Darrang College (Autonomous), Tezpur-784001

Syllabus for FYUGP

Sub: MATHEMATICS (MAJOR)

Approved by :
Board of Studies meeting held on 13-06-2026 &
Academic Council vide Resolution no. DC/AC/3/2026/02 dated-29th June, 2026

Aims of Four Year Under Graduate Programme in Mathematics is to foster a comprehensive understanding and appreciation of Mathematics through innovative teaching, research and application, equipping students with the skills to solve real world problems and advance in their academic and professional pursuits.

Program Outcome: The completion of the FYUGP shall enable a student to:

- Communicate mathematics effectively by oral, written, computational and graphic means
- Create mathematical ideas from basic axioms
- Gauge the hypothesis, theorems, techniques and proofs provisionally
- Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis
- Identify applications of mathematics in other disciplines and in the real world, leading to enhancement of career prospects in a plethora of fields.
- Appreciate the requirement of lifelong learning through continued education and research.

Teaching learning process: The Department of Mathematics at Darrang College (Autonomous) is primarily responsible for organizing the Bachelor of Science/ Bachelor of Arts course with Major in Mathematics. Tutorial and practical related instructions are provided by the respective registering units under the general guidance of Department of Mathematics. There shall be 90 instructional days excluding examination in a semester.

Teaching learning tools: Teaching Learning Tools involves:

- Green-board teaching
- ICT tools- Projector, smart board etc.
- Course-based practical work using Desktop/Laptop computers.
- Along with these there are viva-voce, mock test, demonstration, presentation, classroom tests, and assignments.

The achievement of course is described in each course papers as learning outcomes in detail.

Evaluation/assessment:

The students registered for academic program will study Semester I to VIII at the Darrang College (Autonomous) and during these semesters Major, Minor and SEC courses are offered.

- English shall be the medium of instruction and examination for Major courses and English/Assamese for Minor courses.
- Examinations shall be conducted at the end of each Semester as per the Academic calendar notified by the Darrang College (Autonomous).
- The assessment broadly comprises of Internal Assessment (Sessional Examination, Assignments Presentation/Viva-Voce/Group Discussion, Attendance,) and End Semester Examination.
- Theory papers without practical/presentation consist of total 100 marks divided into 60 marks for theory, 40 marks for internal assessment.
- Theory papers with practical/presentation and Skill Enhancement Courses consists of total 100 marks divided into 60 marks for theory, 20 marks for internal assessment and 20 marks for Practical/Presentation.
- Internal assessment of 40 marks is comprises with 20 marks from sessional examination, 10 marks from assignment, 06marks for Presentation/Viva-Voce/Group Discussion and 4 marks from attendance (4 marks for above 75% attendance).
- Each practical paper will carry 30 marks including 25 marks for continuous evaluation and 2 marks for practical note book and 3 marks for the oral test or viva voce. Hardcopy of practical file has to be maintained by the students for each practical paper and has to be submitted in the concerned department at the time of examination
- Each presentation will carry 20 marks including 15 marks for continuous evaluation and 2 marks for presented report and 3 marks for the oral test or viva voce. The departments will decide the process of continuous evaluation for the task carried-out against the presentation. Hardcopy of the report has to be maintained by the students for each presented paper and has to be submitted in the concerned department at the time of examination.

Course Structure:

The program is a four year course divided into eight semesters. A student is required to complete 176 credits for the completion of course and the award of degree as Major student.

- 4 credit papers = 100 marks (60T+20IA+20P with practical)/ (60T+40IA without practical)
- Question pattern: ➢ For 100 marks papers (60T+40IA) [1 marks × 8 (no options), 2 marks × 6(10 options), 5 marks × 4 (8 options), 10 marks × 2 (5 options)]
- For 75 marks papers (45T+30P) [1 marks × 4 (no options), 2 marks × 3(no options), 5 marks × 3 (6 options), 10 marks × 2 (5options)]

CURRICULUM COMPONENTS

- ➢ **Distribution of Credits in first 3 years:**

Sl No.	**Type**	**Credit**
1	Major 15 x 4	60
2	Minor 06 x 4	24
3	SEC 3+3+3	09

- 1 CREDIT = 15 hours (one hour of classroom instruction per week)

*Skill-based courses may be worked out in line with the UGC guidelines under National Skill Qualification Framework (NSQF)/ National Credit Framework (NCrF)

- **B. A. / B.Sc Course distribution for four years**

Year	Semester	Course Code	Title of the course	Credit
1st Year	1st Semester	MAT-MJ-01014	Algebra -I	4
		MAT-SE-01013 (Major oriented)*	MS Power Point and LaTeX	3
		MAT-MN-01014	Algebra -I	4
		VAC	---	2
		MDC	---	3
		AEC	---	4
	Total	---	---	**20**
	2nd Semester	MAT-MJ-02014	Calculus	4
		MAT-SE-02013 (Major oriented)*	Programming in C	3
		MAT-MN-02014	Calculus	4
		VAC	---	2
		MDC	---	3
		AEC	---	4
	Total	---	---	**20**
2nd year	3rd Semester	MAT-MJ-03014	Ordinary Differential Equations	4
		MAT-MJ-03024	Abstract Algebra	4
		MAT-MN-03014	Ordinary Differential Equations	4
		MAT-SE-03013 (Major oriented)*	Computer Algebra Systems and Related Software	3
		MDC	---	3
		AEC	---	2
	Total	---	---	**20**
		MAT-MJ-04014	Real Analysis-I	4

	4th Semester	MAT-MJ-04024	Linear Algebra	4
		MAT-MJ-04034	Analytical Geometry	4
		MAT-MJ-04044	Number Theory-I	4
		MAT-MN-04014	Analytical Geometry	4
		AEC	---	2
	Total	---	---	**22**
3rd year	**5th Semester**	MAT-MJ-05014	Real Analysis-II	4
		MAT-MJ-05024	Multivariate Calculus	4
		MAT-MJ-05034	Numerical Analysis-I (with practical)	4
		MAT-MJ-05044	Internship	4
		MAT-MN-05014	Multivariate Calculus	4
	Total	---	---	**20**
	6th Semester	MAT-MJ-06014	Complex Analysis-I (with practical)	4
		MAT-MJ-06024	Partial Differential Equations (with practical)	4
		MAT-MJ-06034	Metric Spaces	4
		MAT-MJ-06044	Mechanics-I	4
		MAT-MN-06014	Partial Differential Equations (with practical)	4
	Total	---	---	**20**
4th year	**7th Semester**	MAT-MJ-07014	Algebra-II	4
		MAT-MJ-07024	Functional Analysis	4
		MAT-MJ-07034	Complex Analysis-II	4
		MAT-MJ-07044	Mathematical Methods	4
		MAT-MN-07014	Numerical Analysis	4
	Total	---	---	**20**
		MAT-MJ-08014	Topology	4

	8th Semester	MAT-MJ-08024	Mechanics II	4
		Choose any two papers from 5 papers		
		MAT-MJ-08034	Number Theory-II	4 4
		MAT-MJ-08044	Optimization	
		MAT-MJ-08054	Lebesgue Measure & Probability Theory	
		MAT-MJ-08064	Bio-Mathematics	
		MAT-MJ-08074	Financial mathematics	
		MAT-MN-08014	Complex Analysis	4
	Total	---	---	**20**

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS
SEMESTER-I

Title of the course	**Algebra-I**
Course code	MAT-MJ-01014
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	Mathematics in 10+2 or equivalent standard.

Course Objectives: The primary objective of this course is to explain students about the general structure of equations, fundamental concepts of mathematical logic and reasoning, basic concepts of set theory. Furthermore, basic concepts of matrices will be taught to them.

Learning Outcome: This course will enable the students to:

- Learn how to deal with mathematical statements which are composite or with quantifiers, also, statements with implications.
- Learn the basics of set theory including partial order relation, countability of sets.
- Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, also, finding inverse and rank of a matrix.
- Determine the number of positive/negative real roots of a real polynomial using Descartes' rule of sign, also, learn about symmetric functions of the roots for cubic and biquadratic equations.
- Learn how to solve cubic equations.

