COOCH BEHAR PANCHANAN BARMA UNIVERSITY

PANCHANAN NAGAR, VIVEKANANDA STREET, COOCH BEHAR – 736101

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4 Year Under Graduate Degree (Honours)

in

MATHEMATICS

Programme Objectives:

- To provide a vibrant and more alive learning process of Mathematics, so that math-phobia can be gradually reduced amongst students.
- To improve the scope for individual participation in the process of learning of Mathematics.
- To include authentic learning, based on hands-on experience with computers with different software for better understanding of Mathematics.
- To promote experimental, problem-oriented and discovery learning of Mathematics.
- To help the student to build interest and confidence in learning the subject.
- To explore the scope for greater involvement of both the mind and the hand which facilitates cognition.
- To engage the students in the activity-centered Mathematics laboratory, so that problem solving approaches develop amongst the students through self understanding.

Programme Outcomes:

- The students will acquire the knowledge to use meaningful thought for solving different kinds of mathematical problems and to understand the basic structures of Mathematics.
- The students will be oriented to search for various applications of Mathematics.
- The students will be enriched with various points of view on Mathematics as per modern age requirement.
- To improve retention of mathematical concepts in the student.
- The teachers will be enabled to demonstrate, explain and reinforce the abstract mathematical ideas by using models, charts, graphs, pictures, posters and with the help of different software through computer.
- A student-friendly approach will be developed in the learning process of Mathematics.
- The curriculum will be explored the free and open software tools amongst the students and teachers.
- As per curriculum, the infrastructure will be developed in each of the Mathematics department in every college in order to help the students to explore the mathematical concepts through activities and experimentation.
- A spirit of inquisition will be developed amongst the students.

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Scheme and distribution of credits for Four Year Under Graduate Programme in Mathematics

Semester	Course Code	Course Detail	Contact Hours L	Contact Hours T	Contact Hours P	Credits
First Year						
I	Major – 1	Classical Algebra and Linear Algebra -1	5	1	0	**6**
	Minor – 1* (First Minor Subject is Mathematics)	Differential Calculus and Integral Calculus	5	1	0	**6**
	MDC - 1	Business Mathematics	2	1	0	**3**
	SEC - 1	Decided by the respective College				**3**
	AEC - 1	Decided by the respective College				**4**
	Total Credit of First Semester					**22**
II	Major – 2	Real Analysis – 1 and Ordinary Differential Equation - 1	5	1	0	**6**
	Minor – 2* (First Minor Subject is Mathematics)	Ordinary Differential Equations and Partial Differential Equations	5	1	0	**6**
	VAC - 1	Decided by the respective College				**3**
	SEC - 2	Decided by the respective College				**3**
	INTERN	Decided by the respective College				**4**
	Total Credit of Second Semester					**22**
Total Credit after First Year = 22 + 22 = 44 **Exit Option with Certificate in Mathematics** ***For the students who have taken Chemistry/ Physics/ Computer Science as a Major Subject**						
Second Year						
III	Major – 3	Calculus and Boolean Algebra	5	1	0	**6**
	Major – 4	Complex Analysis and Partial Differential Equations	4	0	2	**6**
	Minor – 3**	Second Minor Subject other than Mathematics	5	1	0	**6**
	MDC - 2	Mathematical Reasoning - 1	2	1	0	**3**
	SEC - 3	Decided by the respective College				**3**
	Total Credit of Third Semester					**24**

