematics	MAT4700704MN	4	3	1	0	Nil	40	60
		OPTION-I: HONOURS									
		VIII	**Topology**	MAT4800104MJ	4	3	1	0	MAT0600304MJ	40	60
			Mechanics and Tensor Calculus	MAT4800304MJ	4	3	1	0	MAT0600404MJ	40	60
			Mathematical Methods	MAT4800404MJ	4	3	1	0	MAT0500304MJ	40	60
			Seminar/ Project	MAT4800504MJ	4	4	0	0	Nil	40	60
			Choose any one paper for other Major students								
			Mathematical Methods	MAT4800404MN	4	3	1	0	MAT0500304MN	40	60
			Optimization Techniques	MAT4800604MN	4	3	1		Nil	40	60
			Financial Mathematics	MAT4800704MN	4	3	1	0	Nil	40	60
		OPTION-II: HONOURS WITH RESEARCH									
		VIII	**Dissertation**	MAT4800812MJ	12	9	3	0	Nil	100	200
			ELECTIVE PAPER (Choose any ONE)								
			Topology	MAT4800104MJ	4	3	1	0	MAT0600304MJ	40	60
			Number Theory	MAT4800204MJ	4	3	1	0	MAT0400204MJ	40	60

			Mechanics and Tensor Calculus	MAT0800304 MJ	4	3	1	0	MAT0600404MJ	40	60
			Mathematical Methods	MAT0800404 MJ	4	3	1	0	MAT0500304MJ	40	60
			Choose any one paper for other Major students								
			Number Theory	MAT4800204 MN	4	3	1	0	MAT0400204MN	40	60
			Optimization Techniques	MAT4800204 MN	4	3	1		Nil	40	60
			Financial Mathematics	MAT0800304 MN	4	3	1	0	Nil	40	60

GAUHATI UNIVERSITY
FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP)
SUBJECT: MATHEMATICS
Syllabus: Version-II

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Programme Code: MAT027

SEMESTER-I

MAT0100104MJ: Classical Algebra

Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Identify symmetric functions of the roots for cubic and biquadratic equations, solve cubic and biquadratic equations.

CO2 Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix and calculate the inverse and rank of a matrix.

CO3 Classify and compute the nature of the roots of a given polynomial equation by Descartes' rule

CO4 Express the basic concepts of exponential, logarithmic and hyperbolic functions of complex numbers.

CO5 Apply De Moivre's theorem in a number of applications to solve numerical problems.

UNIT-1: Statements and logic, statements with quantifier, compound statements, implications, proofs in Mathematic, Cartesian product; Functions, one-one, onto functions and bijections, Composition of functions, Inverse of a function, Image and Inverse image of subsets; Relation, Equivalence relations, Equivalence classes and partitions of a set, congruence modulo n in integers; Induction Principles.

(No. of classes: 15, Marks: 15)

[1] Chapters 1 – 5.

UNIT 2: Polar representation of complex number, De Moivre's theorem (both integral and rational index), Roots of complex numbers, n^{th} roots of unity, Application of De Moivre's Theorem, Exponential and logarithmic functions of complex numbers, Hyperbolic functions. Gregory's series.

[2] Chapter 2. **(No. of classes: 15, Marks: 15)**

UNIT 3: Algebraic equations: Deduction from Fundamental Theorem of Classical Algebra, Descartes' rule of signs, relation between roots and coefficients of a polynomial equation of degree n, symmetric

functions of roots, Transformation of equations, Cardon's method of solution of a cubic equation, Euler's method of solution of a biquadratic equation. **(No. of classes: 15, Marks: 15)**
[2] Chapter 5

UNIT 4: Matrix Algebra, Different types of matrices, Multiplication of matrices and their properties, Transposition, inverse of a matrix, characterizations of invertible matrices; Matrix inversion and properties, Row Echelon form and Rank of a matrix, Reduced row Echelon form, Consistency of linear systems of equations, vector equations, the matrix equation Ax = b, solution sets of linear systems, linear independence, introduction to linear transformations, the matrix of a linear transformation; Determinants, Cramer's rule. **(No. of classes: 15, Marks: 15)**

[3] Chapter 1,2,3

Text Books:

1. A. Kumar, S. Kumaresan and B.K. Sarma, A Foundation Course in Mathematics, Narosa, 2018.
2. S.K. Mapa, Higher Algebra (Classical), Revised 8th Edition, Levant Books, 2011.
3. D.C. Lay, Linear Algebra and its Applications, 3rd Edition, Pearson Education Asia, 2007.

Reference Books:

1. L.E. Dickson, First Course in The Theory of Equations, The Project Gutenberg eBook, http://www.gutenberg.org/ebooks/29785, 2009.
2. W.J. Gilbert and S.A. Vanstone, Classical Algebra, 3rd Edition, Waterloo Mathematics Foundation, Canada, 1993.
3. T. Andreescu and D. Andrica, Complex Numbers from A to Z, Birkhäuser, 2006.
4. S. Barnard and J.M. Child, Higher Algebra, Arihant, 2016.
5. G. Strang, Linear Algebra and its Applications, Cengage Learning, 2005.

SEMESTER-I

MAT0100104MN: Classical Algebra (Minor)

Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Identify symmetric functions of the roots for cubic and biquadratic equations, solve cubic and biquadratic equations.

CO2 Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix and calculate the inverse and rank of a matrix.

CO3 Classify and compute the nature of the roots of a given polynomial equation by Descartes' rule

CO4 Express the basic concepts of exponential, logarithmic and hyperbolic functions of complex numbers.

CO5 Apply De Moivre's theorem in a number of applications to solve numerical problems.

UNIT-1: Statements and logic, statements with quantifier, compound statements, implications, proofs in Mathematic, Cartesian product; Functions, one-one, onto functions and bijections, Composition of functions, Inverse of a function, Image and Inverse image of subsets; Relation, Equivalence relations, Equivalence classes and partitions of a set, congruence modulo n in integers; Induction Principles.

(No. of classes: 15, Marks: 15)

[1] Chapters 1 – 5.

UNIT 2: Polar representation of complex number, De Moivre's theorem (both integral and rational index), Roots of complex numbers, n^{th} roots of unity, Application of De Moivre's Theorem, Exponential and logarithmic functions of complex numbers, Hyperbolic functions. Gregory's series.

[2] Chapter 2. **(No. of classes: 15, Marks: 15)**

UNIT 3: Algebraic equations: Deduction from Fundamental Theorem of Classical Algebra, Descartes' rule of signs, relation between roots and coefficients of a polynomial equation of degree n, symmetric functions of roots, Transformation of equations, Cardon's method of solution of a cubic equation, Euler's method of solution of a biquadratic equation. **(No. of classes: 15, Marks: 15)**
[2] Chapter 5

UNIT 4: Matrix Algebra, Different types of matrices, Multiplication of matrices and their properties, Transposition, inverse of a matrix, characterizations of invertible matrices; Matrix inversion and properties, Row Echelon form and Rank of a matrix, Reduced row Echelon form, Consistency of linear systems of equations, vector equations, the matrix equation Ax = b, solution sets of linear systems, linear independence, introduction to linear transformations, the matrix of a linear transformation; Determinants, Cramer's rule. **(No. of classes: 15, Marks: 15)**

[3] Chapter 1,2,3

Text Books:

1. A. Kumar, S. Kumaresan and B.K. Sarma, A Foundation Course in Mathematics, Narosa, 2018.
2. S.K. Mapa, Higher Algebra (Classical), Revised 8^{th} Edition, Levant Books, 2011.
3. D.C. Lay, Linear Algebra and its Applications, 3^{rd} Edition, Pearson Education Asia, 2007.

Reference Books:

1. L.E. Dickson, First Course in The Theory of Equations, The Project Gutenberg eBook, http://www.gutenberg.org/ebooks/29785, 2009.
2. W.J. Gilbert and S.A. Vanstone, Classical Algebra, 3^{rd} Edition, Waterloo Mathematics Foundation, Canada, 1993.
3. T. Andreescu and D. Andrica, Complex Numbers from A to Z, Birkhäuser, 2006.
4. S. Barnard and J.M. Child, Higher Algebra, Arihant, 2016.
5. G. Strang, Linear Algebra and its Applications, Cengage Learning, 2005.

SEMESTER-I
SEC0100103: C Programming
Total Marks: 75 (Theory 30, Practical 25, Internal 20)
No of Credit: 3 (2+1)
No. of Contact classes: 60 (30+30×1)

Course Outcomes: The students who take this course will be able to:

CO1 Understand and apply the programming concepts of C which is important to mathematical investigation and problem solving.

CO2 Learn about structured data-types in C and learn about applications in factorization of an integer and understanding Cartesian geometry and Pythagorean triples.

CO3 Use of containers and templates in various applications in algebra.

CO4 Use mathematical libraries for computational objectives.

CO5 Represent the outputs of programs visually in terms of well formatted text and plots.

CO6 In practical students learn about the roots of a quadratic equation, solution of an equation using N-R algorithm.

UNIT 1: Variables, constants, variable declaration, initialization, basic data types, operators and expression (arithmetic, relational, logical, assignment, conditional, increment and decrement), hierarchy of operations for arithmetic operators, size of and comma operator, mixed mode operation and automatic (implicit) conversion, cast (explicit) conversion, library functions, structure of a C program, input/output functions and statements. **(No. of classes: 10)**

UNIT 2: Control Statements: if-else statement (including nested if-else statement), switch statement. Loop control Structures (for and nested for, while and do-while). Break, continue, go to statements, exit function. (**No. of classes: 10)**

UNIT 3: Arrays and subscripted variables: One dimensional array declaration, accessing values in an array, initializing values in an array, sorting of numbers in an array, addition and multiplication of matrices with the help of array. (**No. of classes: 10)**

Programmes for practical: (No. of classes: 15)

To find roots of a quadratic equation, value of a piecewise defined function (single variable), factorial of a given positive integer, Fibonacci numbers, square root of a number, cube root of a number, sum of different algebraic and trigonometric series, a given number to be prime or not, sum of the digits of any given positive integer, solution of an equation using N-R algorithm, reversing digits of an integer. Sorting of numbers in an array, to find addition, subtraction and multiplication of matrices.
[1] Chapters 3, 4, 5, 6, 7 and 9

Text Books:

1. T. Jeyapoovan, A First Course in Programming with C, Vikash Publishing House, 2004.

Reference Books:

1. E. Balaguruswamy, Programming with ANSI C, McGraw Hill, 2024.
2. Y. Kanetkar, Let us C, B.P.B. Publications, 2023.

SEMESTER-II
MAT0200104MJ: Calculus (with practical)
Total Marks: 100 (External 45, Practical 25, Internal 30)
No. of Credits: 4 (Theory 3, Practical 1)

No. of Contact classes: 75 (45+30×1)

No. of Non-Contact classes: 0
Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Describe asymptotic behaviour in terms of limits involving infinity.

CO2 Express continuity and differentiability in terms of limits.

CO3 Describe first and second derivative tests for relative extrema and apply the knowledge in problems in business, economics and life sciences.

CO4 Explain how to sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.

CO5 Calculate area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.

C06 Calculate integrations which can be solved by reduction formula

UNIT 1: Functions and their graphs, combining functions: Shifting and scaling graphs, polynomial and Trigonometric functions. Limits and continuity of a function, Limits of a function and limits laws, Properties of continuous functions. Intermediate value theorem.
[1] Chapter 2 **(No. of classes: 15, Marks: 15)**

UNIT 2: Derivative of a function, Differentiation Rules, Higher order derivatives, Successive differentiation, Leibnitz theorem, Recursion formulae for higher derivatives. Linearization and differentials. Concavity, inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hopital's rule. Applications of derivatives in business economics and life sciences.
[1]: Chapter 3, 4, 7(Section 7.5), [2]: Chapter 5, Chapter 10 **(No. of classes: 15, Marks: 15)**

UNIT 3: Area and Estimation of finite sums, limits of finite sums, Definite integrals, Fundamental theorem of Calculus, Indefinite Integrals, Area between curves, Volumes using cross sections, Disk method, Volumes using cylindrical shells, Shell method, Arc length, Areas of surfaces of revolution, Work and fluid forces, moments and centers of mass. Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$, $\int \sec^n x\,dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^m x\,dx$.
[1] Chapter 5, 6, [3] Chapter 4 **(No. of classes: 15, Marks: 15)**

Practical / Lab work to be performed on a computer: (No. of classes: 30, Marks: 25)

List of the practical to be done using Matlab / Mathematica / Maple / Scilab / Maxima etc.

(i) Plotting the graphs of the following functions: ax, $[x]$ (greatest integer function),

$\sqrt{ax+b}, |ax+b|, c \pm |ax+b|, x^{\pm n}, x^{1/n}, n \in Z$

$|x|/x$, $\sin(1/x)$, $x\sin(1/x)$, and , $e^{\pm 1/x}$ for $x \neq 0$.

e^{ax+b}, $\log(ax+b)$, $1/(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $|\sin(ax+b)|$, $|\cos(ax+b)|$.

Observe and discuss the effect of changes in the real constants *a*, *b* and *c* on the graphs.

(ii) Plotting the graphs of polynomial of degree 4 and 5, the graphs of their first and second derivatives, and analysis of these graphs in context of the concepts covered in Unit 1 and 2.

(iii) Sketching parametric curves, e.g., Trochoid, Cycloid, Epicycloid and Hypocycloid.

(iv) Tracing of conic in cartesian coordinates.

(v) Obtaining surface of revolution of curves.

(vi) Graph of hyperbolic functions.

(vii) Complex numbers and their representations, Operations like addition, Multiplication, Division, Modulus. Graphical representation of polar form.

(viii) Find numbers between two real numbers and plotting of finite and infinite subset of R

Text Books:

1. G.B. Thomas, Jr., (revised by J.R. Hass, C.E. Heil, M.D. Weir and P. Bogacki), Thomas' Calculus, 15th Edition, Pearson Education, 2023.
2. S. Narayan and P.K. Mittal, Differential Calculus, S. Chand, 2005.
3. S. Narayan and P.K. Mittal, Integral Calculus, S. Chand, 2007.

Reference Books:

1. H. Anton, I. Bivens and S. Davis, Calculus, 10th Edition, John Wiley & Sons, 2012.
2. G.L. Bradley and K.J. Smith, Calculus, 2nd Edition, Pearson, 1998.
3. J. Stewart, D.K. Clegg and S. Watson, Calculus: Early Transcendentals, 9th Edition, Cengage Learning, 2023.
4. G.B. Thomas, Jr. and R.L. Finney, Calculus and Analytical Geometry, Pearson, 9th Edition, 2010.

SEMESTER-II

MAT0200104MN: Calculus (with practical) (Minor)

Total Marks: 100 (External 45, Practical 25, Internal 30)

No. of Credits: 4 (Theory 3, Practical 1)

No. of Contact classes: 75 (45+30×1)

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Describe asymptotic behaviour in terms of limits involving infinity.

CO2 Express continuity and differentiability in terms of limits.

CO3 Describe first and second derivative tests for relative extrema and apply the knowledge in problems in business, economics and life sciences.

CO4 Explain how to sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.

CO5 Calculate area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.

C06 Calculate integrations which can be solved by reduction formula

UNIT 1: Functions and their graphs, combining functions: Shifting and scaling graphs, polynomial and Trigonometric functions. Limits and continuity of a function, Limits of a function and limits laws, Properties of continuous functions. Intermediate value theorem.
[1] Chapter 2 **(No. of classes: 15, Marks: 15)**

UNIT 2: Derivative of a function, Differentiation Rules, Higher order derivatives, Successive differentiation, Leibnitz theorem, Recursion formulae for higher derivatives. Linearization and differentials. Concavity, inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hopital's rule. Applications of derivatives in business economics and life sciences.
[1]: Chapter 3, 4, 7(Section 7.5), [2]: Chapter 5, Chapter 10 **(No. of classes: 15, Marks: 15)**

UNIT 3: Area and Estimation of finite sums, limits of finite sums, Definite integrals, Fundamental theorem of Calculus, Indefinite Integrals, Area between curves, Volumes using cross sections, Disk method, Volumes using cylindrical shells, Shell method, Arc length, Areas of surfaces of revolution, Work and fluid forces, moments and centers of mass. Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$, $\int \sec^n x\,dx$, $\int (\log x)^n\,dx$, $\int \sin^n x \cos^m x\,dx$.
[1] Chapter 5, 6, [3] Chapter 4 **(No. of classes: 15, Marks: 15)**

Practical / Lab work to be performed on a computer: (No. of classes: 30, Marks: 25)

List of the practical to be done using Matlab / Mathematica / Maple / Scilab / Maxima etc.

(i) Plotting the graphs of the following functions: ax, $[x]$ (greatest integer function), $\sqrt{ax+b}, |ax+b|, c\pm|ax+b|, x^{\pm n}, x^{1/n}, n \in Z$

$|x|/x$, $\sin(1/x)$, $x\sin(1/x)$, and , $e^{\pm 1/x}$ for $x \neq 0$.

e^{ax+b}, $\log(ax+b)$, $1/(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $|\sin(ax+b)|$, $|\cos(ax+b)|$.

Observe and discuss the effect of changes in the real constants *a*, *b* and *c* on the graphs.

(ii) Plotting the graphs of polynomial of degree 4 and 5, the graphs of their first and second derivatives, and analysis of these graphs in context of the concepts covered in Unit 1 and 2.

(iii) Sketching parametric curves, e.g., Trochoid, Cycloid, Epicycloid and Hypocycloid.