Unit	Content	L	T	P	Total Hrs
I	**Mathematical Statement and Logic:** Mathematical statement, Statement with quantifiers "*there exists*" and "*for every*", Compound statement using "*or*" and "*and*", Statements with implications: "*if-then*" statement and "*if and only if*" statement, Contra-positive statement, The Induction Principle, [1] Chapter: 1(Sections: 1.1, 1.2 upto Exercise 1.2.13, 1.3 up-to Exercise 1.3.8, 1.4), Chapter: 5 (Section: 5.1) (15 Marks)	12	02	--	14

II	**Basics of set theory:** Partial order relation, poset, chain, upper and lower bounds in poset, greatest element and least elements, maximal and minimal elements, supremum and infimum, Zorn's Lemma, Finite and infinite sets, countable and uncountable sets. [1] Chapter:6 (Sections: 6.2, 6.3), Chapter: 7 (Sections: 7.1, 7.2) (15 Marks)	13	02	--	15
III	**Matrices:** Elementary operations on a matrix, Matrix inversion and properties, Rank of a matrix, Determination of rank by reduction into echelon form, Symmetric matrix, Hermitian matrix, Elementary matrices and equivalence Consistency of linear systems, Solutions of system of homogeneous linear equations. [2] Chapter: 3 (Sections: 3.7), Chapter: 2 (Sections: 2.1 to 2.4) (15 Marks)	13	02	--	15
IV	**Theory of Equations:** Polynomial and Polynomial 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 for cubic and biquadratic equations, Transformation of equations, Cardan's method of solution of a cubic equation. [3] Chapter: 5 (Sections: 5.1, 5.3.4, 5.4, 5.5, 5.6 upto 5.6.3, 5.11.2) (15 Marks)	13	03	--	16

Text Books:

1. Kumar, A., Kumaresan, S. and Sarma, B.K., (2018). *A Foundation Course in Mathematics*, Narosa.
2. Meyer, Carl .D., (2000). *Matrix Analysis and Applied Linear Algebra*, Society for Industrial and Applied Mathematics (Siam). https://vik.wiki/images/2/21/FmLinalg_jegyzet_2000_Meyer.pdf
3. Mappa, S.K., (2011). *Higher Algebra (Classical)* (Revised 8th Edition), Levant Books.

Reference Books:

1. Andreescu, T. and Andrica, D., (2014). *Complex numbers from A to...Z.* (2nd Edition), Birkhäuser.
2. Dickson, Leonard E., (2009). *First Course in the Theory of Equations,* John Wiley & Sons, Inc. The Project Gutenberg, eBook: http://www.gutenberg.org/ebooks/29785.
3. Halmos, P. R., (2009). *I Set Theory,* Springer.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-II

Title of the course	**Calculus**
Course code	MAT-MJ-02014
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	Mathematics in 10+2 or equivalent std.

Course Objectives: The primary objective of this course is to develop a deep and rigorous understanding of real analysis including real numbers, convergence and divergence of sequences and series of real numbers, also understand the quantitative change in the behavior of the variables and apply basic tools of calculus which are helpful in understanding their applications in many real world problems.

Learning Outcome: This course will enable the students to:

- Understand many properties of the real line R, including completeness and Archimedean properties.
- Learn to define sequences in terms of functions from N to a subset of R.
- Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
- Apply limit comparison tests for convergence of an infinite series of real numbers.
- Understand continuity and differentiability in terms of limits.
- Describe asymptotic behavior in terms of limits involving infinity.

UNIT	CONTENT	L	T	P	Total Hrs
I	**Basic concepts of real numbers:** Algebraic and order properties of R, absolute value and real line, bounded sets, supremum and infimum, completeness property of R, the Archimedean property. **[1]** Chapter:2 (Sections 2.1-2.4.6) **(10 Marks)**	09	01	--	10
II	**Sequence** Real sequences, limit of a sequence, convergent sequence, bounded sequence, Limit theorems, monotone sequences, Monotone convergence theorem, Subsequences and the Bolzano Weierstrass theorem,	13	02	--	15

	monotone subsequence theorem, Cauchy sequences, Cauchy's convergence criterion, properties of divergence sequences **[1]** Chapter:3 (Sections 3.1 to 3.6) **(15 Marks)**				
III	**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: Section: 3.7, Chapter 9: Sections: 9.1-9.3. **(20 Marks)**	17	03	--	20
IV	**Limits, Continuity and Differentiability :** Limit of a function, Continuity and types discontinuities. Differentiability of a function, Successive differentiation: Calculation of the nth derivatives, Leibnitz theorem, Infinite limits, Indeterminate forms. [2] Chapter 3 (Sections 3.1-3.3, 3.5-3.8), Chapter 4 (Sections 4.1, 4.2, 4.4-4.6, 4.8,4.9), Chapter 5 and Chapter 10 (Sections 10.1-10.3) **(15 Marks)**	13	02	--	15

Text books:

1. Bartle, R. G. and Sherbert, D. R., (2002). *Introduction to Real Analysis* (3rd Edition), JohnWiley and Sons. https://sowndarmath.wordpress.com/wp-content/uploads/2017/10/real-analysis-by-bartle.pdf
2. Narayan, S. and Mittal, P.K., (2017). *Differential Calculus*, S. Chand.

Reference book:

1. Kumar, A. and Kumaresan, S., (2014). *Basic Course in Real Analysis*, CRC Press.
2. Thomas Jr,. G. B., Weir, M. D., and Hass, J., (2014). *Thomas' Calculus* (13th Edition), Pearson. https://rodrigopacios.github.io/mrpacios/download/Thomas_Calculus.pdf
3. Anton, H., Bivens, I. and Davis, S. F., (2013). *Calculus (*10th Edition). John Wiley & Sons Singapore Pte. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.https://3lihandam69.wordpress.com/wp-content/uploads/2018/10/calculus-10th-edition-anton.pdf

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-III

Title of the course	**Ordinary Differential Equations**
Course code	MAT-MJ-03014
Nature of Course	Major
Total Credit	04 (Theory: 04+ Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-02014

Course Objectives: The main objective of this course is to introduce the students to the exciting world of differential equations and their solutions methods.

Course Learning Outcomes: The course will enable the students to:

- Learn basics of 1^{st} order ordinary differential equations and 2nd order linear differential Equations
- Learn different techniques for solving the differential equations

UNIT	CONTENT	L	T	P	Total Hrs
I	**First Order Ordinary Differential Equations**: Classification of differential equations; their origin and application. Solutions. Initial-Value Problems, Boundary-Value Problems, and Existence of solutions. First order exact differential equation. Integrating factors, Rules to find an integrating factor. Linear equations and Bernoulli equations. Special Integrating Factors and Transformations **[1]** Chapter 1 & Chapter 2 **(20 Marks)**	17	03	--	20
II	**Higher-Order Linear Differential Equations** : Basic Theory of Linear Differential Equations, Linear homogenous equations with constant coefficients, the method of undetermined coefficients, the method of Variation of Parameters. The Cauchy-Euler equations; Statements and Proofs of Theorems on the Second-Order Homogeneous Linear Equation **[1]** Chapter 4 (Sections 4.1-4.5) (25 **Marks)**	22	03	--	25

III	Application of ordinary differential equation: Orthogonal and Oblique Trajectories, Problems in Mechanics, Rate Problems, Vibrations of a Mass on a Spring, Free; Undamped Motion, Free; Damped Motion. **[1]** Chapter 3 and Chapter 5 (Sections 5.1-5.3) **(15 Marks)**	12	03	--	15

Text Book:

[1] Ross, Shepley L. (1984). Differential Equations (3rd Ed.), John Wiley & Sons,Inc.

Reference Book:

1.Kreyszig, Erwin (2011). Advanced Engineering Mathematics(10th ed.).John Wiley & Sons, Inc. Wiley India Edition 2015.

Title of the course	**Abstract Algebra**
Course code	MAT-MJ-03024
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-01014

Course Objectives: The primary objective of this course is to introduce abstract mathematical objects, viz. groups and study their properties. It is also focussed to study the consequences of these mathematical structures.

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

- Recognize the mathematical objects called group.
- Link the fundamental concepts of groups and symmetries of geometrical objects.
- Explain the significance of the notion of Permutation groups, cosets, cyclic groups, normal subgroups, factor groups.
- Analyze consequences of Lagrange's theorem and Fermat's Little theorem.
- Describe structure preserving mappings between groups and their consequences.

UNIT	CONTENT	L	T	P	Total Hrs
I	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 to Chapter 4. **(20 Marks)**	17	03	--	20
II	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. **[1]** Chapter 5 (up to theorem 5.7), Chapter 7 (up to theorem 7.2), Chapter 9 (up to theorem 9.2) **(20 Marks)**	17	03	--	20
III	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. [1] Chapter 6 (up to theorem 6.3), Chapter 10 (up to theorem 10.4) **(20 Marks)**	17	03	--	20

Text Books:
1. Gallian Joseph A., *Contemporary Abstract Algebra* (8th Edition) , Cengage Learning India Private limited, Delhi, Fourth impression, 2015.