IV	Major – 5	Dynamics of a Particle and Group Theory	5	1	0	**6**
	Major – 6	Analytical Geometry in two and three dimensions	5	1	0	**6**
	Minor – 4**	Second Minor Subject other than Mathematics	5	1	0	**6**
	AEC - 2	Decided by the respective College				**4**
	Total Credit of Fourth Semester					**22**
Total Credit of Second Year = 24 + 22 = 46 **Total Credit after Completion of Second Year = 44 + 46 = 90** **Exit Option with Diploma in Mathematics** **** For the students who have taken Chemistry/ Physics/ Computer Science as a Major Subject**						
Third Year						
V	Major – 7	Linear Programming Problem and Theory of Games	5	1	0	**6**
	Major – 8	Real Analysis – 2 and Ordinary Differential Equations -2	4	0	2	**6**
	Major – 9	Metric Spaces and Ring Theory	5	1	0	**6**
	MDC – 3	Mathematical Reasoning - 2	2	1	0	**3**
	Total Credit of Fifth Semester					**21**
VI	Major – 10	Probability and Logic & Sets	5	1	0	**6**
	Major – 11	Statistics	4	0	2	**6**
	Major - 12	Multivariate Calculus and Vector Analysis	5	1	0	**6**
	VAC - 2	Decided by the respective College				**3**
	Total Credit of Sixth Semester					**21**
Total Credit of Third Year = 21 + 21 = 42 **Total Credit after Completion of Third Year = 44 + 46 + 42 = 132** **Exit Option with Graduate in Mathematics**						

COOCH BEHAR PANCHANAN BARMA UNIVERSITY

PANCHANAN NAGAR, VIVEKANANDA STREET, COOCH BEHAR – 736101

Scheme and distribution of marks for Four Year Under Graduate Programme in Mathematics

Year	Semester	Paper	Semester End Examination			Internal Assessment			Total
			Papers	Th	Practical	CE	Project	A	
1st	I	Major– 1	Classical Algebra & Linear Algebra	75	X	10	10	05	100
		Minor –1	Differential Calculus & Integral Calculus	75	X	10	10	05	100
		MDC -1	Business Mathematics	35	X	10	X	05	50
		SEC -1	Decided by the respective College	X	X	X	X	X	X
		AEC – 1	Decided by the respective College	X	X	X	X	X	X
	II	Major -2	Real Analysis – 1 & Ordinary Differential Equations – 1	75	X	10	10	05	100
		Minor –2	Ordinary Differential Equations & Partial Differential Equations	75	X	10	10	05	100
		VAC - 1	Decided by the respective College	X	X	X	X	X	X
		SEC - 2	Decided by the respective College	X	X	X	X	X	X
		INTERN	Decided by the respective College	X	X	X	X	X	X
2nd	III	Major-3	Calculus & Boolean Algebra	75	X	10	10	05	100
		Major-4	Complex Analysis & Partial Differential Equations	50	25	10	10	05	100
		Minor-3	Second Minor Subject other than Mathematics	X	X	X	X	X	X
		MDC - 2	Mathematical Reasoning – 1	35	X	10	X	05	50

		SEC - 3	Decided by the respective College	X	X	X	X	X	X
	IV	Major – 5	Dynamics of a Particle & Group Theory	75	X	10	10	05	100
		Major – 6	Analytical Geometry in two and three dimensions	75	X	10	10	05	100
		Minor - 4	Second Minor Subject other than Mathematics	X	X	X	X	X	X
		AEC - 2	Decided by the respective College	X	X	X	X	X	X
3rd	V	Major – 7	Linear Programming Problem & Theory of Games	75	X	10	10	05	100
		Major – 8	Real Analysis – 2 & Ordinary Differential Equations -2	50	25	10	10	05	100
		Major - 9	Metric Spaces & Ring Theory	75	X	10	10	05	100
		MDC - 3	Mathematical Reasoning - 2	35	X	10	X	05	50
	VI	Major –10	Probability and Logic & Sets	75	X	10	10	05	100
		Major – 11	Statistics	50	25	10	10	05	100
		Major - 12	Multivariate Calculus & Vector Analysis	75	X	10	10	05	100
		VAC - 2	Decided by the respective College						

Semester wise Syllabus of Major Courses in Mathematics:

First Year, Semester – 1, Course: Major -1
Paper Name: Classical Algebra and Linear Algebra -1
Paper Code: MATMAJ-1
Full Marks: 100 (75=Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Program Objectives:

- Students will learn complex algebra, theory of equations, and inequality in this course.
- Additionally, this course will enable the students to indeterminate roots of different polynomial functions.
- Students will learn how to use algebraic theory in various mathematical problems as part of this course. An extensive discussion will be carried out over vector spaces and matrices.
- Finding solutions for systems of linear equations will be greatly aided by the explanations in this section.