(iv) Tracing of conic in cartesian coordinates.

(v) Obtaining surface of revolution of curves.

(vi) Graph of hyperbolic functions.

(vii) Complex numbers and their representations, Operations like addition, Multiplication, Division, Modulus. Graphical representation of polar form.

(viii) Find numbers between two real numbers and plotting of finite and infinite subset of R

Text Books:

1. G.B. Thomas, Jr., (revised by J.R. Hass, C.E. Heil, M.D. Weir and P. Bogacki), Thomas' Calculus, 15th Edition, Pearson Education, 2023.
2. S. Narayan and P.K. Mittal, Differential Calculus, S. Chand, 2005.
3. S. Narayan and P.K. Mittal, Integral Calculus, S. Chand, 2007.

Reference Books:

1. H. Anton, I. Bivens and S. Davis, Calculus, 10th Edition, John Wiley & Sons, 2012.
2. G.L. Bradley and K.J. Smith, Calculus, 2nd Edition, Pearson, 1998.
3. J. Stewart, D.K. Clegg and S. Watson, Calculus: Early Transcendentals, 9th Edition, Cengage Learning, 2023.

G.B. Thomas, Jr. and R.L. Finney, Calculus and Analytical Geometry, Pearson, 9th Edition, 2010.

SEMESTER-2
SEC02006803: LaTeX

Total Marks: 75 (Theory 30, Practical 25, Internal 20)

No of Credit: 3 (2+1)

No. of Contact classes: 60 (30+30×1)

Course Outcomes: The students who take this course will be able to:

CO1 Create and typeset a LaTeX document.

CO2 Typeset a mathematical document using LaTeX.

CO3 Learn about pictures and graphics in LaTeX.

CO4 Create beamer presentations.

UNIT 1: Elements of LaTeX; Hands-on-training of LaTeX **No of contact hours: 10**

UNIT 2: Graphics in LaTeX; PS Tricks **No of contact hours: 10**

UNIT 3: Beamer presentation **No of contact hours: 10**

[1] Chapter 9, [1,2] Chapter 10, [3] Chapter 11.

Practical: At least six practicals should be done by each student. The teacher can assign practical from the exercises from [1] No of contact hours: 30

Text Books:

1. M.J. Erickson and D. Bindner, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, 2011.

Reference Books:

1. L. Lamport, LATEX: A Document Preparation System, User's Guide and Reference Manual, 2nd Edition, Addison-Wesley, 1994.

SEMESTER-III

MAT0300104MJ: Ordinary Differential Equations (with practical)

Total Marks: 100 (External: 45, Practical 25, Internal Assessment 30)
No. of Credits: 4 (Theory 3, Practical 1)

No. of Contact classes: 75 (45+30×1)

No. of Non-Contact classes: 0
Prerequisites: Mathematics in 10+2 or equivalent standard

Prerequisites: MAT0200104

Course Outcomes: The students who take this course will be able to:

CO1 Identify 1st order ordinary differential equations like exact first order differential equations, Bernoulli equations and rules of finding integrating factors of exact equations.
CO2 Recognize the second order differential equations like homogenous equations with constant coefficients equations, non-homogenous equations and Cauchy-Euler equations
CO3 Solve first order and second order differential equations
CO4 Calculate Wronskian and show its properties.
CO5 Use the method of undetermined coefficients, variation of parameters.

UNIT 1: Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

[2] Chapter 1,2 [3] Chapter 2,3 **(No. of classes: 15, Marks: 15)**

UNIT 2: General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Cauchy-Euler's equation, method of undetermined coefficients, method of variation of parameters.
[2] Chapter 3, [1] Chapter 5 **(No. of classes: 20, Marks: 20)**

UNIT 3: Introduction to compartmental model, exponential decay model, exponential growth of population, limited growth of population, limited growth with harvesting.
[1] Chapter 2,3 **(No. of classes: 10, Marks: 10)**

List of Practical (using any software) **(No. of classes: 30, Marks: 25)**

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).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).

Text Books:

1. B. Barnes and G.R. Fulford, Mathematical Modelling with Case Studies, Using Maple and MATLAB, 3rd Edition, CRC Press, 2015.
2. C.H. Edwards, D.E. Penney and D.T. Calvis, Differential Equation and Boundary Value Problems: Computing and Modeling, 6th Edition, Pearson, 2022.
3. S.L. Ross, Differential Equations, 3rd Edition, John Wiley & Sons, 2004.

Reference Books:

1. M.L Abell and J.P. Braselton, Differential Equations with MATHEMATICA, 4th Edition, Elsevier Academic Press, 2016.
2. C.C. Ross, Differential Equations: An Introduction with Mathematica, 2nd Edition, Springer, 2004.
3. E. Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, Inc., 2020.

SEMESTER-III

MAT0300204MJ: Real Analysis-I

Total Marks: 100 (External60, Internal Assessment 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Identify the properties of the real line *R*, including completeness and Archimedean properties.

CO2 Define sequences in terms of functions from *N* to a subset of *R*.

CO3 Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

CO4 Distinguish alternating series and infer absolute convergence of an infinite series of real numbers.

CO5 Apply limit comparison tests for convergence, the ratio, root, Raabe's, integral tests for convergence of an infinite series of real numbers.

UNIT 1: Algebraic and order properties of R, absolute value and real line, bounded sets, supremum and infimum, completeness property of R, the Archimedean property, the density theorem, intervals, Nested interval theorem, uncountability of R.

[1] Chapter 2 **(No of classes: 15, Marks: 15)**

UNIT 2: Real sequences, limit of a sequence, convergent sequence, bounded sequence, limit theorems, monotone sequences, monotone convergence theorem, subsequences, monotone

subsequence theorem, Bolzano Weierstrass theorem for sequences, Cauchy sequences, Cauchy's convergence criterion, properties of divergence sequences.

[1] Chapter 3 **(No of classes: 20, Marks: 20)**

UNIT 3: Infinite series, convergence and divergence of infinite series, Cauchy criterion, Tests for convergence: comparison test, limit comparison test, ratio test, root test, integral test, Raabes's test, Absolute convergence, rearrangement theorem, alternating series, Leibniz test, conditional (non-absolute) convergence.

[1] Chapter 3, Chapter 9 **(No of classes: 25, Marks: 25)**

Text Books:

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 4th Edition, John Wiley & Sons, 2011.

Reference Books:

1. G.G. Bilodeau, P.R. Thie and G.E. Keough, An Introduction to Analysis, 2nd Edition, Jones and Bartlett, 2010.
2. A. Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
3. K.A. Ross, Elementary Analysis: The Theory of Calculus, 2nd Edition, Springer, 2013.

SEMESTER-III
SEC0316303: Computer Algebra Systems and Related Software
Total Marks: 75 (Theory 30, Practical 25, Internal-20)
No of Credits 3(2+1)
No of contact classes: (2: Lectures, 1 Practical)
No of noncontact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 Use of software; Mathematica/MATLAB/Maxima/Maple, etc. as a calculator, for plotting functions and animations.

CO2 Use of CAS for various applications of matrices such as solving system of equations and finding eigenvalues and eigen vectors.

CO3 Understand the use of the statistical software **R** as calculator and learn to read and get data into **R.**

CO4 Apply **R** in summary calculation, pictorial representation of data and exploring relationship between data.

CO5 Analyze, test, and interpret technical arguments on the basis of geometry.

UNIT 1: Introduction to CAS and Applications: Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, plotting functions of two variables using Plot 3 D and Contour Plot, plotting para metric curves surfaces, customizing plots, animating plots, producing tables of values, working with piecewise defined functions, Combining graphics. **(No. of classes: 15)**

[1] Chapter 12 (Sections 12.1 to 12.5)

[2] Chapter1, and Chapter 3 (Sections 3.1to 3.6, and 3.8) Chapter 6(Sections 6.2 and 6.3)

UNIT 2: Working with Matrices: Simple programming in a CAS, working with matrices, addition, subtraction, multiplication of matrices, Minors and cofactors, working with 3x3 matrices, Solving system of linear equations of three variables.

(No. of classes: 15)

[2] Chapter 7 (Sections 7.1 to 7.8)

Practical:

Six practical should be done by each student. The teacher can assign practical from the exercises from [1,2]. **(No. of classes: 30)**

Text Books:

1. D. Bindner and M. Erickson, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, 2011.
2. B.F. Torrence and E.A. Torrence, The Student's Introduction to Mathematica: A Handbook for Precalculus, Calculus, and Linear Algebra, 2nd Edition, Cambridge University Press, 2009.

Choose any one paper for other Major students and one or both paper for only minor students

SEMESTER-III

MAT0300104MN: Ordinary Differential Equations (with practical) (Minor)

Total Marks: 100 (External: 45, Practical 25, Internal Assessment 30)
No. of Credits: 4 (Theory 3, Practical 1)

No. of Contact classes: 75 (45+30×1)

No. of Non-Contact classes: 0
Prerequisites: Mathematics in 10+2 or equivalent standard

Prerequisites: MAT0200104MN

Course Outcomes: The students who take this course will be able to:

CO1 Identify 1st order ordinary differential equations like exact first order differential equations, Bernoulli equations and rules of finding integrating factors of exact equations.
CO2 Recognize the second order differential equations like homogenous equations with constant coefficients equations, non-homogenous equations and Cauchy-Euler equations
CO3 Solve first order and second order differential equations
CO4 Calculate Wronskian and show its properties.
CO5 Use the method of undetermined coefficients, variation of parameters.

UNIT 1: Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

[2] Chapter 1,2, [3] Chapter 2,3 **(No. of classes: 15, Marks: 15)**

UNIT 2: General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Cauchy-Euler's equation, method of undetermined coefficients, method of variation of parameters.

[2] Chapter 3, [1] Chapter 5 **(No. of classes: 20, Marks: 20)**

UNIT 3: Introduction to compartmental model, exponential decay model, exponential growth of population, limited growth of population, limited growth with harvesting.

[1] Chapter 2,3 **(No. of classes: 10, Marks: 10)**

List of Practical (using any software) **(No. of classes: 30, Marks: 25)**

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).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).

Text Books:

1. B. Barnes and G.R. Fulford, Mathematical Modelling with Case Studies, Using Maple and MATLAB, 3rd Edition, CRC Press, 2015.
2. C.H. Edwards, D.E. Penney and D.T. Calvis, Differential Equation and Boundary Value Problems: Computing and Modeling, 6th Edition, Pearson, 2022.
3. S.L. Ross, Differential Equations, 3rd Edition, John Wiley & Sons, 2004.

Reference Books:

1. M.L Abell and J.P. Braselton, Differential Equations with MATHEMATICA, 4th Edition, Elsevier Academic Press, 2016.
2. C.C. Ross, Differential Equations: An Introduction with Mathematica, 2nd Edition, Springer, 2004.
3. E. Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, Inc., 2020.

SEMESTER-III

MAT0300204MN: Real Analysis-I (Minor)

Total Marks: 100 (External60, Internal Assessment 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Identify the properties of the real line *R*, including completeness and Archimedean properties.

CO2 Define sequences in terms of functions from *N* to a subset of *R*.

CO3 Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

CO4 Distinguish alternating series and infer absolute convergence of an infinite series of real numbers.

CO5 Apply limit comparison tests for convergence, the ratio, root, Raabe's, integral tests for convergence of an infinite series of real numbers.

UNIT 1: Algebraic and order properties of R, absolute value and real line, bounded sets, supremum and infimum, completeness property of R, the Archimedean property, the density theorem, intervals, Nested interval theorem, uncountability of R.

[1] Chapter 2 **(No of classes: 15, Marks: 15)**

UNIT 2: Real sequences, limit of a sequence, convergent sequence, bounded sequence, limit theorems, monotone sequences, monotone convergence theorem, subsequences, monotone subsequence theorem, Bolzano Weierstrass theorem for sequences, Cauchy sequences, Cauchy's convergence criterion, properties of divergence sequences.

[1] Chapter 3 **(No of classes: 20, Marks: 20)**

UNIT 3: Infinite series, convergence and divergence of infinite series, Cauchy criterion, Tests for convergence: comparison test, limit comparison test, ratio test, root test, integral test, Raabes's test, Absolute convergence, rearrangement theorem, alternating series, Leibniz test, conditional (non-absolute) convergence.

[1] Chapter 3, Chapter 9 **(No of classes: 25, Marks: 25)**

Text Books:

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 4th Edition, John Wiley & Sons, 2011.

Reference Books:

1. G.G. Bilodeau, P.R. Thie and G.E. Keough, An Introduction to Analysis, 2nd Edition, Jones and Bartlett, 2010.

2. A. Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.

3. K.A. Ross, Elementary Analysis: The Theory of Calculus, 2nd Edition, Springer, 2013.

SEMESTER-IV

MAT0400104MJ: Abstract Algebra

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Recognize the mathematical objects called group, ring and fields.

CO2 Associate the fundamental concepts of groups and symmetries of geometrical objects.

CO3 Explain the significance of the notion of Permutation groups, cosets, cyclic groups, normal subgroups, factor groups.

CO4 Analyse consequences of Lagrange's theorem and Fermat's Little theorem.

CO5 Describe structure preserving mappings between groups and their consequences.

CO6 Describe the fundamental concepts in ring theory such as of the subrings, integral domains, ideals, factor rings and fields.

UNIT 1: Definition and examples of groups, Elementary properties of groups, Symmetries of a square, Dihedral groups, order of a group, Order of an element in a group, Subgroups, Subgroup Tests, Subgroup generated by an element of a group, Centre of a group, Centralizer of an element in a group, Cyclic groups, Properties of cyclic groups, Fundamental theorem of cyclic groups.

[1] Chapter 1-4. **(No. of classes: 15, Marks: 15)**

UNIT 2: Permutations, Permutation group, Properties of permutations, Even and odd permutations, Alternating groups, Cosets, Properties of cosets, Lagrange's Theorem, Fermat's Little Theorem, Normal subgroups, Factor groups. **(No. of classes: 15, Marks: 15)**

[1] Chapter 5 (up to theorem 5.7), Chapter 7 (up to theorem 7.2), Chapter 9 (up to theorem 9.2)

UNIT 3: Isomorphism of groups, Cayley's Theorem, Properties of isomorphism, Group homomorphism, Kernal of a group homomorphism, Properties of group homomorphism, First isomorphism Theorem of groups. **(No. of classes: 15, Marks: 15)**

[1] Chapter 6 (up to theorem 6.3), Chapter 10 (up to theorem 10.4).

UNIT 4: Rings, Examples of rings, Properties of rings, Subrings, Zero-Divisors in a ring, Integral domains, Fields, Characteristic of a ring, Ideals, Ideal Test, Factor rings, Prime ideals and maximal ideals of a ring.

[1] Chapter 12-14. **(No. of classes: 15, Marks: 15)**

Text Books:

1. J.A. Gallian, Contemporary Abstract Algebra, 8th Edition, Cengage Learning, 2015.

Reference Books:

1. D.S. Dummit and R.M. Foote, Abstract Algebra, 3rd Edition, John Wiley & Sons, 2004.
2. J.B. Fraleigh, A First Course in Abstract Algebra, 7th Edition, Pearson, 2002.
3. G. Santhanam, Algebra, Narosa, 2017.

SEMESTER-IV

MAT0400204MJ: Elementary Number Theory

Total Marks: 100 (External 60, Internal Assessment 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 State Fermat's theorem and Wilson's theorem and use them to solve problems

CO2 Explain division algorithm, Euclid's algorithms, greatest common divisor, the concepts of congruences, linear congruences

CO3 Explore the Chinese Remainder theorem to solve simultaneous linear congruences.

CO4 Apply mathematical ideas and concepts within the context of number theory.

CO5 Summarize number theoretic techniques to a mathematical audience.

CO6 Compute and analyze convergent of continued fractions and use them to obtain best rational approximations.

UNIT 1: Well-Ordering Principle of integers, Archimedean property, First principle of finite induction, Second principle of finite induction, The division algorithm of integers, The greatest common divisor, The Euclidean algorithm, The Diophantine equation $ax + by = c$, Fundamental Theorem of Arithmetic, The sieve of Eratosthenes, The Goldbach Conjecture. **(No of classes:15, Marks:15)**

[1] Chapter 1 (Sections 1.1), Chapter2 (Sections 2.2--2.5), Chapter 3.

UNIT 2: Congruence modulo of a fixed positive integer, Basic properties of congruences, Binary and decimal representation of integers, Linear congruences, Chinese Remainder Theorem, Fermat's Little Theorem, pseudoprimes, Wilson's Theorem. **(No of classes: 15, Marks: 15)**

[1] Chapter 4 (Sections 4.2-4.4) Chapter5 (Sections: 5.2, 5.3).

UNIT 3: Number Theoretic Functions: The sum and number of divisors of a positive integer, Multiplicative functions, Mobius function, The Mobius inversion Formula, The greatest integer function, Euler's Phi-Function, Euler's Theorem, Properties of Euler's Phi function.

[1] Chapter 6 (Sections 6.1-6.3), Chapter 7 (Sections 7.2 to 7.4) **(No of classes:15, Marks: 15)**

UNIT 4: Continued fractions: Finite continued fractions, approximation of rational numbers by finite simple continued fractions, solution of linear Diophantine equations using finite continued fractions, infinite continued fractions, unique representation of irrationals as an infinite continued fraction. **(No of classes:15, Marks: 15)**

[1] Chapter 15

Text Books:

1. D.M. Burton, Elementary Number Theory, 7th Edition, McGraw-Hill, 2011.

Reference Books:

1. G.A. Jones and J.M. Jones, Elementary Number Theory, Springer, 1998.
2. N. Robbins, Beginning Number Theory, 2nd Edition, Narosa, 2006.
3. K.C. Chowdhury, A First Course in Number Theory, Asian Books Pvt. Ltd., 2004.