Reference Books:
1. David S. Dummit and Richard M. Foote, *Abstract Algebra* (2nd Edition) , John Wiley and Sons (Asia) Pvt. Ltd. , Singapore, 2003.
2. John B. Fraleigh, *A First course in Abstract Algebra*, 7th Edition, Pearson, 2002.
3. G. Santhanam. *Algebra,* Narosa Publishing House, 2017.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-IV

Title of the course	**Real Analysis-I**
Course code	MAT-MJ-04014
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment:40)
Prerequisites	Mathematics in 10+2 or equivalent std,

Course Objective: The primary objective of this course is to study limit point of set and limit of a function. The discussion on continuous functions and differentiability with some related theorems will also be focused in this course.

Course Learning Outcomes: This course will enable the students to:

- Have a rigorous understanding of the concept of limit of a function.
- Learn about continuity and uniform continuity of functions defined on intervals.
- Understand geometrical properties of continuous functions on closed and bounded intervals.
- Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications.
- Know about applications of mean value theorems and Taylor's theorem

UNIT	CONTENT	L	T	P	Total Hrs
I	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, Taylor's theorem and applications to inequalities [1] Chapter 6 (upto Sections 6.4.3) (Taylor series as in Section 6.4) Taylor's series expansions of exponential and trigonometric functions, ln(1+x) and $(1+x)^n$. [3] Chapter 6 (Section 8.1-8.6) **(25 Marks)**	22	03	--	25

II	Riemann Integration: upper and lower sums, Darboux Integrability, properties of integral, Fundamental Theorem of calculus, mean value theorems for integrals, Riemann sum and Riemann integrability, Riemann integrability of monotone and comtinuous function on intervals, sum of infinite series as Riemann integrals. **[2]** Chapter 6 (Sections 6.1-6.7) **(15 Marks)**	13	02	--	15
III	Improper integrals and their convergence, various forms of comparison tests, absolute and conditional convergence, Abel's and Dirichlet's tests, beta and gamma functions, Frullani's integral, integral as function of parameter (excluding improper integrals), continuity, derivability and integrability of an integral as a function of a parameter. **[3]** Chapter 11 **(20 Marks)**	17	03	--	20

Text Book:

1. R.G. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons, 2002.
2. A. Kumar and S. Kumaresan, A BASIC COURSE IN REAL ANALYSIS, CRC Press, Indian Edn. 2014.
3. S.C. Malik and S. Arora, Mathematical analysis, New age international.

Reference Books:

1. K.A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer, 2004

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-IV

Title of the course	**Linear Algebra**
Course code	MAT-MJ-04024
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment:40)
Prerequisites	MAT-MJ-03024

Course Objectives: The objective of this course is to introduce the students with the fundamental theory of linear spaces and also emphasizes the application of techniques using the adjoint of linear operator and minimal solutions to systems of linear equations.

Course Learning Outcomes: This course will enable the students to:

- Learn about linear spaces and their general properties, linear dependence and linear independence of vectors, bases and dimensions of vector spaces
- Basic concepts of linear transformations, dimension theorem, matrix representations of linear transformations, and the change of coordinate matrix.
- 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.
- Compute inner products and determine orthogonality on vector spaces including Gram-Schmidt orthogonalization to obtain orthonormal basis.

UNIT	CONTENT	L	T	P	Total Hrs
I	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 combinations of vectors, linearly dependent and independent sets, bases of vector spaces, coordinate systems, dimension of a vector space, ranks, **[1]:** Chapter 4 (Sections 4.1-4.2), [2]: Chapter 4 **(15 Marks)**	13	02	--	15
II	Linear transformations, Kernel and range of a linear transformation, change of basis. **[1]:** Chapter 4 (Sections 4.3-4.7), **[2] :** Chapter 5 **(15 Marks)**	13	02	--	15
III	Eigenvectors and eigenvalues of a matrix, The Characteristic equation, Diagonalization, eigenvector of a linear transformation, Complex eigenvalues. Invariant subspaces and Cayley- Hamilton Theorem. **[1]:** Chapter 5 (Sections 5.1-5.5), **[2]:** Chapter 9, **[3]:** Chapter 5 (Sections 5.4) **(15 Marks)**	13	02	--	15
IV	Inner products, Length and orthogonality, orthogonal sets, orthogonal projections, The Gram- Schmidt process, Inner product spaces. **[1]:** Chapter 6 (Sections 6.1-6.4, 6.7), **[2]:** Chapter 12 **(15 Marks)**	13	02	--	15

Text Books:
1. David C. Lay, *Linear Algebra and its Applications*, 3rd Edition, Pearson Education, Asia, Indian Reprint, 2007
2. Seymour Lipschutz, *Theory and Problems of Linear Algebra*, Schaum's Outline Series, McGraw-Hill Book Company, Singapore
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra*, 4th Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.

Reference Books:
1. S. Kumaresan, *Linear Algebra- A Geometric Approach*, Prentice Hall of India, 2017
2. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007
3. G. Schay, Introduction to Linear Algebra, Narosa, 1997.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-IV

Title of the course	**Analytical Geometry**
Course code	MAT-MJ-04034
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment:40)
Prerequisites	Mathematics in 10+2 or equivalent std.

Course Objectives: The primary objective of this course is to introduce some basic tools of two dimensional and three-dimensional coordinate systems and also to familiarize the use of Vector Algebra in Coordinate Geometry.

Course Learning Outcomes: This course will enable the students to:
- transform coordinate systems
- learn about pair of straight lines
- have a clear understanding of the conic sections and related properties
- Recognize three dimensional surfaces represented by equations of the second degree
- learn two different systems of coordinates which are very useful to define the position of a point in space
- Acquire basic concepts of Vector Algebra and understand the use of geometric view of vectors in Coordinate Geometry.

UNIT	CONTENT	L	T	P	Total Hrs
I	Transformation of coordinates, invariants under orthogonal transformations, pair of straight lines. **[1]** Chapter 1 (Section 1.3), Chapter 2, Chapter 3 **(15 Marks)**	13	02	--	15
II	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) **(15 Marks)**	13	02	--	15
III	Quadric surfaces: Sphere, Cylinder and Cone. Cylindrical and spherical polar coordinates. **[1]** Chapter 6 (Section 6.1 – 6.3), Chapter 12 **(15 Marks)**	13	02	--	15
IV	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 (Section 11.1 - 11.5) **(15 Marks)**	13	02	--	15

Text Books:
1. R.M. Khan, Analytical Geometry of two and three dimensions and Vector Analysis. New Central Book Agency, 2012.
2. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013), Calculus (10th ed.). John Wiley & Sons, Singapore Reprint (2016) by Wiley India Pvt. Ltd., Delhi.
Reference Book:
1. R.J.T. Bell, Coordinate Solid Geometry, Macmillan, 1983.
2. E.H. Askwith, The Analytical Geometry of the Conic Sections, Nabu Press (27 February 2012)
3. B. Das, Analytical Geometry and Vector Analysis, Orient Book Company, Kolkata -700007

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-IV

Title of the course	**Number Theory-I**
Course code	MAT-MJ-04044
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment:40)
Prerequisites	Mathematics in 10+2 or equivalent std.

Course Objectives:

The primary objective of this course is to develop students' understanding of integers, with a focus on their properties and representations, as well as their understanding of number theoretic analysis.

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

- Explain division algorithm, Euclid's algorithms and greatest common divisor.
- Explain the concepts of congruences, linear congruences .
- Explore the Chinese Remainder theorem to solve simultaneous linear congruences.
- Explain Fermat's theorem and Wilson's theorem.
- Solve a range of problems in number theory
- Apply mathematical ideas and concepts within the context of number theory.
- Communicate number theoretic techniques to a mathematical audience.

UNIT	CONTENT	L	T	P	Total Hrs
I	Well-Ordering Principle of integers, Archimedian property, The division algorithm of integers, Prime numbers, The greatest common divisor, The Euclidean algorithm, The Diophantine equation ax+by=c, Fundamental Theorem of Arithmetic, The sieve of Eratosthenes, The Goldbach Conjecture. **[1]** Chapter 1 (Sections 1.1), Chapter2 (sections 2.2 -- 2.5), Chapter3. **(20 Marks)**	17	03	--	20
II	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. **[1]** Chapter 4 (Sections 4.2-4.4) Chapter5 (Sections: 5.2, 5.3). **(20 Marks)**	17	03	--	20

III	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) . **(20 Marks)**	17	03	--	20

Text Books:
1. David M. Burton, *Elementary Number Theory*, 7th Edition, McGraw Hill Education (India) private limited. 2012.