Program Outcomes:

This course will enable student to

- describe the graphical representation of a polynomial, maximum and minimum values of a polynomial.
- acquire the concept of symmetric functions.
- use Newton's theorem to find the sums of power of roots, homogeneous products, limits of the roots of equation.
- derive Sturm's theorem and its application.
- learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.
- basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.
- compute the characteristic polynomial, eigen values, eigenvectors, and eigen spaces, as well as the geometric and the algebraic multiplicities of an eigen value and apply the basic diagonalization result.
- compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain orthonormal basis.

Classical Algebra (45 Hours)

Unit 1: Complex Number

Geometric representation of complex numbers, Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications, trigonometric, logarithmic and exponential functions of complex variable, definition of $a^z (a \neq 0)$, Gregory's series, inverse circular function and hyperbolic function.

(15 Hours)

Unit 2: Theory of equations

Polynomial equations with real coefficients, transformation of equation, Fundamental theorem of Classical Algebra (statement only), nature of roots of an equation, statement of Rolle's theorem, Descartes' rule of signs, Strum's theorem, application of Strum's theorem, relation between roots and coefficients of equations, equation with binomial coefficients, symmetric functions of roots, Newton's theorem on the sums of powers of roots, limits of the roots of equations, reciprocal equations, binomial equations, special roots, cubic and bi-quadratic equation (Euler and Ferraris method).

(20 Hours)

Unit 3: Inequality

Arithmetic, Geometric and Harmonic means, The inequality involving $A.M. \geq G.M. \geq H.M.$, Theorem of weighted means and m-th power theorem (statement only), Weierstrass inequalities, Tchebychev's inequality, Cauchy-Schwartz inequality, application to the problems of maxima and minima.

(10 Hours)

Linear Algebra – 1 (45 Hours)

Unit-1: Matrix and Systems of linear equations

Basic properties and operations of different types of matrices, Inverse of a matrix, characterizations of invertible matrices, elementary operations and elementary matrices, echelon matrix, row reduced echelon matrix, rank of a matrix, normal forms, equivalency and congruency of matrices.

Consistency of Systems of linear equations, the matrix equation $AX = B$ of a system of linear equations, solution sets of linear systems, solution of linear systems using row reduced form.

(15 Hours)

Unit-2: Vector spaces

Subspaces, algebra of subspaces, linear combination of vectors, linear span, linear independence and dependence, deletion theorem, basis and dimension, existence; extension and replacement theorems for basis of a finite dimensional vector space, complement of a subspace, quotient spaces.

(15 Hours)

Unit-3: Rank of Matrix and Eigen values

Row space and column space of a matrix, row rank and column rank, statements of relevant theorems, characteristic equation of a matrix, Eigen values and eigenvectors of a square matrix, Cayley-Hamilton theorem and its use in finding the inverse of a matrix, diagonalisation of matrices.

(15 Hours)

Reference Books:

1.Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. W. S. Burnside and A. W. Panton, The Theory of Equations, Dublin University Press, 1954.
3. C. C. MacDuffee, Theory of Equations, John Wiley & Sons Inc., 1954.
4. S. H. Friedberg, A. J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
5. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005
6. G. Strang, Linear Algebra and its Applications, Thomson, 2007.
7. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
8. K. Hoffman, R. Kunze, Linear Algebra, Prentice-Hall of India Pvt. Ltd., 1971.
9. D. C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
10. K. B. Dutta, Matrix and linear algebra.
11. Higher Algebra (Classical, Abstract& Linear), S. K. Mapa, Sarat Book House.
12. Higher Algebra, R K Ghosh & K C Maity, New Central Book Agency.
13. University Algebra: Gopala Krishnan, N.S, New Age International.
15. Linear Algebra-a Geometric Approach, S. Kumaresan.