SEMESTER-IV

MAT0400304MJ: Analytical Geometry

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Define Vector Algebra and represent the use of geometric view of vectors in Coordinate Geometry.

CO2 Recognize three dimensional surfaces represented by equations of the second degree

CO3 Explain about the change the coordinate systems

CO4 Explain pair of straight lines, conic sections and related properties

CO5 Express systems of coordinates which are very useful to define the position of a point in space

UNIT 1: Transformation of coordinates, invariants under orthogonal transformations, pair of straight lines.

[1] Chapter 1 (Section 1.3), Chapter 2, Chapter 3, **(No. of classes: 15, Marks: 15)**

UNIT 2: Parabola, parametric coordinates, tangent and normal, ellipse and its conjugate diameters with properties, hyperbola and its asymptotes, General conics: tangent, condition of tangency, pole and polar, centre of a conic, equation of pair of tangents, reduction to standard forms, central conics, equation of the axes, and length of the axes, polar equation of a conic, tangent and normal, and properties.
[1] Chapters 4, 5, 6, 7, 9 (upto Section 9.43), **(No. of classes: 15, Marks: 15)**

UNIT 3: Quadric surfaces: Sphere, Cylinder and Cone. Cylindrical and spherical polar coordinates.
[1] Chapter 6 (Section 6.1 – 6.3), Chapter 12, **(No. of classes: 15, Marks: 15)**

UNIT 4: Rectangular coordinates in 3-space, Vector viewed geometrically, Vectors in coordinates system, Vectors determined by length and angle, Dot product, Cross product and their geometrical properties, Triple product, Parametric equations of lines in 2-space and 3-space.
[2] Chapter 11,12 (**No. of classes: 15, Marks: 15)**

Text Books:

1. R.M. Khan, Analytical Geometry of Two and Three Dimensions and Vector Analysis, New Central Book Agency, 2012.
2. H. Anton, I. Bivens and S. Davis, Calculus, 10th Edition, John Wiley & Sons, 2012.

Reference Books:

1. R.J.T. Bell, Coordinate Solid Geometry, Macmillan, 1983.
2. E.H. Askwith, The Analytical Geometry of the Conic Sections, Nabu Press, 2012.
3. B. Das, Analytical Geometry and Vector Analysis, Orient Book Company, 2003.
4. G.B. Thomas, Jr., (revised by J.R. Hass, C.E. Heil, M.D. Weir and P. Bogacki), Thomas' Calculus, 15th Edition, Pearson, 2023.

SEMESTER-IV

MAT0400404MJ: Real Analysis-II

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: MAT0300204MJ

Course Outcomes: The students who take this course will be able to:

CO1 Describe the concept of limit of a function.
CO2 Define differentiability using limits, leading to a better understanding for applications.
CO3 Explain the continuity and uniform continuity of functions defined on intervals.

CO4 Analyze geometrical properties of continuous functions on closed and bounded intervals.
CO5 Apply mean value theorems and Taylor's theorem

UNIT 1: Cluster point or limit point of a set, limits of a function (ε-δ approach), sequential criterion for limits, divergence criteria, limit theorems, one sided limits, infinite limits and limits at infinity.
[1] Chapter 4 **(No. of classes: 15, Marks: 15)**

UNIT 2: Continuous functions, sequential criterion for continuity and discontinuity, algebra of continuous functions, continuous functions on intervals, maximum-minimum theorem, intermediate value theorem, location of roots theorem, preservation of intervals theorem, uniform continuity, uniform continuity theorem, monotone and inverse functions.
[1] Chapter 5 (5.1 to 5.6) **(No. of classes: 20, Marks: 20)**

UNIT 3: Differentiability of a function at a point and in an interval, Caratheodory's theorem, chain rule, derivative of inverse function, Rolle's theorem, mean value theorem, Darboux's theorem, Cauchy mean value theorem, Maclaurin and Taylor polynomials and their sigma notations. Taylor's theorem and applications to inequalities, Taylor's formula with remainder, Introduction to Taylor series and Maclaurin. Taylor's and Maclaurin series expansions of exponential and trigonometric functions, $\ln(1+x)$, $1/(ax+b)$ and $(1+x)^n$.
[1] Chapter 6, and Taylor series as in Section 6.4. **(No. of classes: 25, Marks: 25)**

Text Books:

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 4th Edition, John Wiley & Sons, 2011.

Reference Books:

1. A. Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, 2nd Edition, Springer, 2013.
3. A.P. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006.

Choose any one paper for other Major students and any two or three paper for only minor students

SEMESTER-IV

MAT0400104MN: Abstract Algebra (Minor)

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Recognize the mathematical objects called group, ring and fields.

CO2 Associate the fundamental concepts of groups and symmetries of geometrical objects.

CO3 Explain the significance of the notion of Permutation groups, cosets, cyclic groups, normal subgroups, factor groups.

CO4 Analyse consequences of Lagrange's theorem and Fermat's Little theorem.

CO5 Describe structure preserving mappings between groups and their consequences.

CO6 Describe the fundamental concepts in ring theory such as of the subrings, integral domains, ideals, factor rings and fields.

UNIT 1: Definition and examples of groups, Elementary properties of groups, Symmetries of a square, Dihedral groups, order of a group, Order of an element in a group, Subgroups, Subgroup Tests, Subgroup generated by an element of a group, Centre of a group, Centralizer of an element in a group, Cyclic groups, Properties of cyclic groups, Fundamental theorem of cyclic groups.

[1] Chapter 1-4. **(No. of classes: 15, Marks: 15)**

UNIT 2: Permutations, Permutation group, Properties of permutations, Even and odd permutations, Alternating groups, Cosets, Properties of cosets, Lagrange's Theorem, Fermat's Little Theorem, Normal subgroups, Factor groups. **(No. of classes: 15, Marks: 15)**

[1] Chapter 5 (up to theorem 5.7), Chapter 7 (up to theorem 7.2), Chapter 9 (up to theorem 9.2)

UNIT 3: Isomorphism of groups, Cayley's Theorem, Properties of isomorphism, Group homomorphism, Kernal of a group homomorphism, Properties of group homomorphism, First isomorphism Theorem of groups. **(No. of classes: 15, Marks: 15)**

[1] Chapter 6 (up to theorem 6.3), Chapter 10 (up to theorem 10.4).

UNIT 4: Rings, Examples of rings, Properties of rings, Subrings, Zero-Divisors in a ring, Integral domains, Fields, Characteristic of a ring, Ideals, Ideal Test, Factor rings, Prime ideals and maximal ideals of a ring.

[1] Chapter 12-14. **(No. of classes: 15, Marks: 15)**

Text Books:

1. J.A. Gallian, Contemporary Abstract Algebra, 8th Edition, Cengage Learning, 2015.

Reference Books:

1. D.S. Dummit and R.M. Foote, Abstract Algebra, 3rd Edition, John Wiley & Sons, 2004.
2. J.B. Fraleigh, A First Course in Abstract Algebra, 7th Edition, Pearson, 2002.
3. G. Santhanam, Algebra, Narosa, 2017.

SEMESTER-IV

MAT0400204MN: Elementary Number Theory

Total Marks: 100 (External 60, Internal Assessment 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 State Fermat's theorem and Wilson's theorem and use them to solve problems

CO2 Explain division algorithm, Euclid's algorithms, greatest common divisor, the concepts of congruences, linear congruences

CO3 Explore the Chinese Remainder theorem to solve simultaneous linear congruences.

CO4 Apply mathematical ideas and concepts within the context of number theory.

CO5 Summarize number theoretic techniques to a mathematical audience.

CO6 Compute and analyze convergent of continued fractions and use them to obtain best rational approximations.

UNIT 1: Well-Ordering Principle of integers, Archimedean property, First principle of finite induction, Second principle of finite induction, The division algorithm of integers, The greatest common divisor, The Euclidean algorithm, The Diophantine equation $ax + by = c$, Fundamental Theorem of Arithmetic, The sieve of Eratosthenes, The Goldbach Conjecture. **(No of classes:15, Marks:15)**

[1] Chapter 1 (Sections 1.1), Chapter2 (Sections 2.2--2.5), Chapter 3.

UNIT 2: Congruence modulo of a fixed positive integer, Basic properties of congruences, Binary and decimal representation of integers, Linear congruences, Chinese Remainder Theorem, Fermat's Little Theorem, pseudoprimes, Wilson's Theorem. **(No of classes: 15, Marks: 15)**

[1] Chapter 4 (Sections 4.2-4.4) Chapter5 (Sections: 5.2, 5.3).

UNIT 3: Number Theoretic Functions: The sum and number of divisors of a positive integer, Multiplicative functions, Mobius function, The Mobius inversion Formula, The greatest integer function, Euler's Phi-Function, Euler's Theorem, Properties of Euler's Phi function.
[1] Chapter 6 (Sections 6.1-6.3), Chapter 7 (Sections 7.2 to 7.4) **(No of classes:15, Marks: 15)**

UNIT 4: Continued fractions: Finite continued fractions, approximation of rational numbers by finite simple continued fractions, solution of linear Diophantine equations using finite continued fractions, infinite continued fractions, unique representation of irrationals as an infinite continued fraction. **(No of classes:15, Marks: 15)**
[1] Chapter 15

Text Books:

1. D.M. Burton, Elementary Number Theory, 7th Edition, McGraw-Hill, 2011.

Reference Books:

1. G.A. Jones and J.M. Jones, Elementary Number Theory, Springer, 1998.
2. N. Robbins, Beginning Number Theory, 2nd Edition, Narosa, 2006.
3. K.C. Chowdhury, A First Course in Number Theory, Asian Books Pvt. Ltd., 2004.

SEMESTER-IV

MAT0400304MN: Analytical Geometry

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Define Vector Algebra and represent the use of geometric view of vectors in Coordinate Geometry.
CO2 Recognize three dimensional surfaces represented by equations of the second degree
CO3 Explain about the change the coordinate systems
CO4 Explain pair of straight lines, conic sections and related properties
CO5 Express systems of coordinates which are very useful to define the position of a point in space

UNIT 1: Transformation of coordinates, invariants under orthogonal transformations, pair of straight lines.
[1] Chapter 1 (Section 1.3), Chapter 2, Chapter 3, **(No. of classes: 15, Marks: 15)**

UNIT 2: Parabola, parametric coordinates, tangent and normal, ellipse and its conjugate diameters with properties, hyperbola and its asymptotes, General conics: tangent, condition of tangency, pole and polar, centre of a conic, equation of pair of tangents, reduction to standard forms, central conics, equation of the axes, and length of the axes, polar equation of a conic, tangent and normal, and properties.
[1] Chapters 4, 5, 6, 7, 9 (upto Section 9.43), **(No. of classes: 15, Marks: 15)**

UNIT 3: Quadric surfaces: Sphere, Cylinder and Cone. Cylindrical and spherical polar coordinates.
[1] Chapter 6 (Section 6.1 – 6.3), Chapter 12, **(No. of classes: 15, Marks: 15)**

UNIT 4: Rectangular coordinates in 3-space, Vector viewed geometrically, Vectors in coordinates system, Vectors determined by length and angle, Dot product, Cross product and their geometrical properties, Triple product, Parametric equations of lines in 2-space and 3-space.
[2] Chapter 11,12 (**No. of classes: 15, Marks: 15)**

Text Books:

1. R.M. Khan, Analytical Geometry of Two and Three Dimensions and Vector Analysis, New Central Book Agency, 2012.
2. H. Anton, I. Bivens and S. Davis, Calculus, 10th Edition, John Wiley & Sons, 2012.

Reference Books:

1. R.J.T. Bell, Coordinate Solid Geometry, Macmillan, 1983.
2. E.H. Askwith, The Analytical Geometry of the Conic Sections, Nabu Press, 2012.
3. B. Das, Analytical Geometry and Vector Analysis, Orient Book Company, 2003.
4. G.B. Thomas, Jr., (revised by J.R. Hass, C.E. Heil, M.D. Weir and P. Bogacki), Thomas' Calculus, 15th Edition, Pearson, 2023.

SEMESTER-IV

MAT0400304MN: Real Analysis-II (Minor)

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: MAT0300204MJ

Course Outcomes: The students who take this course will be able to:

CO1 Describe the concept of limit of a function.
CO2 Define differentiability using limits, leading to a better understanding for applications.
CO3 Explain the continuity and uniform continuity of functions defined on intervals.

CO4 Analyze geometrical properties of continuous functions on closed and bounded intervals.
CO5 Apply mean value theorems and Taylor's theorem

UNIT 1: Cluster point or limit point of a set, limits of a function (ε-δ approach), sequential criterion for limits, divergence criteria, limit theorems, one sided limits, infinite limits and limits at infinity.
[1] Chapter 4 **(No. of classes: 15, Marks: 15)**

UNIT 2: Continuous functions, sequential criterion for continuity and discontinuity, algebra of continuous functions, continuous functions on intervals, maximum-minimum theorem, intermediate value theorem, location of roots theorem, preservation of intervals theorem, uniform continuity, uniform continuity theorem, monotone and inverse functions.
[1] Chapter 5 (5.1 to 5.6) **(No. of classes: 20, Marks: 20)**

UNIT 3: Differentiability of a function at a point and in an interval, Caratheodory's theorem, chain rule, derivative of inverse function, Rolle's theorem, mean value theorem, Darboux's theorem, Cauchy mean value theorem, Maclaurin and Taylor polynomials and their sigma notations. Taylor's theorem and applications to inequalities, Taylor's formula with remainder, Introduction to Taylor series and Maclaurin. Taylor's and Maclaurin series expansions of exponential and trigonometric functions, ln(1+x), 1/(ax+b) and $(1+x)^n$.
[1] Chapter 6, and Taylor series as in Section 6.4. **(No. of classes: 25, Marks: 25)**

Text Books:

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 4th Edition, John Wiley & Sons, 2011.

Reference Books:

1. A. Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, 2nd Edition, Springer, 2013.
3. A.P. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006.

SEMESTER-V

MAT0500104MJ: Multivariate Calculus

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

(Use of Scientific calculator is allowed)

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Knowledge on the following topics:

- Functions of single variable, limit, continuity, differentiability and extrema of single variable functions.
- Knowledge of Integration
- Vector valued functions, dot and cross product of vectors.

Course Outcomes: The students who take this course will be able to:

CO1 Identify the conceptual variations when advancing in calculus from one variable to multivariable discussion.

CO2 Describe the maximization and minimization of multivariable functions subject to the given constraints on variables.

CO3 Explain about the inter-relationship amongst the line integral, double and triple integral formulations.

CO4 Assess Green's, Stokes' and Gauss divergence theorems

UNIT 1: Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivative, Chain rule, Directional derivatives, The gradient, Maximal property of the gradient.

[1] Chapter 13 **(No. of classes: 15, Marks: 15)**

UNIT 2: Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of vector field, Divergence and curl.

[1] Chapter 13 **(No. of classes: 15, Marks: 15)**

UNIT 3: Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals.

[1] Chapter 14 **(No. of classes: 15, Marks: 15)**

UNIT4: Line integrals, Applications of line integrals**:** Mass and Work, Fundamental theorem for line

integrals, Conservative vector fields, Green's theorem, Area as a line integral; Surface integrals, Stokes' theorem, The Gauss divergence theorem.

[1] Chapter 15 **(No. of classes: 15, Marks: 15)**

Text Books:

1. H. Anton, I. Bivens and S. Davis, Calculus, 10th Edition, John Wiley & Sons, 2012.

Reference Books:

1. J.E. Marsden, A. Tromba and A. Weinstein, Basic Multivariable Calculus, 2004.
2. G.B. Thomas and R.L. Finney, Calculus, 9th Edition, Pearson, 2005.
3. J. Stewart, Multivariable Calculus: Concepts and Contexts, 3rd Edition, Brooks /Cole, Thomson Learning, 2001.
4. G.L. Bradley and K.J. Smith, Calculus, 2nd Edition, Pearson, 1998.

SEMESTER-V

MAT0500204MJ: Linear Algebra

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: MAT0400104MJ

Course Outcomes: The students who take this course will be able to:

CO1 Define linear spaces and discuss their general properties, linear dependence and linear independence of vectors, bases and dimensions of vector spaces

CO2 Explain the basic concepts of linear transformations, dimension theorem, matrix representations of linear transformations, and the change of coordinate matrix.

CO3 Compute the characteristic polynomial, eigenvalues, eigenvectors and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.

CO4 Determine inner products and orthogonality on vector spaces.

CO5 Use Gram-Schmidt orthogonalization to obtain orthonormal basis.

UNIT 1: Definition and examples of vector spaces, general properties of vector spaces, Definition and examples of subspaces, subspace criterions and algebra of subspaces, null space and column space of a matrix, Linear transformations, Kernel and range of a linear transformation.

[1] Chapter 4, [2] Chapter 4 **(No. of classes: 15, Marks: 15)**

UNIT 2: Linear combinations of vectors, linearly dependent and independent sets, bases of vector spaces, coordinate systems, dimension of a vector space, ranks, change of basis.