Reference Books:
1. G.A. Jones and J. Mary Jones, *Elementary Number Theory*. Undergraduate Mathematics Series (SUMS) , 2005.
2. Neville Robinns, *Beginning Number Theory*. 2nd Ed., Narosa Publishing House Pvt. Ltd. Delhi- 2007
3. K.C. Chowdhury, *A First Course in Number Theory*, Asian Books Publications- 2012.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-V

Title of the course	**Real Analysis-II**
Course code	MAT-MJ-05014
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-04014

Course Objective: The course will develop a deep and rigorous understanding of real line R and of defining terms to prove the results about convergence and divergence of series of real numbers. It is also focused to study limit point of set and limit of a function. The discussion on continuous functions and differentiability with some related theorems will also be focused in this course. These concepts have wide range of applications in real life scenario.

Course Learning Out comes: This course will enable the students to:

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

- Have a rigorous understanding of the concept of limit of a function.
- Learn about continuity and uniform continuity of functions defined on intervals.
- Understand geometrical properties of continuous functions on closed and bounded intervals.

UNIT	CONTENT	L	T	P	Total Hrs
I	Cluster point or limit point of a set, limits of a function ($\varepsilon - \delta$ approach), sequential criterion for limits, divergence criteria, limit theorems, one sided limits, infinite limits and limits at infinity. **[1]** Chapter 4 **(15 Marks)**	13	02	--	15
II	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) **(15 Marks)**	13	02	--	15
III	Pointwise and uniform convergence, Cauchy Criterion for Uniform Convergence, Weierstrass M-test, Interchange of Limits, Series of Functions, Tests for Uniform Convergence, Power series and its convergence, Abel's Theorem (statement and related problems). [**2**] Chapter 12, 13 **(15 Marks)**	13	02	--	15
IV	**Reduction formulae and Tracing of Curves:** Reduction formulae: Reduction formulae for and their applications. **[3]** Chapter 4 (Sections 4.1 – 4.6) **Tracing of Curves:** Asymptotes, Concavity and inflexion points, Singular points, Tangents at the origin and nature of singular points, Curve tracing (cartesian and polar equations) **[4]** Chapter 9 (Sections 9.1, 9.2 and 9.9 (Polar curves only), Chapter 11 **(15 Marks)**	13	02	--	15

Text Book:

1. R.G. Bartle and D.R. Sherbert, *Introduction to Real Analysis*, 3rd Ed., John Wiley and Sons, 2002.
2. S. C. Malik and S. Arora, Mathematical analysis, New age international.

3. Narayan, S. and Mittal, P.K., (2005). *Differential Calculus*, S. Chand.
4. Narayan, S. and Mittal, P.K., (2007). *Integral Calculus*, S. Chand.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-V

Title of the course	**Multivariate Calculus**
Course code	MAT-MJ-05024
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment:40)
Prerequisites	MAT-MJ-04034

Course Objectives: To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. This course will facilitate to become aware of applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

Course Learning Outcomes: This course will enable the students to:

- Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion.
- Understand the maximization and minimization of multivariable functions subject to the given constraints on variables.
- Learn about inter-relationship among the line integral, double and triple integral formulations.
- Familiarize with Green's, Stokes' and Gauss divergence theorems

UNIT	CONTENT	L	T	P	Total Hrs
I	Functions of several variables: Level curves and surfaces, Limits and continuity, Partial derivatives, Higher order partial derivative, Chain rule, Jacobian, Euler's theorem for homogeneous equations, Directional derivatives, The gradient, Maximal property of the gradient, Total Derivative. **[1]** Chapter 11 [(Sections 11.1, 11.2, 11.3, 11.5, Section 11.6 (upto page 743)] **(15 Marks)**	13	02	--	15

II	Properties of a vector field: Divergence and Curl, Extrema of functions of two variables, Method of Lagrange multipliers, [1] Chapter 11 [Section 11.7 (up to page 754), Section 11.8 (pages 761-765)], Chapter13 (Section 13.1) **(15 Marks)**	13	02	--	15
III	Double integration over rectangular and nonrectangular regions, Change of variables, Double integrals in polar coordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals. [1] Chapter 12 (Sections 12.1-12.4) [2] Chapter 7 [sec 1, 2, 3] **(15 Marks)**	13	02	--	15
IV	Definition of vector field, Divergence and curl, 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 13 [(Sections 13.2, 13.3), Section 13.4 (pages 887-891), Section 13.5 (pages 898-901) Section 13.6 (pages 908-913), Section 13.7 (pages 916-919)] **[2] Chapter 8, [section 3, 4, 5]** **(15 Marks)**	13	02	--	15

Text book:

[1] Strauss, Monty J.,Bradley, Gerald L.,& Smith, Karl J.(2012). *Calculus* (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011

[2]Theodore Shifrin, Multivariable Mathematics. Wiley. John Willey & Sons, Inc.

Reference Books:

1. Marsden, J.E., Tromba, A., & Weinstein,A.(2004).*Basic Multivariable Calculus*. Springer (SIE). First Indian Reprint.
2. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
3. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-V

Title of the course	**Numerical Analysis-I (with practical)**
Course code	MAT-MJ-05034
Nature of Course	Major
Total Credit	04 (Theory: 03 + Practical: 01)
Contact Hours	60
Total Marks	100 (End Term: 45, Practical:25, Internal Assessment:30)
Prerequisites	Mathematics in 10+2 or equivalent, Knowledge of Computer Software and Programming Language.

Course Objectives: To comprehend various computational techniques to find approximate value for
possible root(s) of non-algebraic equations, to find the approximate solutions of system of linear equations and Quadratic equations.

Course Learning Outcomes: The course will enable the students to:

- Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and
  solution of a system of linear equations, up to a certain given level of precision.
- Know about iterative and non-iterative methods to solve system of linear equations
- Know interpolation techniques to compute the values for a tabulated function at points not in
  the table.
- Integrate a definite integral that cannot be done analytically
- Find numerical differentiation of functional values
- Solve differential equations that cannot be solved by analytical methods

UNIT	CONTENT	L	T	P	Total Hrs
I	Taylor's Theorem, errors in arithmetic operations, absolute and relative error, truncation and round off errors. **[1]** Chapter 1 (Sections 1.1, 1.3 (1.3.1-1.3.4)) **(5 Marks)**	04	01	--	05

II	Calculus of finite difference: different interpolation formulae with remainder terms, finite difference operators and their operations on function of a single variable, interpolation with equal and unequal intervals, Newton;s formulae, Lagrange's formula, Gauss, Bessel and sterling's formula, Hermite interpolation. **[2]** Chapter 1 (1.8, 1.8.1,1.8.2), Chapter 2, Chapter 3 (Sections 3.1-3.5) **(15 Marks)**	13	02	--	15
III	Numerical differentiation and integration: Numerical differentiation with the help of different interpolation formulae, general quadrature formula, trapezoidal rule. Simpson's one third and three eighth rule. Weddel's rule, Newton-Cote's formula. **[1]** Chapter 4 (Sections 4.1-4.4) , Chapter 7 (Section 7.1-7.5 and 7.6.2) **(15 Marks)**	13	02	--	15
IV	Solution of polynomial and transcendental equations: Bisection method, secant method, regula falsi method, Newton-Raphson method, rate of convergence, Chebyshev Method and comparison of methods. **[1]** Chapter 3 (Sections 3.1-3.4, 3.6, 3.8 and 3.10) **(10 Marks)**	08	02	--	10
	Practicals: 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 **(25 Marks)** **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.	--	--	25	25

Text Books:
[1] Rao-V.-Dukkipati, Numerical-Methods, New Age International Publishers, 2010.
[2] H.C. Saxena, Finite Differences and Numerical Analysis, S. Chand Company, 2008.
[2] Fausett, Laurene V. (2009). *Applied Numerical Analysis Using* MATLAB. Pearson. India
[3] Jain, M.K., Iyengar, S.R.K., & Jain R.K.(2012). *Numerical Methods for Scientific and Engineering Computation* (6th ed.). New Age International Publishers. Delhi.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VI

Title of the course	**Complex Analysis-I (with practical)**
Course code	MAT-MJ-06014
Nature of Course	Major
Total Credit	04 (Theory: 03 + Practical: 01)
Contact Hours	60
Total Marks	100 (End Term: 45, Practical:25, Internal Assessment:30)
Prerequisites	Mathematics in 10+2 or equivalent std, Knowledge of complex number system upto Modulus and geometrical reprentation of complex no.