First Year, Semester – 2, Course : Major -2
Paper Name: Real Analysis – 1 and Ordinary Differential Equation - 1
Paper Code: MATMAJ - 2
Full Marks: 100 (75=Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Program Objectives:

The objective of this course is :

- to learn the axiomatic definition of real number system, in particular, the completeness property, sequence of real numbers and their convergence.
- to understand the Cauchy's Limit Theorems and topology of the real number system.
- concept of sub sequential convergence, limit superior, limit inferior, different forms of completeness of real number system and their equivalence,
- Cauchy's general principle of convergence, absolute and conditional convergence of series of real numbers and related tests.
- to familiarize with the various methods of solving second order, higher order linear.
- to form mathematical model to solve the real problem.

Program Outcomes:

This course will enable the students to:

- understand many properties of the real line $\mathbb{R}$, including completeness and Archimedean properties.
- learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$.
- recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
- apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
- learn basics of differential equations and mathematical modeling.
- formulate differential equations for various mathematical models.
- solve first order non-linear differential equations and linear differential equations of higher order using various techniques.
- apply these techniques to solve and analyze various mathematical models.

Real Analysis - I (50 Hours)

Unit-1: Review of Algebraic and Order Properties of R, δ-neighborhood of a point set in R. Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of R. The Archimedean Property, Arithmetic continuum, Linear continuum. Density of Rational (and Irrational) numbers in R with special reference to well-ordering property. Limit points of set, isolated points, open sets, closed sets, Derived set, Union, Intersection, Complement of open and closed set in R. Closure of a set and interior of a set. The basic properties of closure of a set and interior of a set. Proof of Bolzano-Weierstrass theorem for sets.

(25 Hours)

Unit-2: Sequences, Bounded sequence, Limit of a sequence, Convergent sequence. Proof of Sandwich theorem and it's applications. Monotone Sequences, Monotone Convergence Theorem, Nested interval theorem. Subsequences, Divergence criteria, Monotone Subsequence Theorem, Proof of Bolzano Weierstrass Theorem for Sequences. Subsequential limit. limsup and liminf of a sequence. A sequence is convergent iff its upper and lower limits be equal. Cauchy sequence, Cauchy's Convergence Criterion. Cauchy's first and second Limit Theorems with applications.

(15 Hours)

Unit-3: Convergence and divergence of infinite series, Cauchy's criterion of convergence; Test for convergence of positive term series: comparison test, limit comparison test, D'Alembert's ratio test, Cauchy's n^{th} root test, Raabe's test, Logarithmic test. Alternating series, absolute and conditional convergence, Leibnitz test, Abel's and Dirichlet's test (Statement and applications). Rearrangement of series through examples.

(10 Hours)

References books:

1. Introduction to Real Analysis, Bartle&, Sherbert, Wiley..
2. Calculus (Vol. I), T. M. Apostol, Wiley India Pvt. Ltd
3. Undergraduate Analysis, S. Lang, Springer-Verlag, New York .1997.
4. Mathematical Analysis, S. C. Malik and Arora, New Age International.
5. An Introduction to Classical Analysis, Louis Brand, Dover.
6. A First Course in Real Analysis, S. K. Berberian, Springer.
7. Advanced Calculus, D. Widder , Dover.
8. Mathematical Analysis, Elias Zakon, Trillia Group, 2004.
9. Real Analysis, S.K. Mapa, Sarat Book House
10. Principles of Mathematical Analysis, Walter Rudin, McGraw Hill.
11. Mathematical Analysis, Shanti Narayan, S. Chand & Co.
12. Method of Real Analysis, R.R. Goldberg , Oxford & IBH Pub., 1970.