[1] Chapter 4 [2] Chapter 5 **(No. of classes: 15, Marks: 15)**

UNIT 3: Eigenvectors and eigenvalues of a matrix, The Characteristic equation, Diagonalization, eigenvector of a linear transformation, Complex eigenvalues. Invariant subspaces and Cayley-Hamilton Theorem. **(No. of classes: 15, Marks: 15)**

[1] Chapter 5, [2] Chapter 9, [3] Chapter 5

UNIT 4: Inner products, Length and orthogonality, orthogonal sets, orthogonal projections, The Gram-Schmidt process, Inner product spaces. Bilinear and quadratic forms.

[1]: Chapter 6, [2]: Chapter 12 **(No. of classes: 15, Marks: 15)**

Text Books:

1. D.C. Lay, Linear Algebra and its Applications, 3rd Edition, Pearson, 2007.

Reference Books:

1. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall of India, 2017.
2. G. Strang, Linear Algebra and its Applications, Cengage Learning, 2005.
3. G. Schay, Introduction to Linear Algebra, Narosa, 1997.
4. S. Lipschutz, Linear Algebra, 5th Edition, McGraw-Hill, 2013.
5. S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, 4th Edition, Prentice Hall of India, 2004.
6. S. Axler, Linear Algebra Done Right, 4th Edition, Springer, 2026.

SEMESTER-V

MAT0500304MJ: Numerical Analysis (with practical)

Total Marks: 100 (External 45, Practical 25, Internal30)

No. of Credits: 4 (Theory 3, Practical 1)

(Use of Scientific calculator is allowed)

No. of Contact classes: 75 (45+30×1)

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard, Knowledge on computer software and programming

Course Outcomes: The students who take this course will be able to:

CO1 Apply numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, upto a certain given level of precision.

CO2 Compute the values for a tabulated function at points not in the table using interpolation techniques.

CO3 Measure a definite integral that cannot be done analytically

CO4 Estimate numerical differentiation of functional values

CO5 Solve differential equations that cannot be solved by analytical methods

UNIT 1: Gaussian elimination method (with row pivoting), Gauss-Jordan method; Iterative methods**:** Jacobi method, Gauss-Seidel method; Interpolation**:** Lagrange form, Newton form, Finite difference operators, Gregory-Newton forward and backward difference interpolations, Piecewise polynomial interpolation (Linear and Quadratic).

[1] Chapter3 (Sections 3.1, 3.2), Chapter 6 (Sections 6.1, 6.2) Chapter 8 (Section 8.1, Section 8.3 (8.3.1 and 8.3.2))

[2] Chapter 3 (Sections 3.2, 3.4) Chapter 4 (Sections 4.2, 4.3, 4.4)

[1] Chapter 18 (Sections 18.1 to 18.3) **(No. of classes: 20, Marks: 25)**

UNIT 2: Numerical differentiation**:** First and second order derivatives; Numerical integration**:** Trapezoid rule, Simpson's rule; Extrapolation methods**:** Richardson extrapolation, Romberg integration; Numerical solutions of ODE**:** Euler's method, Modified Euler's methods.

[2] Chapter 11 [Sections 11.1 (11.1.1, 11.1.2, 11.1.4), and11.2 (11.2.1, 11.2.2, 11.2.4)]

[1] Chapter 22 (Sections 22.1, 22.2, 22.3) **(No. of classes: 25, Marks: 20)**

Practical /Lab work to be performed on a computer:

Use of computer aided software (CAS),for example *Matlab/Mathematica/Maple,* etc., for developing the following numerical programs:

(i) Lagrange's interpolation method

(ii) Newton's interpolation method

(iii) To calculate forward and backward differences

(iv) Trapezoidal rule

(v) Simpson's rule

Note: For any of the CAS *Matlab/Mathematica/Maple* etc., 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.

(No. of practical classes: 30, Marks: 25)

Text Books:

1. S.C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, 4th Edition, McGraw-Hill Education, 2018.
2. L.V. Fausett, Applied Numerical Analysis Using MATLAB. Pearson, 2009.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International Publishers, 2012.
4. S.S. Sastry, Introductory Methods of Numerical Analysis, 4th Edition, Prentice Hall of India, 2006.

Choose any one paper for other Major students and any two or three paper for only minor students

SEMESTER-V

MAT0500104MN: Multivariate Calculus (Minor)

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

(Use of Scientific calculator is allowed)

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Knowledge on the following topics:

- Functions of single variable, limit, continuity, differentiability and extrema of single variable functions.
- Knowledge of Integration
- Vector valued functions, dot and cross product of vectors.

Course Outcomes: The students who take this course will be able to:

CO1 Identify the conceptual variations when advancing in calculus from one variable to multivariable discussion.

CO2 Describe the maximization and minimization of multivariable functions subject to the given constraints on variables.

CO3 Explain about the inter-relationship amongst the line integral, double and triple integral formulations.

CO4 Assess Green's, Stokes' and Gauss divergence theorems

UNIT 1: Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivative, Chain rule, Directional derivatives, The gradient, Maximal property of the gradient.

[1] Chapter 13 **(No. of classes: 15, Marks: 15)**

UNIT 2: Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of vector field, Divergence and curl.

[1] Chapter 13 **(No. of classes: 15, Marks: 15)**

UNIT 3: Double integration over rectangular and nonrectangular regions, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals.

[1] Chapter 14 **(No. of classes: 15, Marks: 15)**

UNIT4: Line integrals, Applications of line integrals**:** Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral; Surface integrals, Stokes' theorem, The Gauss divergence theorem.

[1] Chapter 15 **(No. of classes: 15, Marks: 15)**

Text Books:

1. H. Anton, I. Bivens and S. Davis, Calculus, 10th Edition, John Wiley & Sons, 2012.

Reference Books:

1. J.E. Marsden, A. Tromba and A. Weinstein, Basic Multivariable Calculus, 2004.
2. G.B. Thomas and R.L. Finney, Calculus, 9th Edition, Pearson, 2005.
3. J. Stewart, Multivariable Calculus: Concepts and Contexts, 3rd Edition, Brooks /Cole, Thomson Learning, 2001.
4. G.L. Bradley and K.J. Smith, Calculus, 2nd Edition, Pearson, 1998.

SEMESTER-V

MAT0500204MN: Linear Algebra (Minor)

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: MAT0400104MJ

Course Outcomes: The students who take this course will be able to:

CO1 Define linear spaces and discuss their general properties, linear dependence and linear independence of vectors, bases and dimensions of vector spaces

CO2 Explain the basic concepts of linear transformations, dimension theorem, matrix representations of linear transformations, and the change of coordinate matrix.

CO3 Compute the characteristic polynomial, eigenvalues, eigenvectors and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.

CO4 Determine inner products and orthogonality on vector spaces.

CO5 Use Gram-Schmidt orthogonalization to obtain orthonormal basis.

UNIT 1: Definition and examples of vector spaces, general properties of vector spaces, Definition and examples of subspaces, subspace criterions and algebra of subspaces, null space and column space of a matrix, Linear transformations, Kernel and range of a linear transformation.

[1] Chapter 4, [2] Chapter 4 **(No. of classes: 15, Marks: 15)**

UNIT 2: Linear combinations of vectors, linearly dependent and independent sets, bases of vector spaces, coordinate systems, dimension of a vector space, ranks, change of basis.
[1] Chapter 4 [2] Chapter 5 **(No. of classes: 15, Marks: 15)**

UNIT 3: Eigenvectors and eigenvalues of a matrix, The Characteristic equation, Diagonalization, eigenvector of a linear transformation, Complex eigenvalues. Invariant subspaces and Cayley-Hamilton Theorem. **(No. of classes: 15, Marks: 15)**
[1] Chapter 5, [2] Chapter 9, [3] Chapter 5

UNIT 4: Inner products, Length and orthogonality, orthogonal sets, orthogonal projections, The Gram-Schmidt process, Inner product spaces. Bilinear and quadratic forms.
[1]: Chapter 6, [2]: Chapter 12 **(No. of classes: 15, Marks: 15)**

Text Books:

1. D.C. Lay, Linear Algebra and its Applications, 3rd Edition, Pearson, 2007.

Reference Books:

1. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall of India, 2017.
2. G. Strang, Linear Algebra and its Applications, Cengage Learning, 2005.
3. G. Schay, Introduction to Linear Algebra, Narosa, 1997.
4. S. Lipschutz, Linear Algebra, 5th Edition, McGraw-Hill, 2013.
5. S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, 4th Edition, Prentice Hall of India, 2004.
6. S. Axler, Linear Algebra Done Right, 4th Edition, Springer, 2026.

SEMESTER-V

MAT0500304MN: Numerical Analysis (with practical) (Minor)

Total Marks: 100 (External 45, Practical 25, Internal30)

No. of Credits: 4 (Theory 3, Practical 1)

(Use of Scientific calculator is allowed)

No. of Contact classes: 75 (45+30×1)

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard, Knowledge on computer software and programming

Course Outcomes: The students who take this course will be able to:

CO1 Apply numerical methods to find the zeroes of nonlinear functions of a single variable and

solution of a system of linear equations, upto a certain given level of precision.

CO2 Compute the values for a tabulated function at points not in the table using interpolation techniques.

CO3 Measure a definite integral that cannot be done analytically

CO4 Estimate numerical differentiation of functional values

CO5 Solve differential equations that cannot be solved by analytical methods

UNIT 1: Gaussian elimination method (with row pivoting), Gauss-Jordan method; Iterative methods**:** Jacobi method, Gauss-Seidel method; Interpolation**:** Lagrange form, Newton form, Finite difference operators, Gregory-Newton forward and backward difference interpolations, Piecewise polynomial interpolation (Linear and Quadratic).

[3] Chapter3 (Sections 3.1, 3.2), Chapter 6 (Sections 6.1, 6.2) Chapter 8 (Section 8.1, Section 8.3 (8.3.1 and 8.3.2))

[4] Chapter 3 (Sections 3.2, 3.4) Chapter 4 (Sections 4.2, 4.3, 4.4)

[1] Chapter 18 (Sections 18.1 to 18.3) **(No. of classes: 20, Marks: 25)**

UNIT 2: Numerical differentiation**:** First and second order derivatives; Numerical integration**:** Trapezoid rule, Simpson's rule; Extrapolation methods**:** Richardson extrapolation, Romberg integration; Numerical solutions of ODE**:** Euler's method, Modified Euler's methods.

[2] Chapter 11 [Sections 11.1 (11.1.1, 11.1.2, 11.1.4), and11.2 (11.2.1, 11.2.2, 11.2.4)]

[1] Chapter 22 (Sections 22.1, 22.2, 22.3) **(No. of classes: 25, Marks: 20)**

Practical /Lab work to be performed on a computer:

Use of computer aided software (CAS),for example *Matlab/Mathematica/Maple,* etc., for developing the following numerical programs:

(i) Lagrange's interpolation method

(ii) Newton's interpolation method

(iii) To calculate forward and backward differences

(iv) Trapezoidal rule

(v) Simpson's rule

Note: For any of the CAS *Matlab/Mathematica/Maple* etc., 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.

(No. of practical classes: 30, Marks: 25)

Text Books:

1. S.C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, 4th Edition, McGraw-Hill Education, 2018.
2. L.V. Fausett, Applied Numerical Analysis Using MATLAB. Pearson, 2009.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International Publishers, 2012.
4. S.S. Sastry, Introductory Methods of Numerical Analysis, 4th Edition, Prentice Hall of India, 2006.

SEMESTER-VI

MAT0600104MJ: Complex Analysis-I (with practical)

Total Marks: 100 (External 45, Practical 25, Internal 30)

No. of Credits: 4 (Theory 3, Practical 1)

No. of Contact classes: 75 (45+30×1)

No. of Non-Contact classes: 0

Prerequisites: Knowledge on

- Complex number system as the extension of real number system
- Algebra of complex numbers.
- Properties of complex number.
- Modulus, argument and geometrical representation of complex numbers

Course Outcomes: The students who take this course will be able to:

CO1 List some elementary functions and evaluate the contour integrals.

CO2 State Cauchy−Goursat theorem and the Cauchy integral formula

CO3 Discuss the differentiability of complex functions

CO4 Explain the concept of Cauchy-Riemann equations.

CO5 Apply Cauchy-Riemann equations, Cauchy−Goursat theorem and the Cauchy integral formula.

UNIT 1: Functions of complex variable, mappings, limits, theorems on limits, limits involving point at infinity, continuity. Derivatives, rules for differentiation, Cauchy-Riemann equations, sufficient conditions for differentiability. **(No. of classes: 10, Marks: 15)**

[1]: Chapter 2 (Section 13, 14, 15,16,17, 18,19,20, 21,22,23,24)

UNIT 2: Analytic functions, examples of analytic functions, harmonic function. The exponential function, Logarithmic function, examples, branches and derivatives of logarithms, some identities involving logarithms, the power function. Trigonometric function, zeros and singularities of trigonometric functions derivatives of functions, definite integrals of functions.

[1] Chapter 2 (Sections25, 26,27), Chapter 3 (Sections30, 31,32,33,34, 35,36,37,38), Chapter 4

(Section 41, 42) **(No. of classes: 15, Marks: 10)**

UNIT 3: Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals, antiderivatives, proof of antiderivative theorem.

[l] Chapter 4 (Section43, 44, 45,47, 48, 49) **(No. of classes: 10, Marks: 10)**

UNIT4: Cauchy-Goursat theorem, simply connected domains, multiply connected domains, Cauchy integral formula, extension of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.

[1] Chapter 4 (Sections 50, 52,53,54, 55, 58) **(No. of classes: 10, Marks: 10)**

Practical/Lab work to be performed on a Computer:

(MODELING OF THE FOLLOWING PROBLEMS USING MATLAB/MATHEMATICA/MAPLE etc.)

1. Declaring a complex number and graphical representation. e.g. $Z1=3+4i$, $Z2= 4–7i$
2. Program to discuss the algebra of complex numbers, e.g., $Z1=3+4i$, $Z2=4– 7i$, then find $Z1+Z2$, $Z1-Z2$, $Z1*Z2$ and $Z1/ Z2$
3. To find conjugate, modulus and phase angle of an array of complex numbers.
e.g.$Z= [2+ 3i,4-2i, 6+11i,2-5i]$
4. To compute the integral over a straight line path between the two specified end points.

   e. g., $\oint \mathrm{Sin} z\, dz$, along the contour C which is a straight line path from- 1+ I to 2 -i.
5. To perform contour integration.,e.g.,

(i) $\oint (z^2-2z+1)dz$ along the Contour C given by $x=y^2+1; -2\leq y\leq 2$.

(ii) $\oint (z^3+2z^2+1)dz$ along the contour C given by$x^2+y^2=1$,which can be parameterized by

$x = \cos(t)$, $y= \sin(t)$for $0\leq y\leq 2\pi$.

6. To plot the complex functions and analyze the graph. e.g., $f(z) = z, iz, z^2, z^3, e^z$ and $(z^4-1)^{1/4}$, etc

(No. of practical classes: 30, Marks: 25)

Text Books:

1. J.W. Brown and R.V. Churchill, Complex Variables and Applications, 9th Edition, McGraw-Hill, 2021.

Reference Books:

1. J. Bak and D.J. Newman, Complex Analysis, 2nd Edition, Springer-Verlag, 1997.
2. M.R. Spiegel, Complex Variables, McGraw Hill, 2017.
3. S. Ponnusamy and H. Silverman, Complex Variables with Applications, Birkhäuser, 2006.
4. D. Sarason, Complex Function Theory, 2nd Edition, Hindustan Book Agency, 2008.

SEMESTER-VI

MAT0600204MJ: Partial Differential Equations (with practical)

Total Marks: 100 (External 45, Practical 25, Internal 30)

No. of Credits: 4 (Theory 3, Practical 1)

No. of Contact classes: 75 (15×3+30×1)

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard, Knowledge on computer software

Course Outcomes: The students who take this course will be able to:

CO1 Formulate, classify and transform first order PDEs into canonical form.

CO2 Explain method of characteristics, separation of variables and solve first order PDE's.

CO3 Classify and solve second order linear PDEs.

CO4 Discuss Cauchy problem for second order PDE and homogeneous and non-homogeneous wave equations.

CO5 Apply the method of separation of variables for solving many well-known second-order PDEs.

UNIT 1: Introduction, Construction of first order partial differential equations (PDE). Classification, Linear, Quasilinear and Non-linear equations. Cauchy's problem for first order equations, linear equations of the first order, Integral surfaces passing through a given curve, Nonlinear partial differential equations of the first order, Cauchy's method of characteristics, Charpit's method.

[1] Chapter 2 (Sections 2.1 to 2.3), [2] Chapter 2 (Section 3, 4,5, 7,8,10,12, 13)
(No. of classes: 25, Marks: 25)

UNIT 2: Canonical form of first order PDE, Method of separation of variables for first order PDE.
[1] Chapter 2 **(No. of classes: 10, Marks: 10)**

UNIT 3: General solution **of higher order PDE with constant coefficients.**
[1] Chapter 4, [2] Chapter 3 **(No. of classes: 10, Marks: 10)**

Practical /Lab work to be performed in a Computer Lab:

(No. of practical classes: 30, Marks: 25)

Modelling of the following similar problems using Mathematica /MATLAB/ Maple/ Maxima/Scilab etc.