Course Objectives: The main objective of this course is to develop a deep understanding of the complex plane together with various related concepts. These concepts have wide applicability indifferent aspects.
Course Learning Outcomes: The completion of the course will enable the students to:
- Learn the significance of differentiability of complex functions leading to the understanding of Cauchy−Riemann equations.
- Learn some elementary functions and valuate the contour integrals.
- Understand the role of Cauchy-Goursat theorem and the Cauchy integral formula

UNIT	CONTENT	L	T	P	Total Hrs
I	Polar representation of complex numbers, De Moivre's Theorem (both integral and rational index) and its applications, Roots of a complex number, n^{th} roots of unity. Functions of complex variable, mappings, limits, theorems on limits, limits involving point at infinity,	13	02	--	15

	continuity. Derivatives, rules for differentiation, Cauchy-Riemann equations, sufficient conditions for differentiability, polar co-ordinates. **[1]:** Chapter 1 (Section 6-9), Chapter 2 (Section 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24) **(15 Marks)**				
II	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 (Sections 25, 26, 27), Chapter 3 (Sections 30, 31,32,33,34, 35, 36, 37, 38), Chapter 4(Section 41, 42) **(10 Marks)**	08	02	--	10
III	Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals, antiderivatives, proof of antiderivative theorem. **[1]:** Chapter 4 (Section 43, 44, 45,47, 48, 49) **(10 Marks)**	08	02	--	10
IV	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) **(10 Marks)**	08	02	--	10
	PRACTICALS: (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., $\oint \sin z\, dz$, along the contour C which is a straight line path from -1+ i to 2 - i. 5. To perform contour integration., e.g., a) $\oint(z^2 - 2z + 1)dz$ along the Contour C given by $x = y^2 + 1;\ -2 \le y \le 2$. b) $\oint(z^3 + 2z^2 + 1)dz$ along the contour C given by	--	--	25	25

	$x^2 + y^2 = 1$, which can be parameterized by x = cos (t), y = sin (t) for $0 \le y \le 2\pi$. 6. To plot the complex functions and analyze the graph. e.g., $f(z) = z, iz, z^2, z^3, e^z$ and $(z^4-1)/4$, etc **(25 Marks)**					

Text Book:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications (Ninth Edition), McGraw-Hill Indian Edition, 2021.

Reference Book:

1. Joseph Bak and Donald J. Newman, *Complex analysis* (2nd Edition), Undergraduate Texts in
2. Mathematics, Springer-Verlag New York, Inc., New York, 1997.
3. M.R. Spiegel, *Complex Variables*. Schaum's Outlines series, McGraw Hill Education, 2017.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS
SEMESTER-VI

Title of the course	**Partial Differential Equations (with practical)**
Course code	MAT-MJ-06024
Nature of Course	Major
Total Credit	04 (Theory: 03 + Practical: 01)
Contact Hours	60
Total Marks	100 (End Term: 45, Practical:25, Internal Assessment:30)
Prerequisites	Mathematics in 10+2 or equivalent std., knowledge in computer software

Course Objectives: The main objectives of this course are to teach students to form and solve partial differential equations and use them in solving some physical problems.

Course Learning Outcomes: The course will enable the students to:

- Formulate, classify and transform first order PDEs into canonical form.
- Learn about method of characteristics and separation of variables to solve first order PDE's.
- Classify and solve second order linear PDEs.

- Learn about Cauchy problem for second order PDE and homogeneous and non-homogeneous
  wave equations.
- Apply the method of separation of variables for solving many well-known second-order PDEs.

UNIT	CONTENT	L	T	P	Total Hrs
I	**Partial Differential Equation of first order:** Introduction, Classification, Construction of first order Partial Differential Equations, Solution of Partial Differential Equations of first order, Intergral surfaces passing through a given curve, Cauchy Problem for First Order Equation. First Order Non-linear Equation,Cauchy Method of Characteristics, Charpit's Method, Jecobi's Method. [1] Chapter 2 (Sections 2.1 to 2.3), [2] Chapter 2 (Section 3, 4,5, 7,8,10,12, 13) [3] Chapter 0 (sections 0.1, 0.4-0.70.9, 0.11 **(15 Marks)**	13	02	--	15
II	2nd order PDE and its classification; Canonical transformation, Reduction to canonical form for Hyperbolic Equation, Parabolic Equation, Elliptic Equation [1] Chapter 2 (Sections 2.6 and 2.7) [3] Chapter 1 (sections 1.1-1.3) **(15 Marks)**	13	02	--	15
III	Linear Partial differential equations with constant coefficients, General Method for finding Complementary Function (CF) of irreducible Non homogeneous Linear PDE, Method of finding Particular Integral (PI) Homogeneous Linear PDE with constant Coefficients, Method of Finding its CF and PI. [2] Chapter 1 (sec 1.6-1.7) **(10 Marks)**	08	02	--	10
IV	Method of separation of variables for 2nd order PDE with special emphasis on Laplace, Diffusion and Wave equation . [4] Chapter 2 (sec 2.1 and 2.3), Chapter 6 (sec 6.1) **(5 Marks)**	04	01	--	05
	Practical /Lab work to be performed in a Computer Lab: Modelling of the following similar problems using Mathematica /MATLAB/ Maple/ Maxima/ Scilab etc. 1. Solution of Cauchy problem for first order PDE.	--	--	25	25

	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 5. Solving systems of ordinary differential equations 6. Solution of one-Dimensional heat equation **(25 Marks)**				
		--	--	25	60

(No. of practical classes: 30, Marks: 20)

Text Book:

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

4. K Sankara Rao. Introduction to Partial Differential equations, 3rd edition. Estern Economy Edition.
5. *4.Partial Differential Equations: An Introduction,* 2^{nd} edition, Walter A. Strauss.

Reference Book:

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

2. M. D. Raisinghania, Advanced Differential Equations, S. Chand & Company LTD.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VI

Title of the course	**Metric Spaces**
Course code	MAT-MJ-06034
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment:40)
Prerequisites	MAT-MJ-0414

Course Objectives: Up to this stage, students do study the concepts of analysis which evidently rely on the notion of distance. In this course, the objective is to develop the usual idea of distance into an abstract form on any set of objects, maintaining its inherent characteristics, and the resulting consequences.

Course Learning Outcomes: The course will enable the students to:

- Learn various natural and abstract formulations of distance on the sets of usual or unusuaentities. Become aware one such formulations leading to metric spaces.
- Analyse how a theory adMAT-MJ-vances from a particular frame to a general frame.
- Appreciate the mathematical understanding of various geometrical concepts, viz. Balls or connected sets etc. in an abstract setting.
- Learn about the two important topological properties of metric spaces, namely connectedness and compactness.

UNIT	CONTENT	L	T	P	Total Hrs
I	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, Sections: 1.1-1.4, Chapter 2, Sections: 2.1, 2.2, 2.3.12 - 2.3.16 **(15 Marks)**	13	02	--	15
II	Continuity: Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Equivalent metrics, Isometry. Contraction mappings. [1] Chapter 3, Sections 3.1, 3.4, 3.5, 3.7 (upto 3.7.2) **(15 Marks)**	13	02	--	15
III	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 **(30 Marks)**	25	05	--	30

Text Book:

1. Satish Shirali & Harikishan L. Vasudeva, Metric Spaces, Springer Verlag London (2006) (First Indian Reprint2009)

Reference Books:

1. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
2. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
3. Micheal O. Searcoid, Metric Spaces, Springer Publication, 2007.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VI

Title of the course	**Mechanics – I**
Course code	MAT-MJ-06044
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment:40)
Prerequisites	Mathematics in 10+2 or equivalent std.

Course Objectives: The course aims at understanding the various concepts of physical quantities and the related motion of bodies under the action of forces.

Course Learning Outcomes: The course will enable the students to:

- Know about the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.
- Understand the theory behind friction and center of gravity.
- Know about conservation of mechanical energy and work-energy equations.
- Learn about translational and rotational motion of rigid bodies.