1. Solution of Cauchy problem for first order PDE.

2. Plotting the characteristics for the first order PDE.

3. Plot the integral surfaces of a given first order PDE with initial data.

4. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ for any two of the following associated conditions:

(a) $u(x,0) = \phi(x);\ u(x,0) = \psi(x), x \in R; t > 0$

(b) $u(x,0)=\phi(x); u_t(x,0)=\psi(x);\ \ u(0,t)=0, x>0; t>0$

(c) $u(x,0)=\phi(x); u_t(x,0)=\psi(x);\ \ u_x(0,t)=0, x>0; t>0$

(d) $u(x,0)=\phi(x); u_t(x,0)=\psi(x);\ \ u(0,t)=0, u(l,t)=0; x>0; t>0$

5. Solving systems of ordinary differential equations.

6. Solution of one-Dimensional heat equation $u_t = k\, u_{xx}$, for a homogeneous rod of length l.

That is - solve the IBVP:

$$u_t = k\, u_{xx}, \qquad 0 < x < l, \qquad t > 0$$
$$u(0,t) = 0, \qquad u(l,t) = 0, \qquad t \geq 0$$
$$u(0,t) = f(x), \quad 0 \leq x \leq l$$

Text Book:

1. Tyn Myint-U and Lokenath Debnath**,** *Linear Partial Differential Equation for Scientists and Engineers*, Springer, Indian reprint, 2006.
2. T. Myint-U, Ordinary Differential Equations, Elsevier, North-Holland, 1978.
3. Sneddon, I. N. (2006). *Elements of Partial Differential Equations*, Dover Publications. Indian Reprint.

Reference Book:

1. Stavroulakis, Ioannis P & Tersian, Stepan A. (2004). *Partial Differential Equations*: *An Introduction with Mathematica and* MAPLE (2nd ed.). World Scientific.

SEMESTER-VI

MAT0600304MJ: Metric Spaces

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: MAT0300204, MAT0400404

Course Outcomes: The students who take this course will be able to:

CO1 Define various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces.
CO2 Analyse how a theory advances from a particular frame to a general frame.
CO3 Construct the mathematical understanding of various geometrical concepts, viz. Balls or connected sets etc. in an abstract setting.
CO4 Develop the two important topological properties of metric spaces, namely connectedness and compactness.

UNIT 1: Definition and examples of Metric spaces, sequences in metric spaces, Cauchy sequences, complete metric spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces.

[1] Chapter 1, 2 **(No. of classes: 15, Marks: 15)**

UNIT 2: Continuity: Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Equivalent metrics, Isometry. Contraction mappings.

[1] Chapter 3 **(No. of classes: 15, Marks: 15)**

UNIT 3: Connected metric spaces: Connectedness, connected subsets of real numbers, connectedness and continuous mappings, components. Compact metric spaces: bounded sets and compactness, other characterisations of compactness, continuous functions on compact spaces.

[1] Chapter 4, Sections 4.1, Chapter 5, Sections 5.1, 5.2, 5.3 **(No. of classes: 30, Marks: 30)**

Text Books:

1. S. Shirali and H.L. Vasudeva, Metric Spaces, Springer Verlag, 2006.

Reference Books:

1. S. Kumaresan, Topology of Metric Spaces, 2nd Edition, Narosa, 2011.
2. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
3. M.Ó. Searcóid, Metric Spaces, Springer-Verlag, 2007.

SEMESTER-VI

MAT0600404MJ: Mechanics

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Define the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.

CO2 Explain the theory behind friction and center of gravity.

CO3 Formulate conservation of mechanical energy and work-energy equations.

CO4 Illustrate translational and rotational motion of rigid bodies.

UNIT1: Composition and resolution of forces, Parallelogram of forces, Triangle of forces, Converse of triangle of forces, Lami's Theorem, Parallel forces, Moment of a force about a point and an axis. Couple, Resultant of a system of forces. Equilibrium of coplanar forces. Friction, C.G of an arc, plane area, surface of revolution, solid of revolution.

[3] Chapter I-X **(No. of classes: 30, Marks: 30)**

UNIT 2: Velocities and acceleration along radial and transverse directions and along

tangential and normal directions, motion in a straight line under variable acceleration, simple harmonic motion and elastic string. Newton's law of motion. Work, Energy and momentum, Conservative forces-Potential energy, Impulsive forces, Motion in resisting medium.

[1] Chapter I (Sections 1.1, 1.2,1.3), Chapter 2 (Sections 2.1,2.2), Chapter 3 (Sections 3.1.3.2), Chapter 4 (Sections 4.1), Chapter 5 (Sections5.1,5.3), Chapter 6 (Sections 6.1,6.3).

[2] Chapter 3 (Sections:3.1,3.2,3.3,3.4). **(No. of classes: 30, Marks: 30)**

Text Books:

1. S.L. Loney, An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies, Cambridge University Press, 2017.
2. F. Chorlton, Textbook of Dynamics, 2nd Edition, CBS Publishers & Distributors, 2002.
3. B.C. Das and B.N. Mukherjee, Statics, U. N. Dhur & Sons Pvt. Ltd., 2018.

Reference Books:

1. M.R. Spiegel, Theory and Problems of Theoretical Mechanics, McGraw-Hill, 2010.

Choose any one paper for other Major students and any two or three paper for only minor students

SEMESTER-VI

MAT0600104MN: Complex Analysis-I (with practical) (Minor)

Total Marks: 100 (External 45, Practical 25, Internal 30)

No. of Credits: 4 (Theory 3, Practical 1)

No. of Contact classes: 75 (45+30×1)

No. of Non-Contact classes: 0

Prerequisites: Knowledge on

- Complex number system as the extension of real number system
- Algebra of complex numbers.
- Properties of complex number.
- Modulus, argument and geometrical representation of complex numbers

Course Outcomes: The students who take this course will be able to:

CO1 List some elementary functions and evaluate the contour integrals.

CO2 State Cauchy−Goursat theorem and the Cauchy integral formula

CO3 Discuss the differentiability of complex functions

CO4 Explain the concept of Cauchy-Riemann equations.

CO5 Apply Cauchy-Riemann equations, Cauchy−Goursat theorem and the Cauchy integral formula.

UNIT 1: Functions of complex variable, mappings, limits, theorems on limits, limits involving point at infinity, continuity. Derivatives, rules for differentiation, Cauchy-Riemann equations, sufficient

conditions for differentiability. **(No. of classes: 10, Marks: 15)**

[1]: Chapter 2 (Section 13, 14, 15,16,17, 18,19,20, 21,22,23,24)

UNIT 2: Analytic functions, examples of analytic functions, harmonic function. The exponential function, Logarithmic function, examples, branches and derivatives of logarithms, some identities involving logarithms, the power function. Trigonometric function, zeros and singularities of trigonometric functions derivatives of functions, definite integrals of functions.

[1] Chapter 2 (Sections25, 26,27), Chapter 3 (Sections30, 31,32,33,34, 35,36,37,38), Chapter 4 (Section 41, 42) **(No. of classes: 15, Marks: 10)**

UNIT 3: Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals, antiderivatives, proof of antiderivative theorem.

[l] Chapter 4 (Section43, 44, 45,47, 48, 49) **(No. of classes: 10, Marks: 10)**

UNIT4: Cauchy-Goursat theorem, simply connected domains, multiply connected domains, Cauchy integral formula, extension of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.

[1] Chapter 4 (Sections 50, 52,53,54, 55, 58) **(No. of classes: 10, Marks: 10)**

Practical/Lab work to be performed on a Computer:

(MODELING OF THE FOLLOWING PROBLEMS USING MATLAB/MATHEMATICA/MAPLE etc.)

1. Declaring a complex number and graphical representation. e.g. Z_1=3+4i, Z_2= 4–7i
2. Program to discuss the algebra of complex numbers, e.g., Z_1=3+4i, Z_2=4– 7i, then find Z_1+Z_2, Z_1-Z_2, Z_1*Z_2 and Z_1/Z_2
3. To find conjugate, modulus and phase angle of an array of complex numbers.

e.g.Z= [2+ 3i,4-2i, 6+11i,2-5i]

4. To compute the integral over a straight line path between the two specified end points.

   e. g., $\oint \mathrm{Sin}z\, dz$, along the contour C which is a straight line path from- 1+ I to 2 -i.

5. To perform contour integration.,e.g.,

(i) $\oint(z^2-2z+1)dz$ along the Contour C given by $x=y^2+1; -2\leq y\leq 2$.

(ii) $\oint(z^3+2z^2+1)dz$ along the contour C given by$x^2+y^2=1$,which can be parameterized by

x = cos(t), y= sin(t)for $0\leq y\leq 2\pi$.

6. To plot the complex functions and analyze the graph. e.g., f(z) = z, iz, z^2, z^3, e^z and $(z^4-1)^{1/4}$, etc

(No. of practical classes: 30, Marks: 25)

Text Books:

1. J.W. Brown and R.V. Churchill, Complex Variables and Applications, 9th Edition, McGraw-Hill, 2021.

Reference Books:

1. J. Bak and D.J. Newman, Complex Analysis, 2nd Edition, Springer-Verlag, 1997.

2. M.R. Spiegel, Complex Variables, McGraw Hill, 2017.

3. S. Ponnusamy and H. Silverman, Complex Variables with Applications, Birkhäuser, 2006.

4. D. Sarason, Complex Function Theory, 2nd Edition, Hindustan Book Agency, 2008.

SEMESTER-VI

MAT0600204MN: Partial Differential Equations (with practical) (Minor)

Total Marks: 100 (External 45, Practical 25, Internal 30)

No. of Credits: 4 (Theory 3, Practical 1)

No. of Contact classes: 75 (15×3+30×1)

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard, Knowledge on computer software

Course Outcomes: The students who take this course will be able to:

CO1 Formulate, classify and transform first order PDEs into canonical form.

CO2 Explain method of characteristics, separation of variables and solve first order PDE's.

CO3 Classify and solve second order linear PDEs.

CO4 Discuss Cauchy problem for second order PDE and homogeneous and non-homogeneous wave equations.

CO5 Apply the method of separation of variables for solving many well-known second-order PDEs.

UNIT 1: Introduction, Construction of first order partial differential equations (PDE). Classification, Linear, Quasilinear and Non-linear equations. Cauchy's problem for first order equations, linear equations of the first order, Integral surfaces passing through a given curve, Nonlinear partial differential equations of the first order, Cauchy's method of characteristics, Charpit's method.

[1] Chapter 2 (Sections 2.1 to 2.3), [2] Chapter 2 (Section 3, 4,5, 7,8,10,12, 13)
(No. of classes: 25, Marks: 25)

UNIT 2: Canonical form of first order PDE, Method of separation of variables for first order PDE.
[1] Chapter 2 **(No. of classes: 10, Marks: 10)**

UNIT 3: General solution of higher order PDE with constant coefficients.

[1] Chapter 4, [2] Chapter 3 **(No. of classes: 10, Marks: 10)**

Practical /Lab work to be performed in a Computer Lab:

(No. of practical classes: 30, Marks: 25)

Modelling of the following similar problems using Mathematica /MATLAB/ Maple/ Maxima/Scilab etc.

1. Solution of Cauchy problem for first order PDE.
2. Plotting the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.
4. Solution of wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ for any two of the following associated conditions:

(a) $u(x,0) = \phi(x);\ u(x,0) = \psi(x), x \in R; t > 0$

(b) $u(x,0) = \phi(x); u_t(x,0) = \psi(x);\ \ u(0,t) = 0, x > 0; t > 0$

(c) $u(x,0) = \phi(x); u_t(x,0) = \psi(x);\ \ u_x(0,t) = 0, x > 0; t > 0$

(d) $u(x,0) = \phi(x); u_t(x,0) = \psi(x);\ \ u(0,t) = 0, u(l,t) = 0; x > 0; t > 0$

5. Solving systems of ordinary differential equations.
6. Solution of one-Dimensional heat equation $u_t = k\, u_{xx}$, for a homogeneous rod of length l.

   That is - solve the IBVP:

$$u_t = k\, u_{xx}, \qquad 0 < x < l, \qquad t > 0$$
$$u(0,t) = 0, \qquad u(l,t) = 0, \qquad t \geq 0$$
$$u(0,t) = f(x), \ \ 0 \leq x \leq l$$

Text Book:

1. Tyn Myint-U and Lokenath Debnath**,** *Linear Partial Differential Equation for Scientists and Engineers*, Springer, Indian reprint, 2006.
2. T. Myint-U, Ordinary Differential Equations, Elsevier, North-Holland, 1978.
3. I. N. Sneddon, *Elements of Partial Differential Equations*, Dover Publications. Indian Reprint 2006.

Reference Book:

1. Ioannis P. Stavroulakis, & Stepan A. Tersian,. *Partial Differential Equations*: *An Introduction with Mathematica and* MAPLE (2nd ed.). World Scientific 2004.

SEMESTER-VI

MAT0600304MN: Metric Spaces

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: MAT0300204MN, MAT0400404MN

Course Outcomes: The students who take this course will be able to:

CO1 Define various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces.
CO2 Analyse how a theory advances from a particular frame to a general frame.
CO3 Construct the mathematical understanding of various geometrical concepts, viz. Balls or connected sets etc. in an abstract setting.
CO4 Develop the two important topological properties of metric spaces, namely connectedness and compactness.

UNIT 1: Definition and examples of Metric spaces, sequences in metric spaces, Cauchy sequences, complete metric spaces. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces.

[1] Chapter 1, 2 **(No. of classes: 15, Marks: 15)**

UNIT 2: Continuity: Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Equivalent metrics, Isometry. Contraction mappings.

[1] Chapter 3 **(No. of classes: 15, Marks: 15)**

UNIT 3: Connected metric spaces: Connectedness, connected subsets of real numbers, connectedness and continuous mappings, components. Compact metric spaces: bounded sets and compactness, other characterisations of compactness, continuous functions on compact spaces.

[1] Chapter 4, Sections 4.1, Chapter 5, Sections 5.1, 5.2, 5.3 **(No. of classes: 30, Marks: 30)**

Text Books:

1. S. Shirali and H.L. Vasudeva, Metric Spaces, Springer Verlag, 2006.

Reference Books:

1. S. Kumaresan, Topology of Metric Spaces, 2nd Edition, Narosa, 2011.
2. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
3. M.Ó. Searcóid, Metric Spaces, Springer-Verlag, 2007.

SEMESTER-VI

MAT0600404MN: Mechanics

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: Mathematics in 10+2 or equivalent standard

Course Outcomes: The students who take this course will be able to:

CO1 Define the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.

CO2 Explain the theory behind friction and center of gravity.

CO3 Formulate conservation of mechanical energy and work-energy equations.

CO4 Illustrate translational and rotational motion of rigid bodies.

UNIT1: Composition and resolution of forces, Parallelogram of forces, Triangle of forces, Converse of triangle of forces, Lami's Theorem, Parallel forces, Moment of a force about a point and an axis. Couple, Resultant of a system of forces. Equilibrium of coplanar forces. Friction, C.G of an arc, plane area, surface of revolution, solid of revolution.

[3] Chapter I-X **(No. of classes: 30, Marks: 30)**

UNIT 2: Velocities and acceleration along radial and transverse directions and along tangential and normal directions, motion in a straight line under variable acceleration, simple harmonic motion and elastic string. Newton's law of motion. Work, Energy and momentum, Conservative forces-Potential energy, Impulsive forces, Motion in resisting medium.

[1] Chapter I (Sections 1.1, 1.2,1.3), Chapter 2 (Sections 2.1,2.2), Chapter 3 (Sections 3.1.3.2), Chapter 4 (Sections 4.1), Chapter 5 (Sections5.1,5.3), Chapter 6 (Sections 6.1,6.3).

[2] Chapter 3 (Sections:3.1,3.2,3.3,3.4). **(No. of classes: 30, Marks: 30)**

Text Books:

1. S.L. Loney, An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies, Cambridge University Press, 2017.

2. F. Chorlton, Textbook of Dynamics, 2nd Edition, CBS Publishers & Distributors, 2002.

3. B.C. Das and B.N. Mukherjee, Statics, U. N. Dhur & Sons Pvt. Ltd., 2018.

Reference Books:

1. M.R. Spiegel, Theory and Problems of Theoretical Mechanics, McGraw-Hill, 2010.

SEMESTER-VII

OPTION-I: HONOURS/ OPTION-II: HONOURS WITH RESEARCH

MAT4700104MJ: Algebra

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact Classes: 60

No. of Non-Contact Classes: 0

Prerequisite for the paper: MAT0400104MJ: Abstract Algebra & MAT0500204MJ: Linear Algebra

Course Outcomes: The students who take this course will be able to:

CO1 Understand and apply Sylow's Theorems to determine the existence, number, and structure of p-subgroups of finite groups.

CO2 Describe direct product of groups and different kinds of subnormal series of groups.

CO3 Explain polynomial rings over commutative rings, PID, Euclidean Domain and UFD.

CO4 Discuss field extension and its application to geometry.

CO5 Identify about similarity of linear transforms and classify Jordan canonical forms and quadratic forms.

UNIT 1: Sylow's theorems and their applications. Direct product and Direct sums of Groups, Internal direct product and Decomposable Groups, Normal and Subnormal series of Groups, Solvable Groups, Composition series of Groups, Jordan-Holder theorem.

(No. of classes: 15, Marks: 15)

UNIT 2: Polynomial rings over commutative rings, Divisibility in commutative rings, Principal Ideal Domain (PID), Euclidean Domain, Unique Factorization Domains (UFD) and their properties. Eisenstein's irreducibility criterion. **(No. of classes: 15, Marks: 15)**

UNIT 3: Subfields and Prime fields, Extensions of fields, Algebraic and Transcendental elements, Algebraic extensions, Splitting fields, Perfect fields, Finite fields, Moore's theorem, Construction by ruler and compass. **(No. of classes: 15, Marks: 15)**

UNIT 4: Canonical forms, Similarity of linear transforms, Invariant subspaces, Reduction to triangular forms, Nilpotent transformations, Primary decomposition theorem, Jordan blocks and Jordan canonical form, Quadratic forms, Reduction and classification of quadratic forms.

(No. of classes: 15, Marks: 15)

Text Books:

1. I.N. Herstein, Topics in Algebra, 2nd Edition, John Wiley & Sons, 1975.
2. S. Singh and Q. Zameeruddin, 9th Edition, Modern Algebra, Vikas Publishing House, 2006.
3. D. S. Dummit, R. M. Foote, Abstract Algebra (2rd Ed.), Wiley, 2011

Reference Books:

1. D.S. Malik, J.M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, McGraw-Hill, 1997.
2. C. Musili, Introduction to Rings and Modules, 2nd Revised Edition, Narosa, 1997.
3. K. Hoffman and R. Kunz, Linear Algebra, 2nd Edition, Prentice Hall, 1971.
4. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India, 2004.
5. S. Lipschutz, Linear Algebra, 5th Edition, McGraw-Hill, 2013.

SEMESTER-VII

MAT4700204MJ: Real Analysis and Lebesgue Measure

Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact Classes: 60
No. of Non-Contact Classes: 0

Pre-requisite for the paper: MAT0300204: Real Analysis-I, MAT0400404: Real Analysis-II

Course outcomes: The students who take this course will be able to:

CO1 Identify the region of convergence of power series.

CO2 Illustrate Lebesgue measure on R, and construct integrals using Lebesgue measure.

CO3 Explain basic convergence theorems for the Lebesgue integral.

CO4 Explain sequences of functions and their uniform convergence

CO5 Develop the core skills of the subject and research skills in this areas.

UNIT 1: Pointwise and uniform convergence, Cauchy Criterion for Uniform Convergence, Interchange of Limits, Series of Functions, Tests for Uniform Convergence, Weierstrass approximation theorem, Power series. Abel's and Tauber's theorem **(No. of classes: 15, Marks: 15)**

UNIT 2: Vector valued function, continuity, differentiation, Functions of bounded variation, their continuity, and monotonicity. Improper Integrals, Definition of the Riemann Integral, examples, Some Properties of the Integral, Riemann Integrable Functions, The Fundamental Theorem, The Darboux Integral, Definition of Riemann Steiltjes integral, examples and properties, Integration and Differentiation, Fundamental theorem of calculus. **(No. of classes: 15, Marks: 15)**

UNIT 3: Lebesgue outer measure, Measurable sets and properties, Borel sets and their measurability, Characterization of measurable sets, Non-measurable sets, Measurable functions and their properties, Operations of measurable functions, Sets of measure zero, Sequence of measurable functions, Convergence in measure. Construction of Lebesgue measure, Measure spaces, Measurable functions, simple functions.

(No. of classes: 15, Marks: 15)

UNIT 4: Lebesgue integral, Lebesgue integral of a bounded function, Comparison of Riemann integral and Lebesgue integral, Integral of a non-negative measurable function, General Lebesgue integral, Convergence of Lebesgue integral, Bounded convergence theorem, Monotone convergence theorem, Lebesgue convergence theorem. Fatou's theorem.

(No. of classes: 15, Marks: 15)

Text Books:

1. W. Rudin, Principles of Mathematical Analysis, 3rd Edition, McGraw-Hill, 2023.

2. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 4th Edition, John Wiley & Sons, 2011.
3. S.C. Malik and S. Arora, Mathematical Analysis, New Age International Publishers, 2017.
4. R.R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing, 2012.
5. S. Axler, Measure, Integration & Real Analysis, Springer, 2020.
6. M.T. Nair, Measure and Integration: A First Course, CRC Press, 2019.

SEMESTER VII

MAT4700304MJ: Complex Analysis-II
Total Marks: 100 (External 60, Internal 40)
No of credit: 4
No of contact classes; 60
No of non contact classes: 0

Prerequisites: MAT0600104: Complex Analysis-I

Course learning outcomes: The students who take this course will be able to:

CO1 Define Conformal mappings and illustrate with examples.
CO2 Discuss analytic continuation and Gamma function.
CO3 Compute integrals of complex functions using Residue theorem.
CO4 Understand the concept of Riemann surface.
CO5 Formulate Power series expansions of complex valued functions.

UNIT 1: Power Series: Taylor's and Laurent's Theorem, Zero and Singularity of an analytic function, The Argument Principle, Rouche's theorem. **(No. of classes: 15, Marks: 15)**

UNIT 2: Theory of Residues: Residue, Calculation of Residues, Cauchy's residue theorem, Evaluation of definite integrals, Special theorems used in evaluating integrals, Mittag-Leffer's theorem. **(No. of classes: 15, Marks: 15)**

UNIT 3: Analytic functions as mappings: Isogonal and Conformal Transformation, Necessary and sufficient condition of conformal transformation, Bilinear transformations, Geometrical inversion, Invariance of cross ratio, Fixed points of a bilinear transformation, some special bilinear transformation e.g. real axis on itself, unit circle on itself, real axis on unit circle etc. Branch point and Branch line, Concept of the Riemann surface. **(No. of classes: 15, Marks: 15)**

UNIT 4: Analytic Continuation: Analytical continuation, Schwarz's reflection principle, Infinite products, Gamma Function and its properties **(No. of classes: 15, Marks: 15)**

Text Books:

1. M.R. Spiegel, Complex Variables, McGraw Hill, 2017.

2. E.G. Phillips, Functions of a Complex Variables with Applications, Oliver and Boyd, 1957.

Reference Books:

1. W. Rudin, Real and Complex Analysis, 3rd Edition, McGraw Hill, 2023.
2. L.V. Ahlfors, Complex Analysis, 3rd Edition, McGraw Hill, 2017.
3. H.A. Priestly, Introduction to Complex Analysis, 2nd Edition, Oxford University Press,

2003.
4. M.J. Ablowitz and A.S. Fokas, Complex Variables: Introduction and Applications, Cambridge University Press, 2003.
5. J.B. Conway, Functions of Complex Variable, 2nd Edition, Springer-Verlag, 1978.
6. S. Ponnusamy and H. Silverman, Complex Variables with Applications, Birkhäuser, 2006.
7. D. Sarason, Complex Function Theory, 2nd Edition, Hindustan Book Agency, 2008.

SEMESTER VII

MAT4700504MJ: RESEARCH METHODOLOGY

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 Identify importance of hypothesis in different types of research.

CO2 Classify the different types of research methods.

CO3 Discuss the criteria of a good problem.

CO4 Analyze and distinguish the interpretation of data

CO5 Develop the idea of formulation of scientific articles, report writing and synopsis

CO6 Explain the subject classification number and the preparation of bibliography.

UNIT 1: (a) Research-Introduction: Knowledge and Research, Research and Scientific Thinking, Distinguishing characteristics of scientific thinking. Steps in the progress of scientific thinking. Characteristics of research. Classifications of research. Comparison of fundamental research and action research.

(b) Research Problem: The source of problem. Criteria of a good problem. A guide to judge a research problem. Formulating and starting the problem. Definition of problem. Determination of the problem. Justification of the problem. **(Marks: 10, No of class 10)**

UNIT 2: (a) Hypothesis: The meaning of hypothesis. Importance of hypothesis, Source of hypothesis, Characteristics of hypothesis. The use of hypothesis in different types of research. Different forms of hypothesis. Difficulties in the formulation of hypothesis. Testing of hypothesis.

(b) Survey of related studies: Purpose of survey of related studies, Research reading. The search of sources. Use of library, Note-taking. The bibliography. **(Marks: 10, No of class 10)**

UNIT 3: Classification of Research Methods: Historical methods, normative survey method, Survey testing. The questionnaire, Documentary frequency studies, Interview, Observation. Appraisal procedure, Experimental methods (Bases of experiential method, Variable control, Control of the experiment, purpose of control, methods of control, types of experiments, characteristics of an experiment, major steps in the experimental methods, experimental designs, limitations of experimental method). **(Marks: 10, No of class 10)**

UNIT 4 (a) Some tools and Techniques of Research: Inquiry forms, Schedule, Opinionnaire, Sociometry, Social distance scale, Guess-who technique, Q-sort technique, Situational test, follow-up study, Quantitative studies, qualitative studies.

(b) Sampling: The sampling theory, Bases of sampling, Importance of sampling. Advantage of sampling, Disadvantages of sampling, Characteristics of a good sampling. Steps in sampling procedure. Methods of sampling, Size of sampling. Errors in sampling. **(Marks: 10, No of class 10)**

UNIT 5: Analysis and Interpretation of Data: Analysis from the very beginning, Various steps in analysis and interpretation, Common statistical methods of analysis, Interpretation, Necessary precautions in interpretation, Comparison in interpretation, Conclusions and generalizations.

(Marks: 10, No of class 10)

UNIT 6: The Research Report: Preliminary Section, Main body of the report, Reference section, Style of writing, Tables, Figures, Quotations, Footnotes, Bibliography, Headings, Preparations of the report, Typing the report. Writing style of Synopsis. Strategy and steps for writing scientific articles.

(Marks: 10, No of class 10)

Text Books:

1. C.R. Kothari, Research Methodology: Methods and Techniques, 3rd Edition, New Age International Publishers, 2004.
2. A.E. Kelly and R.A. Lesh, Handbook of Research Design in Mathematics and Science Education, Lawrence Erlbaum Associates, 2000.
3. M.P. Marder, Research Methods for Science, Cambridge University Press, 2011.

Reference Books

1. S.J. Taylor, R. Bogdan and M. DeVault, Introduction to Qualitative Research Methods: A Guidenook and Resource, 4th Edition, Wiley, 2015.
2. N.J. Higham, Handbook of Writing for the Mathematical Sciences, 3rd Edition, Siam Publications, 2020.
3. M. Cargill and P. O'Connor, Writing Scientific Research Articles: Strategy and Steps, Wiley-Blackwell, 2013.

Choose any one paper for other Major students

SEMESTER VII

MAT4700404MN: Differential Equations
Total Marks: 100 (External 60, Internal 40)
No of credit: 4
No of contact classes: 60
No of non contact classes: 0

Prerequisites: MAT0300104MN: Ordinary Differential Equations, MAT0600204MN: Partial Differential Equations.

Course Outcomes: The students who take this course will be able to:

CO1 Identify critical point of an autonomous system and analyse their stability.

CO2 Discuss Frobenius method of series solution for differential equations.

CO3 Explain the existence and uniqueness of solution of first order differential equations

CO4 Construct Green's function, and illustrate Sturm Liouville systems

CO5 Explain the characteristics second order linear PDE.

UNIT 1: Well posed problems, Existence, uniqueness and continuity of solution of ODEs of first order, Picard's method, Existence and uniqueness of solution of differential equations of first order, Sturm separation and comparison theorems, Homogeneous linear systems, Non-homogeneous linear systems. **(No. of classes: 15, Marks: 15)**

UNIT 2: Linear homogeneous differential equation-Ordinary and singular points, Series solution, Method of Frobenius, Solutions of Bessel's and Legendre equations.

(No. of classes: 10, Marks: 10)

UNIT 3: Two point boundary value problems, Green's function, Construction of Green's function, Sturm Liouville systems, Eigen values and eigen functions, Stability of autonomous system of differential equations, Critical point of an autonomous system and their classification as stable, Asymptotically stable, Strictly stable and unstable, Stability of linear systems with constant coefficients, Linear plane autonomous systems, Perturbed systems, Method of Lyapunov for nonlinear systems. **(No. of classes: 25, Marks:-25)**

UNIT 4: Second order linear PDE-Classification, Reduction to canonical form.

(No. of classes: 10 Marks: 10)

Text Books:

1. S.L. Ross, Differential Equations, Second Edition, John Wiley & Sons, India, 2007.
2. T. Myint-U, Ordinary Differential Equations, Elsevier, North-Holland, 1978.
3. I.N. Sneddon, Elements of Partial Differential Equations, Mcgraw Hill 2006
4. K.S. Rao, Introduction to partial differential equations, Prentice Hall, New Delhi, 1997.

Reference Books:

1. Lawrence C. Evans, Partial Differential Equations, Second Edition, American Mathematical Society, 2014.
2. Erich Zauderer, Partial Differential Equations of Applied Mathematics, A Wiley-Interscience Publication, John Wiley and Sons, 1983.
3. H.F. Weinberger, A first course in partial differential equations, Blaisdell, 1965.
4. C.R. Chester, Techniques in partial differential equations, McGraw Hill, New York, 1971.
5. R. Courant and D. Hilbert: Methods of Mathematical Physics: Partial differential equations, Vol –II, Wiley-VCH, 1989
6. W.E. Williams, Partial Differential Equations, Oxford University Press,1980
7. F.H. Miller, Partial Differential Equations, J. Wiley & Sons; London, Chapman & Hall, 1941.
8. A. Sommerfeld, Partial differential equations in physics, Academic Press, New York, 1967.
9. I. Stakgold, Green's functions and boundary value problems, Wiley, New York, 1979.

SEMESTER VII

MAT4700604MN: Bio-Mathematics
Total Marks: 100 (External 60, Internal 40)
No of credit: 4
No of contact classes: 60
No of non contact classes: 0

Prerequisites: MAT0300104MN: Ordinary Differential Equations

Course outcomes: The students who take this course will be able to:

CO1 Formulate mathematical models using differential equations and develop, analysis and interpretation of bio mathematical models such as population growth, cell division, and predator-prey models.

CO2 Develop and analyze mathematical models of heart dynamics and cardiac pacemakers.

CO3 Apply phase plane analysis to heart beat models and threshold phenomena

CO4 Identify and interpret chaotic behavior in dynamical systems.

CO5 Examine stability changes associated with bifurcations.

CO6 Apply Poincaré plane techniques to analyze system dynamics.

CO7 Describe matrix models for DNA base substitutions

CO8 Apply probability distributions in genetic analysis

UNIT 1: Basic concepts and definitions, Mathematical model, properly posed mathematical problems, System of differential equation, Existence theorems, Homogeneous linear systems, Non-homogeneous linear systems, Linear systems with constant coefficients, Eigenvalues and eigenvectors, Linear equation with periodic coefficients. Population growth model, administration of drug and epidemics, Cell division Predator Prey Model, Chemical reactions and enzymatic catalysis.
[4] Chapter 1 and Chapter 5 [2] Chapter 1 (Sections 1.1 to 1.3), Chapter 4 (Sections 4.4 to 4.5)
(No. of classes: 15, Marks: 15)

UNIT 2: Stability and Modeling of Biological phenomenon
The Phase Plane, Local Stability, Autonomous Systems, Stability of Linear Autonomous Systems with Constant Coefficients, Linear Plane Autonomous Systems, Method of Lyapunov for Non–Linear Systems, Limit Cycles, Forced Oscillations. Mathematics of Heart Physiology**:** The local model, The Threshold effect, The phase plane analysis and the Heart beat model, Physiological considerations of the Heart beat model, A model of the Cardiac pace-maker. Mathematics of Nerve impulse transmission**:** Excitability & repetitive firing, Travelling waves. **(No. of classes: 15, Marks: 15)**
[4] Chapter 8 (Sections 8.1 to 8.6)
[2] Chapter 4 (Sections 4.1 to 4.3), Chapter 5 (Sections 5.1 and 5.7), Chapter 6 (Sections 6.4 and 6.5), Chapter 7 (Sections 7.1 and 7.3)

UNIT 3: Bifurcation and Chaos
Bifurcation and chaos**:** Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation, Chaos, Stability, The Poincare plane.
[2] Chapter 13 (Sections 13.1 to 13.4 **(No. of classes: 15, Marks: 15)**

UNIT 4: Modelling Molecular Evolution and Genetics
Modelling Molecular Evolution**:** Matrix models of base substitutions for DNA sequences, The Jukes-Cantor Model, the Kimura Models, Phylogenetic distances.
Constructing Phylogenetic trees**:** Unweighted pair-group method with arithmetic means (UPGMA), Neighbour- Joining Method, Maximum Likelihood approaches.

Genetics**:** Mendelian Genetics, Probability distributions in Genetics, Linked genes and Genetic Mapping, Statistical Methods and Prediction techniques.
[1] Chapter 4 (Sections 4.4 and 4.5), Chapter 5 (Section 5.1 to 5.3), Chapter 6 (Sections 6.1 and 6.2)
(No. of classes: 15, Marks: 15)

Text Books:
1. Elizabeth S. Allman & John A. Rhodes, *Mathematical Models in Biology.* Cambridge University Press 2004.
2. D. S. Jones & B. D. Sleeman, *Differential Equations and Mathematical Biology,* Chapman & Hall, CRC Press, London, UK 2003.
3. J. D. Murray, *An Introduction to Mathematical Biology*. Springer 2002.
4. Tyn– I. Myint, *Ordinary Differential Equation*. Elsevier Science Ltd 1977.
5. G. F. Simmons & S. G. Krant, *Differential Equations*. McGraw Hill Education 2015.
6. Steven H. Strogatz, *Nonlinear Dynamics and Chaos*. Perseus Book Publishing. LLC 1994.

SEMESTER VII

MAT4700704MN: History of Mathematics
Total Marks: 100 (External 60, Internal Assessment 40)
No. of credits: 4
No. of Contact Classes: 60
No. of Non-Contact Classes: 0

Prerequisite for the paper: Mathematics in 10+2 or equivalent standard.

Course Outcomes: After the completion of the course, the student will:

CO 1 Understand and trace the historical development of various mathematical processes, thought, areas, and topics including causes and effects.