UNIT	CONTENT	L	T	P	Total Hrs
I	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. [1] Chapter I-VIII **(20 Marks)**	17	03	--	20
II	Friction, C.G of an arc, plane area, surface of revolution, solid of revolution. [1] Chapter IX-X **(10 Marks)**	08	02	--	10
III	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. [2] Chapter I, II, III, and VI **(15 Marks)**	13	02	--	15
IV	Work, Energy and momentum, Conservative forces-Potential energy, Impulsive forces, Motion in resisting medium. [1] Chapter XII **(15 Marks)**	13	02	--	15

Text Books:

1. B.C. Das & B. N. Mukherjee, Statics, U. N. Dhur & Sons Pvt. Ltd
2. S.L. Loney, An elementary treatise on the dynamics of a particle and of rigid bodies, Surjeet publications
3. F.Chorlton,Text book of Dynamics, CBS,Publications2ndEdition,1985

Reference books:

1. M.R.Spiegel, Theoretical Mechanics, Schaum Series 2010.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VII

Title of the course	**Algebra – II**
Course code	MAT-MJ-07014
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-03024 and MAT-MJ-04024

Course Objective: To develop a deep understanding of advanced abstract algebra, including group theory, ring theory, field extensions, and linear algebraic structures, and to build the ability to analyze algebraic systems using key concepts such as Sylow theorems, factorization domains, field extensions, canonical forms, and quadratic forms, with emphasis on mathematical reasoning and structural understanding.

Course Learning Out comes: On successful completion of the course students will be able to:

- Describe direct product of groups and different kinds of subnormal series of groups.
- Explain polynomial rings over commutative rings, PID, Euclidean Domain and UFD.
- Discuss field extension and its application to geometry.
- Identify about similarity of linear transforms and classify Jordan canonical forms and quadratic forms.

UNIT	CONTENT	L	T	P	Total Hrs
I	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. [1] Chapter 4 (Section 1), Chapter 5. **(15 Marks)**	13	02	--	15
II	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. [1] Chapter 9, Chapter 10. **(15 Marks)**	13	02	--	15

III	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. [1] Chapter 13, Chapter 14 (Section 4). **(15 Marks)**	13	02	--	15
IV	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. [2] Chapter 6 . **(15 Marks)**	13	02	--	15

Text Book:

1. S. Singh and Q. Zameeruddin, Modern Algebra, Vikas Publishing House, 9th Revised Edition, 2006.
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons, 2nd Edition, 1975.

Reference Books:

1. D. S. Malik, J. M. Mordeson and M. K. Sen, Fundamentals of Abstract Algebra, McGraw Hill Company, 1997.
2. C. Musili, Introduction to Rings and Modules, Narosa Publishing House, 1994.
3. K. Hoffman and R. Kunz, Linear Algebra, Prentice Hall, 1965.
4. K. B. Datta, Matrix and Linear Algebra, Prentice Hall of India, 2004.
5. S. Lipschutz, Schaum's Outline Series of Linear Algebra, McGraw Hill, 2013.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VII

Title of the course	**Functional Analysis**
Course code	MAT-MJ-07024
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)

Course Objective: The course provides a foundation in functional analysis covering normed and Banach spaces, bounded linear operators, and key theorems such as the Open Mapping, Closed Graph, and Uniform Boundedness principles. It also includes quotient spaces, Hahn–Banach theorem, dual spaces, and reflexivity, along with an introduction to Hilbert spaces and operator theory involving adjoint, self-adjoint, unitary, and compact operators.

Course Learning Out comes: Students will be able to:

- Understand and analyze the structure of normed linear spaces, Banach spaces, and Hilbert spaces, along with their important examples and properties.
- Examine the continuity and boundedness of linear operators and linear functionals, and compute operator norms for finite and infinite dimensional transformations.
- Apply the fundamental results of Functional Analysis including:
    - Stefan Banach–Steinhaus theorem,
    - Hans Hahn–Stefan Banach theorem,
    - Open Mapping theorem,
    - Closed Graph theorem,
    - Uniform Boundedness Principle,

to solve problems involving bounded linear operators and functional spaces.

- Understand and work with dual spaces, weak and weak* convergence, reflexive spaces, and spectra of bounded and compact operators.
- Analyze bounded linear operators on Hilbert spaces, including adjoint, self-adjoint, unitary, and normal operators, and apply the spectral theorem for compact self-adjoint operators.
- Apply the Stefan Banach Fixed Point Theorem to problems arising in differential equations, integral equations, and related mathematical models.

UNIT	CONTENT	L	T	P	Total Hrs
I	Normed linear spaces and Banach spaces, and examples; Continuity of linear maps. Linear functionals, Examples of continuous linear maps, Necessary conditions for the continuity of transformations defined by infinite matrices, Operator norm of bounded linear maps, Operator norm of transformations defined by finite matrices. **(20 Marks)**	16	04	--	20
II	Fundamental theorems: Hahn-Banach theorem, open mapping and closed graph theorems, Uniform Bounded Principle and its applications, Banach-Steinhaus Theorem. Duals and transposes, weak and weak* convergence, reflexivity, Spectra of bounded linear operators, compact operators and their spectra. **(20 Marks)**	16	04	--	20

III	Hilbert spaces, bounded linear operators on Hilbert spaces, Adjoint operators, normal, unitary, self-adjoint operators and their spectra. Spectral theorem for compact self-adjoint operators. Banach fixed point theorem and its applications. **(20 Marks)**	16	04	--	20

Text Book:

1. E. Kreyszig, Introduction to Functional Analysis with Applications, John Wiley and Sons, 1978.
2. B. V. Limaye, Functional Analysis, 2nd edition, Wiley Eastern, 1996.
3. J.B. Conway, A Course in Functional Analysis, Springer, 1990.
4. Peter D. Lax, Functional Analysis, Wiley, 2002
5. Nicholas Young, An Introduction to Hilbert Space, Cambridge, 1988

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VII

Title of the course	**Complex Analysis – II**
Course code	MAT-MJ-07034
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-06014

Course Objective: To develop a deep and rigorous understanding of advanced complex analysis, including power series representations, singularities, and residue theory, and to strengthen the ability to study and evaluate complex functions using powerful analytical tools such as Taylor and Laurent expansions, Cauchy’s residue theorem, and analytic continuation, with emphasis on conformal mappings and their applications.

Course Learning Out comes: This course will enable the students to:

- Define Conformal mappings and illustrate with examples.
- Discuss analytic continuation and Gamma function.
- Compute integrals of complex functions using Residue theorem.
- Understand the concept of Riemann surface.

- Formulate Power series expansions of complex valued functions.

UNIT	CONTENT	L	T	P	Total Hrs
I	**Power Series:** Taylor's and Laurent's Theorem, Zero and Singularity of an analytic function, The Argument Principle, Rouche's theorem. **(15 Marks)**	13	02	--	15
II	**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. **(15 Marks)**	13	02	--	15
III	**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. **(15 Marks)**	13	02	--	15
IV	**Analytic Continuation:** Analytical continuation, Schwarz's reflection principle, Infinite products, Gamma Function and its properties . **(15 Marks)**	13	02	--	15

Text Book:

1. M.R. Spiegel, Complex Variables. Schaum's Outlines series, McGraw Hill Education, 2017
2. E.G. Philips, Functions of acomplex variables with applications, Oliver and Boyd,1957.
3.

Reference Books:

1. Walter Rudin, Real and Complex Analysis, McGraw Hill Education, 2017
2. L.V. Ahlfors, Complex Analysis, McGraw Hill, 2000
3. H.A. Priestly, Introduction to Complex Analysis, Clarendon Press Oxford, 1990
4. Mark J. Ablowitz and A.S. Fokas, Complex Variables, Introduction and Application, CUP, 1998.
5. John B Conway, Functions of Complex Variable, Springer, 1872.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VII

Title of the course	**Mathematical Methods**
Course code	MAT-MJ-07044
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)

Course Objective: The course develops understanding of integral equations, Fourier and Laplace transforms, and calculus of variations. It trains students to solve Fredholm and Volterra integral equations, apply transform methods to differential equations, and use variational techniques such as Euler–Lagrange equations to solve physical and engineering problems.

Course Learning Out comes: Students will be able to:

- Identify Fredholm integral equations and Volterra integral equations.
- Apply Fourier transform to solve ordinary and partial differential equations of initial and boundary value problems.
- Apply Laplace transform to solve ordinary, partial differential equations of initial and boundary value problems, and to evaluate definite integrals.
- Use calculus of variations to extremize a functional with fixed boundaries.
- Formulate and solve isoperimetric problems.