CO 2 Understand the roles that various mathematicians and cultures have played in the historical development of mathematics.

CO 3 Develop the capacity to identify and explain how specific mathematical developments changed a given society.

CO 4 Learn the importance of avoiding the imposition of modern views of mathematics and society on the development and use of earlier mathematics.

UNIT 1: Mesopotamia and Egypt (2000 – 1500 BCE):

Sketches of two millennia of Mesopotamian history, countings, number system, computations and geometry in Mesopotamia, Egyptian numerals and arithmetic, algebra and geometry in ancient Egypt.

[1] Chapters 1-2; [2] Chapters 3–7; [3] Chapter 1 **(No. of classes: 8, Marks: 8)**

UNIT 2: Greek Mathematics (500 BCE-500CE):

Pythagoras, Plato's Philosophy, Greek number theory and Geometry, classical problems in Athenian mathematics, contributions of Euclid, Archimedes, Apollonius, Zenodorus, Heron, Ptolemy, Diophantus, Pappus, Theon and Hypatia.

[1] Chapters 3-5; [2] Chapters 8–18 **(No. of classes: 8, Marks: 8)**

UNIT 3: Indian Mathematics (1200 BCE - 2000 CE)

Vedas to Aryabhata, Vedic ritual geometry, Hindu-Arabic Numerals, problems from the sulva sutras, Aryabhata's geometry and trigonometry, Kuttaka, Brahmagupta's geometry, number theory and algebra, story of zero, Bhaskara's algebra, combinatorics and geometry, contributions of Madhava of Sangamagrama, Srinivas Ramanujan and Subbayya Sivasankaranarayana Pillai.

[2] Chapters 19–21; [3] Chapter 9 **(No. of classes: 7, Marks: 7)**

UNIT 4: Chinese, Arabian and Japanese Mathematics (500 BCE-1700 CE):

The Chinese Number System, Contents of the Jiu Zhang Suan Shu, contributions of Chinese in algebra and Geometry, contributions of Japanese in geometry and algebra, sangaku, contributions of Arabians in algebra, geometry and number theory.

[2] Chapters 21–27; [3] Chapters 7, 9 **(No. of classes: 8, Marks: 8)**

UNIT 5: European Mathematics (500 - 1900 CE):

Discovery of logarithms, Solution of the cubic equations and introduction of complex numbers (Tartaglia, Cardano, Bombelli), The Fibonacci Sequence, Contributions of Chuquet, Pacioli, Viete, Works of Copernicus, Galileo, Kepler, Newton, Leibnitz, Fermat, Pascal, Descartes, Huygens, Bernoulli family, Euler, Fermat, Laplace, Hilbert, Lagrange and Abel.

[1] Chapters 7-11; [2] Chapters 28–34. **(No. of classes: 10, Marks: 10)**

UNIT 6: Modem Mathematics:

Analysis, probability, algebra, number theory, geometry in eighteenth and nineteenth centuries, mathematical aspects of the twentieth century and beyond.

[3] Chapters 17-25 **(No. of classes: 9, Marks: 9)**

UNIT 7: Faces and dramas behind theorems:

Lagrange, Laplace, Sophie Germain, Fourier, Cauchy, Abel, Galois, Gauss, Lobachevsky, Riemann, Weierstrass, Chebyshev, Argand, Hamilton, Möbius, Maxwell, Cayley, Sylvester, Heaviside, Kelvin.

[3] Chapters 12, 17, 18, 21, 22, 24 **(No. of classes: 5, Marks: 5)**

UNIT 8: Women in Mathematics:

Maria Agnesi, Sophie Germain, Sofya Kovalevskaya, Grace Chisholm Young, Emmy Noether, Olga Ladyzhenskaya, Maryam Mirzakhani, Karen Uhlenbeck.

[2] Chapter 35 **(No. of classes: 5, Marks: 5)**

Text Books:

1. David M. Burton, The History of Mathematics: An Introduction, 7th edition, Macgraw-Hill, New York, 2011.
2. Roger L. Cooke, The History of Mathematics: A Brief Course, 3rd edition, John Wiley & Sons, New Jersey, 2013.
3. Victor J. Katz, A History of Mathematics, 3rd edition, Pearson, New York, 2009.

Reference Books:

1. W. Dunham, Journey Through Genius: The Great Theorems of Mathematics, Penguin Books, New York, 1991.
2. W. Berlinghoff and F. Gouvea, Math through the ages: a gentle history for teachers and others, Oxton House Publishing, Farmington, 2014.

SEMESTER-VIII

OPTION-I: HONOURS

MAT4800104MJ: Topology

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Prerequisites: MAT0600304: Metric Spaces

Course Outcomes: The students who take this course will be able to:

CO1 identify topological spaces and construct examples of such spaces.

CO2 classify different spaces like first countable, second countable, separable spaces and give the characterization of these spaces using some important results like Urysohn's lemma, Tietze extension theorem.

CO3 use the idea of compactness and connectedness and give their different characterizations.

CO4 explain the product topology and its relationship with compactness, connectedness, and countability.

CO5 provide examples of metrizable spaces and explain the relationship between embedding and metrization.

UNIT 1: Definition and examples of topological spaces, Closed sets and closure, Dense subsets, Neighbourhood, Interior, Exterior and Boundary, Accumulation Points and Derived sets, Bases and subbases. Subbase and Relative Topology, Continuous Functions and Homeomorphism.

(No. of classes: 11, Marks: 10)

UNIT 2: Countable and uncountable sets, First and second Countable spaces, Lindelof's theorem, Separable spaces, Second Countability and Separability.

(No. of classes: 5, Marks: 10)

UNIT 3: Separation Axioms: T_0, T_1, T_2, $T_{3\frac{1}{2}}$, T_4 ; their characterizations and basic properties, Urysohn's lemma, Tietze Extension Theorem. **(No. of classes: 10, Marks: 10)**

UNIT 4: Compactness, continuous functions and compact sets. Basic properties of compactness and related theorems, Sequentially and Countably compact sets, Local Compactness and one point compactification, Stone-Cech Compactification. **(No. of classes: 11, Marks: 10)**

UNIT 5: Connected spaces, connectedness on the real line, components, totally disconnected spaces, Locally connected spaces. **(No. of classes: 11, Marks: 10)**

UNIT 6: Tychonoff product topology in terms of standard subbase and its characterizations, Projection Maps, Separation Axioms and Product Spaces, Connectedness and Product spaces, Compactness and Product Spaces (Tychonoff's Theorem), Countability and Product Spaces, Embedding and Metrization, Urysohn's Metrization theorem. **(No. of classes: 12, Marks: 10)**

Text Books:

1. J.R. Munkres, Topology, 2nd Edition, Prentice Hall of India, 2002.
2. S. Willard, General Topology, Dover Publications, 2004.
3. J. Dugundji, Topology, Allyn and Bacon, 1966.

Reference Books:

1. K.D. Joshi, Introduction to General Topology, 2nd Edition, New Age International Publishers, 2017.
2. S. Lipschutz, Theory and Problems of General Topology, McGraw-Hill, 1965.
3. M.G. Murdeshwar, General Topology, 3rd Edition, New Age International Publishers, 2020.

SEMESTER-VIII

MAT4800304MJ: Mechanics and Tensor Calculus

Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Prerequisites: MAT0600404MJ: Mechanics

Course Outcomes: The students who take this course will be able to:

CO1 Explain various physical laws of motion, Hamiltonian's principle etc. with mathematical tools.

CO2 Distinguish Tensors and perform algebraic operations on tensors, to obtain covariant derivatives of various tensors and to express Laplacian in tensor form.

CO3 Apply various tools of vector algebra as well as vector calculus, calculus of variations to discuss the motion of rigid bodies under certain constraints.

CO4 Differentiate the properties of motion in various coordinate systems viz. cylindrical, spherical, conical surfaces.

CO5 Construct mathematical models viz. rigid body to describe motions under certain constraints or no constraints which are able to analyse the physical scenario.

Group-A: Mechanics

Total marks: 30 **Credit: 2**

UNIT 1: Central forces, Central orbit, Laws of inverse square, Kepler's laws of planetary motion; Velocity and acceleration in cylindrical and spherical polar coordinates.

Motion of a rigid body about a fixed point: Euler's equations, Motion under no external forces.

(No. of classes 15, Marks 15)

UNIT 2: Generalized coordinates: Lagrange's equations of motion for finite forces in holonomic systems, Case of conservative forces and theory of small oscillations. Hamilton's equations of motion, Variational methods, Hamilton's principle and Principle of least action.

(No of classes 15, Marks 15)

Group-B: Tensor Calculus

Total Marks: 30 **Credit: 2**

UNIT 1: Transformation laws of covariant and contravariant tensors, Mixed tensor, Rank of tensors. Kronecker delta. Algebraic operations on tensors: addition, subtraction, contraction, inner and outer product of tensors, Quotient law, Group property of tensors, symmetric and anti-symmetric tensors. Related theorems.

Riemannian metric and Fundamental tensors. Christoffel symbols of the first and second kinds and their properties. Transformation laws of Christoffel symbols. **(No of classes 15, Marks 15)**

UNIT 2: Covariant derivatives of tensors A_i, A^i, A_{ij}, A^{ij} and A^i_j , Generalizations. Covariant derivatives of fundamental tensors and scalar invariant function. Gradient of an invariant function. Divergence and curl of vectors. Laplacian in tensor form. Application in problems. **(No of classes 15, Marks 15)**

Text Books:

1. S.L. Loney, An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies, Cambridge University Press, 2017.
2. M.R. Spiegel, Theory and Problems of Theoretical Mechanics, McGraw-Hill, 2010.
3. C.E. Weatherburn, An Introduction to Riemannian Geometry and the Tensor Calculus, Cambridge University Press, 2008.

Reference Books:

1. F. Chorlton, Textbook of Dynamics, 2nd Edition, CBS Publishers & Distributors, 2002.
2. B.C. Kalita, Tensor Calculus and Applications: Simplified Tools and Techniques, CRC Press, 2019.
3. D.C. Kay, Tensor Calculus, McGraw Hill, 2011
4. L.P. Eisenhart, Riemannian Geometry, Princeton University Press, 1997.

SEMESTER-VIII

MAT4800404MJ: Mathematical Methods
Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 identify Fredholm integral equations and Volterra integral equations.

CO2 apply Fourier transform to solve ordinary and partial differential equations of initial and boundary value problems.

CO3 apply Laplace transform to solve ordinary, partial differential equations of initial and boundary value problems, and to evaluate definite integrals.

CO4 use calculus of variations to extremize a functional with fixed boundaries.

CO5 formulate and solve isoperimetric problems.

UNIT 1: Integral Equations: Definition of Integral Equation, Reduction of ordinary differential equations into integral equations. Fredholm integral equations with separable kernels, Eigen values and Eigen functions, Method of successive approximation, Iterative scheme for Fredholm Integral equations of second kind. Volterra Integral Equations of second kind, Resolvent kernal of Volterra equation and its results, Application of iterative scheme to Volterra equation of the second kind, Convolution type kernals. **(No of classes 15, Marks 15)**

UNIT 2: Fourier Transform: Fourier Integral Transform. Properties of Fourier Transform, Fourier sine and cosine transforms, Application of Fourier transform to ordinary and partial differential equations of initial and boundary value problems. Evaluation of definite integrals.

(No of classes 15, Marks 15)

UNIT 3: Laplace Transform: Basic properties of Laplace Transform, Convolution theorem and properties of convolution, Inverse Laplace Transform. Application of Laplace Transform to solution of ordinary and partial differential equations of initial and boundary value problems. The inversion theorem, Evaluation of inverse transforms by residue method. **(No of classes 15, Marks 15)**

UNIT 4: Calculus of variations: Calculus of variation with one independent variable: Basic ideas of calculus of variations, Euler's equation with fixed boundary of the functional Containing only the first order derivative of the only dependent variable with respect to one independent variable, Variational problems with functional having higher order derivatives of the only dependent variable, general case of Euler's equation, applications. Calculus of Variation with several independent variables: Variational problems with functional dependent on functions of several independent variables having first order derivatives. Variational problems in parametric form, Variational problems with subsidiary condition: Isoperimetric problems. **(No of classes 15, Marks 15)**

Text Books:

1. M.D. Raisinghania, Integral Equations and Boundary Value Problems, S. Chand, 2010.

2. M.R. Spiegel, Fourier Analysis with Applications to Boundary Value Problems, McGraw-Hill, 1974.

3. M.R. Spiegel, Theory and Problems of Laplace Transforms, McGraw-Hill, 1965.

4. I.M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall, 1963.

SEMSTER-VIII

MAT4800504MJ: SEMINAR / PROJECT

Total Marks: 100 (External: 60 Internal: 40)
No. of Credits: 4

Choose any one paper for other Major students

SEMESTER-VIII

MAT4800404MN: Mathematical Methods
Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 identify Fredholm integral equations and Volterra integral equations.

CO2 apply Fourier transform to solve ordinary and partial differential equations of initial and boundary value problems.

CO3 apply Laplace transform to solve ordinary, partial differential equations of initial and boundary value problems, and to evaluate definite integrals.

CO4 use calculus of variations to extremize a functional with fixed boundaries.

CO5 formulate and solve isoperimetric problems.

UNIT 1: Integral Equations: Definition of Integral Equation, Reduction of ordinary differential equations into integral equations. Fredholm integral equations with separable kernels, Eigen values and Eigen functions, Method of successive approximation, Iterative scheme for Fredholm Integral equations of second kind. Volterra Integral Equations of second kind, Resolvent kernal of Volterra equation and its results, Application of iterative scheme to Volterra equation of the second kind, Convolution type kernals. **(No of classes 15, Marks 15)**

UNIT 2: Fourier Transform: Fourier Integral Transform. Properties of Fourier Transform, Fourier sine and cosine transforms, Application of Fourier transform to ordinary and partial differential equations of initial and boundary value problems. Evaluation of definite integrals.

(No of classes 15, Marks 15)

UNIT 3: Laplace Transform: Basic properties of Laplace Transform, Convolution theorem and properties of convolution, Inverse Laplace Transform. Application of Laplace Transform to solution of ordinary and partial differential equations of initial and boundary value problems. The inversion theorem, Evaluation of inverse transforms by residue method. **(No of classes 15, Marks 15)**

UNIT 4: Calculus of variations: Calculus of variation with one independent variable: Basic ideas of calculus of variations, Euler's equation with fixed boundary of the functional Containing only the first order derivative of the only dependent variable with respect to one independent variable, Variational problems with functional having higher order derivatives of the only dependent variable, general case of Euler's equation, applications. Calculus of Variation with several independent variables: Variational problems with functional dependent on functions of several independent variables having first order derivatives. Variational problems in parametric form, Variational problems with subsidiary condition: Isoperimetric problems. **(No of classes 15, Marks 15)**

Text Books:

1. M.D. Raisinghania, Integral Equations and Boundary Value Problems, S. Chand, 2010.

2. M.R. Spiegel, Fourier Analysis with Applications to Boundary Value Problems, McGraw-Hill, 1974.

3. M.R. Spiegel, Theory and Problems of Laplace Transforms, McGraw-Hill, 1965.

4. I.M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall, 1963.

SEMESTER-VIII

MAT4800604MN: Optimization Techniques

Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO 1 Describe about the graphical solution of linear programming problem with two variables.

CO2 Compute the relation between basic feasible solutions and extreme points.

CO3 Understand the theory of the simplex method used to solve linear programming problems.

CO4 Explain about two-phase and big-M methods to deal with problems involving artificial variables.

CO5 Analyze the relationships between the primal and dual problems.

CO6 Solve transportation and assignment problems.

CO7 Apply linear programming method to solve two-person zero-sum game problems.

UNIT 1: The Linear Programming Problem**:** Convex and polyhedral sets, Hyperplanes, Extreme points. Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points. (**No of classes 15, Marks 15)**

UNIT 2: Simplex Method**:** Optimal solution, Termination criteria for optimal solution of the Linear Programming Problem, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method.

(**No of classes 15, Marks 15)**

UNIT 3: Motivation and Formulation of Dual problem; Primal-Dual relationships; Fundamental Theorem of Duality; Complimentary Slackness. (**No of classes 15, Marks 15)**

UNIT 4: Applications

*Transportation Problem***:** Definition and formulation; Methods of finding initial basic feasible solutions; North West corner rule. Least cost method; Vogel's Approximation method; Algorithm for solving Transportation Problem.

*Assignment Problem***:** Mathematical formulation and Hungarian method of solving.

*Game Theory***:** Basic concept, Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear Programming method of solving a game. (**No of classes 15, Marks 15)**

Text Books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows* (4th ed.). John Wiley and Sons 2010.
2. G. Hadley, *Linear Programming*. Narosa Publishing House. New Delhi 1997.
3. Hamdy A. Taha, *Operations Research*: *An Introduction* (9th ed.). Pearson 2010.

Reference Books:

1. Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research* (10th ed.). McGraw-Hill Education (India) Pvt. Ltd 2015.
2. Paul R.Thie and G. E. Keough, *An Introduction to Linear Programming and Game Theory*. (3rd ed.). Wiley India Pvt. Ltd 2014.

SEMESTER-VIII

MAT480704MN: Financial Mathematics
Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 Understand fundamentals of financial markets, derivatives, options, and futures.
CO2 Apply pricing and hedging techniques for options and interest rate swaps.
CO3 Explain no-arbitrage pricing principles and types of options.
CO4 Apply stochastic methods (Itô formula, Itô integration) and the Black–Scholes model.
CO5 Analyze trading strategies and value currency swaps.

UNIT 1: Interest Rates: Types of rates, Measuring interest rates, Zero rates, Bond pricing, Forward rate, Duration, Convexity, Exchange traded markets and OTC markets, Derivatives--Forward contracts, Futures contract, Options, Types of traders, Hedging, Speculation, Arbitrage.

(**No of classes 15, Marks 15)**

UNIT 2: Mechanics and Properties of Options: No Arbitrage principle, Short selling, Forward price for an investment asset, Types of Options,Option positions, Underlying assets, Factors affecting option prices, Bounds on option prices,Put-call parity, Early exercise, Effect of dividends.

(**No of classes 15, Marks 15)**

UNIT 3: Stochastic Analysis of Stock Prices and Black-Scholes Model
Binomial option pricing model, Risk neutral valuation (for European and American options on assets following binomial tree model), Lognormal property of stock prices, Distribution of rate of return, expected return, Volatility, estimating volatility from historical data, Extension of risk neutral valuation to assets following GBM, Black-Scholes formula for European options.

(**No of classes 15, Marks 15)**

UNIT 4: Hedging Parameters, Trading Strategies and Swaps
Hedging parameters (the Greeks: Delta, Gamma, Theta, Rho and Vega), Trading strategies involving options, Swaps, Mechanics of interest rate swaps, Comparative advantage argument, Valuation of interest rate swap s, Currency swaps, Valuation of currency swaps.

(**No of classes 15, Marks 15)**

Text Book:

1. J. C. Hull and S. Basu, *Options, Futures and Other Derivatives* (7th ed.) Pearson Education. New Delhi 2010.
2. David G. Luenberger, *Investment Science*, Oxford University Press. Delhi 1998.
3. Sheldon M. Ross, *An elementary Introduction to Mathematical Finance* (3rd ed.). Cambridge University Press. USA 2011.

SEMSTER-VIII

OPTION-II: HONOURS WITH RESEARCH

MAT4800812MJ: Dissertation

Total Marks: 300 (External: 200 Internal: 100)

No. of Credits: 12
No. of Non-Contact classes: 0

ELECTIVE PAPER (Choose any one)

MAT4800104MJ: Topology

Total Marks: 100 (External 60, Internal 40)

No. of Credits: 4

No. of Contact classes: 60

No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 identify topological spaces and construct examples of such spaces.
CO2 classify different spaces like first countable, second countable, separable spaces and give the characterization of these spaces using some important results like Urysohn's lemma, Tietze extension theorem.
CO3 use the idea of compactness and connectedness and give their different characterizations.
CO4 explain the product topology and its relationship with compactness, connectedness, and countability.
CO5 provide examples of metrizable spaces and explain the relationship between embedding and metrization.

UNIT 1: Definition and examples of topological spaces, Closed sets and closure, Dense subsets, Neighbourhood, Interior, Exterior and Boundary, Accumulation Points and Derived sets, Bases and subbases. Subbase and Relative Topology, Continuous Functions and Homeomorphism.

(No. of classes: 11, Marks: 10)

UNIT 2: Countable and uncountable sets, First and second Countable spaces, Lindelof's theorem, Separable spaces, Second Countability and Separability.

(No. of classes: 5, Marks: 10)

UNIT 3: Separation Axioms: T_0, T_1, T_2, $T_{3\frac{1}{2}}$, T_4 ; their characterizations and basic properties, Urysohn's lemma, Tietze Extension Theorem. **(No. of classes: 10, Marks: 10)**

UNIT 4: Compactness, continuous functions and compact sets. Basic properties of compactness and related theorems, Sequentially and Countably compact sets, Local Compactness and one point compactification, Stone-Cech Compactification. **(No. of classes: 11, Marks: 10)**

UNIT 5: Connected spaces, connectedness on the real line, components, totally disconnected spaces, Locally connected spaces. **(No. of classes: 11, Marks: 10)**

UNIT 6: Tychonoff product topology in terms of standard subbase and its characterizations, Projection Maps, Separation Axioms and Product Spaces, Connectedness and Product spaces, Compactness and Product Spaces (Tychonoff's Theorem), Countability and Product Spaces, Embedding and Metrization, Urysohn's Metrization theorem. **(No. of classes: 12, Marks: 10)**

Text Books:

1. J.R. Munkres, Topology, 2nd Edition, Prentice Hall of India, 2002.

2. S. Willard, General Topology, Dover Publications, 2004.

3. J. Dugundji, Topology, Allyn and Bacon, 1966.

Reference Books:

1. K.D. Joshi, Introduction to General Topology, 2nd Edition, New Age International Publishers, 2017.

2. S. Lipschutz, Theory and Problems of General Topology, McGraw-Hill, 1965.

3. M.G. Murdeshwar, General Topology, 3rd Edition, New Age International Publishers, 2020.

SEMESTER-VIII
MAT4800204MJ: Number Theory
Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact Classes: 60
No. of Non-Contact Classes: 0

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

CO1 Describe primitive roots and indices for solvability of congruence of higher order.

CO2 Explain the quadratic reciprocity law using Legendre's and Jacobi's symbol.

CO3 Generate Fibonacci numbers and discuss related identities.

CO4 Explain partition functions and develop graphical representations.

UNIT 1: Primitive roots: order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, theory of indices. **(No. of classes: 15, Marks: 15)**

UNIT 2: Quadratic residues: Euler's criterion, Legendre's symbol and its properties, Quadratic Reciprocity Law, Quadratic congruences with composite moduli.

(No. of classes: 15, Marks: 15)

UNIT 3: Diophantine problems: The Pythagorean equation and its applications, Fermat's infinite descent, Fermat's last theorem, sums of two squares, representation of integers by certain forms, solving Pell equations by continued fractions. **(No. of classes: 15, Marks: 15)**

UNIT 4: Partitions, Graphical representation of partitions. Euler's partition theorem, Searching for partition identities, Partition generating functions. **(No. of classes: 15, Marks: 15)**

Text Books:

1. D.M. Burton, Elementary Number Theory, 7th Edition, McGraw-Hill, 2010.
2. G.E. Andrews, Number Theory, Dover Publications, 2012.

Reference Books:

1. I. Niven, H.S. Zuckerman and H.L. Montgomery, Introduction to Theory of Numbers, 5th Edition, Wiley India, 2008.

SEMESTER-VIII

MAT4800304MJ: Mechanics and Tensor Calculus

Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 Explain various physical laws of motion, Hamiltonian's principle etc. with mathematical tools.

CO2 Distinguish Tensors and perform algebraic operations on tensors, to obtain covariant derivatives of various tensors and to express Laplacian in tensor form.

CO3 Apply various tools of vector algebra as well as vector calculus, calculus of variations to discuss the motion of rigid bodies under certain constraints.

CO4 Differentiate the properties of motion in various coordinate systems viz. cylindrical, spherical, conical surfaces.

CO5 Construct mathematical models viz. rigid body to describe motions under certain constraints or no constraints which are able to analyse the physical scenario.

Group-A: Mechanics

Total marks: 30 **Credit: 2**

UNIT 1: Central forces, Central orbit, Laws of inverse square, Kepler's laws of planetary motion; Velocity and acceleration in cylindrical and spherical polar coordinates.

Motion of a rigid body about a fixed point: Euler's equations, Motion under no external forces.

(No. of classes 15, Marks 15)

UNIT 2: Generalized coordinates: Lagrange's equations of motion for finite forces in holonomic systems, Case of conservative forces and theory of small oscillations. Hamilton's equations of motion, Variational methods, Hamilton's principle and Principle of least action.

(No of classes 15, Marks 15)

Group-B: Tensor Calculus

Total Marks: 30 **Credit: 2**

UNIT 1: Transformation laws of covariant and contravariant tensors, Mixed tensor, Rank of tensors. Kronecker delta. Algebraic operations on tensors: addition, subtraction, contraction, inner and outer product of tensors, Quotient law, Group property of tensors, symmetric and anti-symmetric tensors. Related theorems.

Riemannian metric and Fundamental tensors. Christoffel symbols of the first and second kinds and their properties. Transformation laws of Christoffel symbols. **(No of classes 15, Marks 15)**

UNIT 2: Covariant derivatives of tensors A_i, A^i, A_{ij}, A^{ij} and A^i_j , Generalizations. Covariant derivatives of fundamental tensors and scalar invariant function. Gradient of an invariant function. Divergence and curl of vectors. Laplacian in tensor form. Application in problems. **(No of classes 15, Marks 15)**

Text Books:

1. S.L. Loney, An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies, Cambridge University Press, 2017.
2. M.R. Spiegel, Theory and Problems of Theoretical Mechanics, McGraw-Hill, 2010.
3. C.E. Weatherburn, An Introduction to Riemannian Geometry and the Tensor Calculus, Cambridge University Press, 2008.

Reference Books:

1. F. Chorlton, Textbook of Dynamics, 2nd Edition, CBS Publishers & Distributors, 2002.
2. B.C. Kalita, Tensor Calculus and Applications: Simplified Tools and Techniques, CRC Press, 2019.
3. D.C. Kay, Tensor Calculus, McGraw Hill, 2011
4. L.P. Eisenhart, Riemannian Geometry, Princeton University Press, 1997.

SEMESTER-VIII

MAT4800404MJ: Mathematical Methods
Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 identify Fredholm integral equations and Volterra integral equations.

CO2 apply Fourier transform to solve ordinary and partial differential equations of initial and boundary value problems.

CO3 apply Laplace transform to solve ordinary, partial differential equations of initial and boundary value problems, and to evaluate definite integrals.

CO4 use calculus of variations to extremize a functional with fixed boundaries.

CO5 formulate and solve isoperimetric problems.

UNIT 1: Integral Equations: Definition of Integral Equation, Reduction of ordinary differential equations into integral equations. Fredholm integral equations with separable kernels, Eigen values and Eigen functions, Method of successive approximation, Iterative scheme for Fredholm Integral equations of second kind. Volterra Integral Equations of second kind, Resolvent kernal of Volterra equation and its results, Application of iterative scheme to Volterra equation of the second kind, Convolution type kernals. **(No of classes 15, Marks 15)**

UNIT 2: Fourier Transform: Fourier Integral Transform. Properties of Fourier Transform, Fourier sine and cosine transforms, Application of Fourier transform to ordinary and partial differential equations of initial and boundary value problems. Evaluation of definite integrals.

(No of classes 15, Marks 15)

UNIT 3: Laplace Transform: Basic properties of Laplace Transform, Convolution theorem and properties of convolution, Inverse Laplace Transform. Application of Laplace Transform to solution of

ordinary and partial differential equations of initial and boundary value problems. The inversion theorem, Evaluation of inverse transforms by residue method. **(No of classes 15, Marks 15)**

UNIT 4: Calculus of variations: Calculus of variation with one independent variable: Basic ideas of calculus of variations, Euler's equation with fixed boundary of the functional Containing only the first order derivative of the only dependent variable with respect to one independent variable, Variational problems with functional having higher order derivatives of the only dependent variable, general case of Euler's equation, applications. Calculus of Variation with several independent variables: Variational problems with functional dependent on functions of several independent variables having first order derivatives. Variational problems in parametric form, Variational problems with subsidiary condition: Isoperimetric problems. **(No of classes 15, Marks 15)**

Text Books:

1. M.D. Raisinghania, Integral Equations and Boundary Value Problems, S. Chand, 2010.

2. M.R. Spiegel, Fourier Analysis with Applications to Boundary Value Problems, McGraw-Hill, 1974.

3. M.R. Spiegel, Theory and Problems of Laplace Transforms, McGraw-Hill, 1965.

4. I.M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall, 1963.

Choose any one paper for other Major students

SEMESTER-VIII
MAT4800204MN: Number Theory
Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact Classes: 60
No. of Non-Contact Classes: 0

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

CO1 Describe primitive roots and indices for solvability of congruence of higher order.

CO2 Explain the quadratic reciprocity law using Legendre's and Jacobi's symbol.

CO3 Generate Fibonacci numbers and discuss related identities.

CO4 Explain partition functions and develop graphical representations.

UNIT 1: Primitive roots: order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, theory of indices. **(No. of classes: 15, Marks: 15)**

UNIT 2: Quadratic residues: Euler's criterion, Legendre's symbol and its properties, Quadratic Reciprocity Law, Quadratic congruences with composite moduli.

(No. of classes: 15, Marks: 15)

UNIT 3: Diophantine problems: The Pythagorean equation and its applications, Fermat's infinite descent, Fermat's last theorem, sums of two squares, representation of integers by certain forms, solving Pell equations by continued fractions. **(No. of classes: 15, Marks: 15)**

UNIT 4: Partitions, Graphical representation of partitions. Euler's partition theorem, Searching for partition identities, Partition generating functions. **(No. of classes: 15, Marks: 15)**

Text Books:

1. D.M. Burton, Elementary Number Theory, 7th Edition, McGraw-Hill, 2010.
2. G.E. Andrews, Number Theory, Dover Publications, 2012.

Reference Books:

1. Niven, H.S. Zuckerman and H.L. Montgomery, Introduction to Theory of Numbers, 5th Edition, Wiley India, 2008.

SEMESTER-VIII

MAT4800604MN: Optimization Techniques

Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO 1 Describe about the graphical solution of linear programming problem with two variables.

CO2 Compute the relation between basic feasible solutions and extreme points.

CO3 Understand the theory of the simplex method used to solve linear programming problems.

CO4 Explain about two-phase and big-M methods to deal with problems involving artificial variables.

CO5 Analyze the relationships between the primal and dual problems.

CO6 Solve transportation and assignment problems.

CO7 Apply linear programming method to solve two-person zero-sum game problems.

UNIT 1: The Linear Programming Problem**:** Convex and polyhedral sets, Hyperplanes, Extreme points. Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points. (**No of classes 15, Marks 15)**

UNIT 2: Simplex Method**:** Optimal solution, Termination criteria for optimal solution of the Linear Programming Problem, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method.

(**No of classes 15, Marks 15)**

UNIT 3: Motivation and Formulation of Dual problem; Primal-Dual relationships; Fundamental Theorem of Duality; Complimentary Slackness. **(No of classes 15, Marks 15)**

UNIT 4: Applications
*Transportation Problem***:** Definition and formulation; Methods of finding initial basic feasible solutions; North West corner rule. Least cost method; Vogel's Approximation method; Algorithm for solving

Transportation Problem. *Assignment Problem***:** Mathematical formulation and Hungarian method of solving. *Game Theory***:** Basic concept, Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear Programming method of solving a game. **(No of classes 15, Marks 15)**

Text Books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows* (4th ed.). John Wiley and Sons 2010.
2. G. Hadley, *Linear Programming*. Narosa Publishing House. New Delhi 1997.
3. Hamdy A. Taha, *Operations Research*: *An Introduction* (9th ed.). Pearson 2010.

Reference Books:

1. Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research* (10th ed.). McGraw-Hill Education (India) Pvt. Ltd 2015.
2. Paul R.Thie and G. E. Keough, *An Introduction to Linear Programming and Game Theory*. (3rd ed.). Wiley India Pvt. Ltd 2014.

SEMESTER-VIII

MAT4800704MN: Financial Mathematics
Total Marks: 100 (External 60, Internal 40)
No. of Credits: 4
No. of Contact classes: 60
No. of Non-Contact classes: 0

Course Outcomes: The students who take this course will be able to:

CO1 Understand fundamentals of financial markets, derivatives, options, and futures.
CO2 Apply pricing and hedging techniques for options and interest rate swaps.
CO3 Explain no-arbitrage pricing principles and types of options.
CO4 Apply stochastic methods (Itô formula, Itô integration) and the Black–Scholes model.
CO5 Analyze trading strategies and value currency swaps.

UNIT 1: Interest Rates: Types of rates, Measuring interest rates, Zero rates, Bond pricing, Forward rate, Duration, Convexity, Exchange traded markets and OTC markets, Derivatives--Forward contracts, Futures contract, Options, Types of traders, Hedging, Speculation, Arbitrage.
(No of classes 15, Marks 15)

UNIT 2: Mechanics and Properties of Options: No Arbitrage principle, Short selling, Forward price for an investment asset, Types of Options,Option positions, Underlying assets, Factors affecting option prices, Bounds on option prices,Put-call parity, Early exercise, Effect of dividends.
(No of classes 15, Marks 15)

UNIT 3: Stochastic Analysis of Stock Prices and Black-Scholes Model
Binomial option pricing model, Risk neutral valuation (for European and American options on assets following binomial tree model), Lognormal property of stock prices, Distribution of rate of return, expected return, Volatility, estimating volatility from historical data, Extension of risk neutral valuation to assets following GBM, Black-Scholes formula for European options.
(No of classes 15, Marks 15)

UNIT 4: Hedging Parameters, Trading Strategies and Swaps

Hedging parameters (the Greeks: Delta, Gamma, Theta, Rho and Vega), Trading strategies involving options, Swaps, Mechanics of interest rate swaps, Comparative advantage argument, Valuation of interest rate swap s, Currency swaps, Valuation of currency swaps.

(**No of classes 15, Marks 15)**

Text Books:

1. J. C. Hull and S. Basu, *Options, Futures and Other Derivatives* (7th ed.) Pearson Education. New Delhi 2010.
2. David G. Luenberger, *Investment Science*, Oxford University Press. Delhi 1998.
3. Sheldon M. Ross, *An elementary Introduction to Mathematical Finance* (3rd ed.). Cambridge University Press. USA 2011.

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