UNIT	CONTENT	L	T	P	Total Hrs
I	**Integral Equations:** Definition of Integral Equation, Reduction of ordinary differential equations into integral equations. Fredholm integral equations with separable kernels, Eigenvalues 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. **(15 Marks)**	13	02	--	15

II	**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. **(15 Marks)**	13	02	--	15
III	**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. **(15 Marks)**	13	02	--	15
IV	**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. **(15 Marks)**	13	02	--	15

Text Book:

1. M. D. Raisinghania, Integral Equation & Boundary Value Problem, S. Chand, 2010.
2. Murray Spiegel, Schaum's Outline of Fourier Analysis with Applications to Boundary Value Problems , McGraw-Hill Education, 1974
3. M. R. Spiegel, Schaum's Outline Series: Theory and Problems of Laplace Transforms, McGraw- Hill Book Company, 1965.
4. I.M Gelfand and S.V. Fomin: Calculus of Variations, Prentice Hall, INC, 1963, Edited by R.A. Silvarman.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VIII

Title of the course	**Topology**
Course code	MAT-MJ-08014
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-06034

Course Objective: To develop a rigorous understanding of general topology, including topological spaces, continuity, convergence, compactness, connectedness, and separation axioms, and to build the ability to analyze abstract mathematical structures using open and closed sets, bases, product spaces, and key theorems such as Urysohn's and Tychonoff's, with emphasis on logical reasoning and mathematical abstraction.

Course Learning Out comes: The course will enable the students to:

- identify topological spaces and construct examples of such spaces.
- 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.
- use the idea of compactness and connectedness and give their different characterizations.
- explain the product topology and its relationship with compactness, connectedness, and countability.
- provide examples of metrizable spaces and explain the relationship between embedding and metrization.

UNIT	CONTENT	L	T	P	Total Hrs
I	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. **(10 Marks)**	09	02	--	11

II	Countable and uncountable sets, First and second Countable spaces, Lindelof's theorem, Separable spaces, Second Countability and Separability. **(10 Marks)**	04	01	--	05
III	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. **(10 Marks)**	08	02	--	10
IV	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. **(10 Marks)**	09	02	--	11
V	Connected spaces, connectedness on the real line, components, totally disconnected spaces, Locally connected spaces. **(10 Marks)**	09	02	--	11
VI	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. **(10 Marks)**	09	03	--	12

Text Book:

1. J. R. Munkres, Topology: A first course, Prentice Hall of India, 1974.
2. S. Willard, General Topology, Dover Publications, 2004.
3. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India By PHI)

Reference Books:

1. K.D. Joshi, Introduction to General Topology, New Age International Private Limited, 2017
2. S. Lipschutz, Theory and Problems of General Topology, Schaum's Outline Series, McGraw-Hill Book Company, 1965.
3. M. G. Murdeshwar, General Topology, New Age International, 1990.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VIII

Title of the course	**Mechanics – II and Tensor Calculus**
Course code	MAT-MJ-08024
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-05024 and MAT-MJ-06044

Course Objective: The course develops a foundation in classical mechanics by covering central force motion and its application to planetary motion and Kepler's laws. It introduces cylindrical and spherical coordinate systems for analyzing motion, rigid body dynamics using Euler's equations, and analytical mechanics through Lagrangian and Hamiltonian formulations. The course also includes small oscillations and variational principles such as Hamilton's principle and the principle of least action.

Course Learning Out comes: Students will be able to:

- Explain various physical laws of motion, Hamiltonian's principle etc. with mathematical tools.
- Distinguish Tensors and perform algebraic operations on tensors, to obtain covariant derivatives of various tensors and to express Laplacian in tensor form.
- Apply various tools of vector algebra as well as vector calculus, calculus of variations to discuss the motion of rigid bodies under certain constraints.
- Differentiate the properties of motion in various coordinate systems viz. cylindrical, spherical, conical surfaces.
- Construct mathematical models viz. rigid body to describe motions under certain constraints or no constraints which are able to analyse the physical scenario.

UNIT	CONTENT	L	T	P	Total Hrs
	Group – A: Mechanics – II				
I	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. **(15 Marks)**	13	02	--	15

II	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. **(15 Marks)**	13	02	--	15
Group – B: Tensor Calculus					
III	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. **(15 Marks)**	13	02	--	15
IV	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. **(15 Marks)**	13	02	--	15

Text Book:

1. S L Loney, An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies, Cambridge University Press, 2017
2. Murray Spiegel, Theory & Problems of Theoretical Mechanics (Schaum's Outline Series), McGraw Hill Education, 2017
3. C. E. Weatherburn, An Introduction to Riemannian Geometry and the Tensor Calculus, Cambridge University Press, Paperback, 2008

Reference Books:

1. F. Chorlton, Text Books of Dynamics, John Wiley & Sons, 1983
2. B. C. Kalita, Tensor Calculus and Applications: Simplified Tools and Techniques, CRC Press, Taylor &Francis Group, 2019
3. David C. Kay, Tensor Calculus (Schaum's Outline Series), McGraw Hill Education, 2011
4. L. P. Eisenhart, Riemannian Geometry, Princeton University Press, 1997.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS
SEMESTER-VIII

Title of the course	**Number Theory – II**
Course code	MAT-MJ-08034
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-04044 and MAT-MJ-03024

Course Objective: This course aims to introduce the fundamental concepts of Number Theory; primitive roots, quadratic residues, continued fractions, Pell equations. Also, the course aims to introduce the fundamental principles of classical and modern cryptographic systems and to provide insight into discrete logarithms and their role in modern cryptographic protocols.

Course Learning Out comes: On successful completion of the course students will be able to:

- Describe primitive roots and indices for solvability of congruence of higher order.
- Explain the quadratic reciprocity law using Legendre's and Jacobi's symbol.
- To describe continued fractions and Pell's equation.
- Explain the basic concepts, terminology, and objectives of cryptography and secure communication.
- Demonstrate an understanding of the principles and mathematical foundations of public-key cryptography.
- Analyze and implement the RSA cryptosystem for secure encryption and digital communication.
- Describe and apply the Diffie–Hellman key exchange protocol for secure key establishment.
- Explain the structure, operation, and security features of the ElGamal cryptosystem.

UNIT	CONTENT	L	T	P	TOTAL HRS
I	Primitive roots: order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, theory of indices. [1] Chapter 8 (Sections 8.1 to 8.4). **(15 Marks)**	13	2	--	15
II	Quadratic residues: Euler's criterion, Legendre's and its properties, Quadratic Reciprocity Law, Quadratic congruences with composite moduli. [1] Chapter 9 (Sections 9.1 to 9.4). **(15 Marks)**	13	2	--	15

III	Finite Continued fractions, Infinite Continued Fraction, Pell's equation. [1] Chapter 15 (Sections 15.2, 15.3 and 15.4). **(12 Marks)**	10	2	--	12
IV	Some simple cryptosystems, Basic notations, Digraph Transformation, Enciphering matrices, The idea of Public Key Cryptography, RSA, Discrete log, Diffie-Hellman key exchange, ElGamal cryptosystem. [2] Chapter 3 (Section 1 to 2) and Chapter 4 (Section 1 to 3).**(18 Marks)**	15	3	--	18

Text Book:

1. David M. Burton, Elementary Number Theory, McGraw Hill Education, Seventh Edition, 2011.
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, Wiley, 2008.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VIII

Title of the course	Optimization
Course code	MAT-MJ-08044
Nature of Course	Major
Total Credit	04 (Theory: 04+ Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	

Course Objectives: The optimization algorithms deal with optimizing several real-valued functions with some constraints. We will study linear and nonlinear programmingtechniques. The linear programming deals with optimizing linear functions withlinear constraints using hyperplanes. A lot of realworldproblems occurring in science and industry, which involves optimization,will be discussed in this course.

Course Learning Outcomes: The course will enable the students to:

- Understand the mathematical background of Linear Programming (LP), simplex algorithm and different types of LPP.
- Formulate and solve transportation and assignment problems using appropriate method.

- Analyze and Identify strategic situations and solve simple games using various techniques such as pure and mixed strategies, geometric method and LP method.
- Apply different results of Linear Programming & Game Theory to solveproblems of Social Science, Science and Engineering.

UNIT	CONTENT	L	T	P	Total Hrs
I	Convex sets and functions, separating hyperplanes theorem, Introduction to optimization, Mathematical formulation on Linear Programming Problems – Graphical solution method - some exceptional cases - Canonical and standard forms of Linear Programming Problem - Simplex method. **(15 Marks)**	14	01	--	15
II	Use of Artificial Variables (Big M method - Two phase method) – Duality in Linear Programming - General primal-dual pair - Formulating a Dual problem - Primal-dual pair in matrix form -Dual simplex method. **(15 Marks)**	14	01	--	15
III	Transportation problem - LP formulation of the TP - Solution of a TP - Finding an initial basic feasible solution (NWCM - LCM -VAM) – Degeneracy in TP - Transportation Algorithm (MODI Method) - Assignment problem - Solution methods of assignment problem – special cases in assignment problem. **(15 Marks)**	14	01	--	15
IV	Games and Strategies – Two person zero sum - Some basic terms - the maximin-minimax principle -Games without saddle points-Mixed strategies - graphic solution 2xn and mx2 games, nonlinear optimization: basic theory, method of Lagrange multipliers, Karush-Kuhn Tucker theory, convex optimization. **(15 Marks)**	14	01		15

Text Books

1. Swarup, K, Gupta, P.K., Mohan, M.,Operations Research (14th edition), Sultan Chand & Sons, New Delhi, 2008.
2. Hadely, G., Linear Programming, Narosa Publishing House, New Delhi, 2002.

Reference Books:

1. Gupta, P.K. and Hira, D.S., Operations Research, 2nd Edn, S.Chand & Co., New Delhi, 2004.

2. Taha, H.A., Operations Research-An Introduction.8th edition,Pearson Prentice Hall.

3. Bronson, R. andNaadimurhu,G., Opertion Research, Tata MxGraw Hill, 2017.

4. Chong, E.K.P and Zak, S.H.,An Introduction to Optimization, 2nd edition, Wiley, 2010.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VIII

Title of the course	**Lebesgue Measure & Probability Theory**
Course code	MAT-MJ-08054
Nature of Course	Major
Total Credit	04 (Theory: 04 + Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-04014 & MAT-MJ-05014

Course Objective: To develop a rigorous understanding of measure theory through Lebesgue measure and integration, and to build the ability to analyze measurable functions, and integrability using advanced mathematical frameworks and convergence theorems. Also, to develop a strong theoretical foundation in probability through the study of probability spaces and measures and to enable students to apply probabilistic techniques in mathematical and statistical analysis.

Course Learning Out comes: After completing this course, students should be able to:

- Understand the fundamental concepts of measure theory, including algebras, σ-algebras, Borel sets, outer measures, and Lebesgue measure.
- Construct measures using the Carathéodory extension process and analyze properties of measurable sets and measurable functions.
- Develop a rigorous understanding of Lebesgue integration and compare it with the Riemann integral.

- Study L^p-spaces and understand their importance in modern analysis, functional analysis, and probability theory.
- Understand absolutely continuous functions and the Fundamental Theorem of Calculus in the Lebesgue setting.
- Learn the axiomatic foundations of probability through probability spaces, probability measures, probability distributions functions
- Compute expectations, moments, variances, covariance, and correlation, and use generating functions and characteristic functions in probabilistic analysis.
- Apply inequalities and probabilistic techniques to solve theoretical and applied problems in mathematics, statistics, data science, and related fields.

UNIT	CONTENT	L	T	P	Total Hrs
Group – A: Measure Theory					
I	Lebesgue outer measure, Lebesgue measurable sets, Lebesgue measure. Algebra and sigma-algebra of sets, Borel sets, Outer measures and measures, Caratheodory construction. Measurable functionsand examples, Lusin's theorem, Egoroff's theorem. **(15 Marks)**	13	02	--	15
II	Integration of measurable functions, Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem. L^p -spaces. Absolutely continuous functions, Fundamental theorem of calculus for Lebesgue integral. **(15 Marks)**	13	02	--	15
Group – B: Probability Theory					
III	Axiomatic definition of probability, probability spaces, probability measures on countable and uncountable spaces, conditional probability, independence; Random variables, distribution functions, probability mass and density functions, functions of random variables, standard univariate discrete and continuous distributions and their properties. **(15 Marks)**	13	02	--	15
IV	Mathematical expectations, moments, moment generating functions, characteristic functions, inequalities; Random vectors, joint, marginal and conditional distributions, conditional expectations, independence, covariance, correlation, standard multivariate distributions. **(15 Marks)**	13	02	--	15

Text Book:

1. G. de Barra: Measure Theory and Integration, New Age Publishers, 1st ed, 2013.
2. J. Jacod and P. Protter, Probability Essentials, Springer, 2004.

Reference Books:

1. D. L. Cohn: Measure Theory, Birkhauser, 1994
2. W. Rudin: Real and Complex Analysis, McGraw-Hill India, 2017
3. G. B. Folland: Real Analysis (2nd ed.), Wiley, 1999
4. H. L. Royden & P. M. Fitzpatrick: Real Analysis, Pearson India, 2015
5. V. K. Rohatgi and A. K. Md. E. Saleh, An Introduction to Probability and Statistics, 2nd Edn., Wiley, 2001.
6. G. R. Grimmett and D. R. Stirzaker, Probability and Random Processes, 3rd Edn., Oxford University Press, 2001.
7. S. Ross, A First Course in Probability, 6th Edn., Pearson, 2002.
8. J. Rosenthal, A First Look at Rigorous Probability Theory, 2nd Edn., World Scientific, 2006.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VIII

Title of the course	Bio-Mathematics
Course code	MAT-MJ-08064
Nature of Course	Major
Total Credit	04 (Theory: 04+ Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)
Prerequisites	MAT-MJ-03014

Course Objectives: To develop a strong foundation in mathematical modeling of dynamical systems, with emphasis on differential equations, stability theory, bifurcation, chaos, and biological applications, and to equip students with the ability to analyze, interpret, and simulate complex systems arising in physics, biology, and genetics using analytical, qualitative, and computational techniques.

Course Learning Outcomes: The course will enable the students to:

- 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.
- Develop and analyze mathematical models of heart dynamics and cardiac pacemakers.
- Apply phase plane analysis to heart beat models and threshold phenomena
- Identify and interpret chaotic behavior in dynamical systems.
- Examine stability changes associated with bifurcations.
- Apply Poincaré plane techniques to analyze system dynamics.
- Describe matrix models for DNA base substitutions
- Apply probability distributions in genetic analysis

UNIT	CONTENT	L	T	P	Total Hrs
I	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. [3] Chapter 1 and Chapter 5 [2] Chapter 1 (Sections 1.1 to 1.3), Chapter 4 (Sections 4.4 to 4.5 **(15 Marks)**	14	01	--	15
II	**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	18	02	--	20

	impulse transmission: Excitability & repetitive firing, Travelling waves. [3] 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) **(20 Marks)**				
III	**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) **(15 Marks)**	10	00		10
IV	**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) **(15 Marks)**	15	00		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.

[4] Tyn– I. Myint, Ordinary Differential Equation. Elsevier Science Ltd 1977.

Reference Books:

1. J. D. Murray, An Introduction to Mathematical Biology. Springer 2002.

2. G. F. Simmons & S. G. Krant, Differential Equations. McGraw Hill Education 2015.

3. Steven H. Strogatz, Nonlinear Dynamics and Chaos. Perseus Book Publishing. LLC 1994.

FOUR YEAR UNDERGRADUATE PROGRAMME IN MATHEMATICS

SEMESTER-VIII

Title of the course	Financial mathematics
Course code	MAT-MJ-08074
Nature of Course	Major
Total Credit	04 (Theory: 04+ Practical: 00)
Contact Hours	60
Total Marks	100 (End Term: 60, Internal Assessment: 40)

Course Objectives: The course aims to build a foundation in financial mathematics covering interest rates, bonds, and derivative instruments such as forwards, futures, and options. It develops understanding of option pricing using no-arbitrage principles, binomial and Black–Scholes models, and risk-neutral valuation. The course also focuses on hedging techniques using Greeks, trading strategies, and valuation of interest rate and currency swaps.

Course Learning Outcomes: The course will enable the students to:

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

UNIT	CONTENT	L	T	P	Total Hrs
I	**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. **(15 Marks)**	14	01	--	15

II	**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. **(15 Marks)**	14	01	--	15
III	**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. **(15 Marks)**	14	01	--	15
IV	**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 swaps, Currency swaps, Valuation of currency swaps. **(15 Marks)**	15	00	--	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.

Reference Books:

1.Sheldon M. Ross, An elementary Introduction to Mathematical Finance (3rd ed.). Cambridge University Press. USA 2011.

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