Ordinary Differential Equation - I (40 Hours)

Unit-1: Equation of first order and first degree: Picard's Existence theorem (statement only). Lipschitz condition. Separable, Homogeneous and Exact equations, Condition of exactness, Integrating factor, Rules of finding integrating factor. Equation reducible to linear equation (Bernoulli's equation).
Equation of first order but not of first degree: Clairaut's equation, Singular solution.
Applications: Geometric applications**,** Orthogonal trajectories.

(15 Hours)

Unit-2: Higher order linear equation with constant coefficients: Complementary Function, Particular Integral. Method of undetermined coefficients, Wronskian – It's properties and applications, Method of variation of parameters. Cauchy-Euler's homogeneous equation and Reduction to an equation with constant coefficients. Simple Eigen Value Problem.

(15 Hours)

Unit-3: Second order linear equations with variable coefficients: Reduction of order when one solution is known. Complete solution. Reduction to Normal form. Change of independent variable.
Simultaneous linear differential equations of the form $\frac{dx}{P}=\frac{dy}{Q}=\frac{dz}{R}$.
Total differential equations.

(10 Hours)

References Books:

1. Differential Equations, S.L. Ross , John Wiley & Sons, New York, 1980.
2. Differential Equations with Historical Notes, G. F. Simmons , McGraw Hill Education.
3. Linear Partial Differential Equations for Scientists and Engineers, TynMyint-U and Lokenath Debnath, Birkhäuser Boston.
4. Differential Equations with MATHEMATICA, Martha L Abell, James P Braselton, Elsevier.
5. Difference equations: An Introduction with Applications, Walter Kelley & Allan Peterson, Academic Press, 2000.
6. Fundamentals of Differential Equations, R. Kent Nagle, Edward B. Saff, Arthur David Snider, Pearson.
7. Introductory Course in Differential Equation, B.A. Murray, Orient Longman Limited, 1967.
8. An Introduction to Differential Equations, R. K . Ghosh & K. C. Maity, New Central Book Agency.

9. Ordinary and Partial differential Equation, Dr. M. D. Raisinghania , S. Chand Publishing.
10. Differential Equation, J.G. Chakravorty &P.R. Ghosh,(U.N. Dhar and Sons.
11. Differential Equation, G. F. Simmons , Tata McGraw Hill.

Second Year, Semester – 3, Course: Major – 3
Paper Name: Calculus and Boolean Algebra
Paper Code: MATMAJ - 3
Full Marks: 100 (75 =Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Program Objectives:

This course will help the students:

- to understand various notions of calculus, such as, standard functions and their graphs, techniques to find the limits and integrations.
- to calculate area and volume of a surface of revolution.
- to know the real life applications of calculus.
- for curve tracing.
- to understand the preliminary idea about Boolean algebra and its implementation to modern day computers.
- to understand, how to design the switching and logic circuits.

Program Outcomes:

The course will enable the students to:

- learn the basics of differential calculus.
- analyze the various types of the integrals that occurs in the fields of engineering and science.
- understand the relationships between quantities such as rates of changes, area, volume, properties of curves and their mathematical equivalents.
- understand about the relationship between the mathematics and computer science.

Calculus (45 Hours)

Unit -1:

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b} sinx$, $e^{ax+b} cosx$, $(ax+b)^n sinx, (ax+b)^n cosx$, concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

(23 Hours)

Unit -2:
Reduction formulae, derivations and illustrations of reduction formulae of the type
$sin^n x dx, \int \cos^n x\, dx, \int \tan^n x\, dx, \int \sec^n x\, dx, \int (logx)^n dx, \int \sin^n x sin^m x dx$, parametric equations, parameterizing a curve, arc length of a curve, arc length of parametric curves, area under a curve, area and volume of surface of revolution, techniques of sketching conics.

(22 Hours)

Boolean Algebra (45 Hours)

Unit -1:
Boolean Algebra: Huntington postulates for Boolean algebra, Algebra of sets and switching algebra as examples of Boolean Algebra, duality principle, Boolean functions, Normal forms, minimal and maximal forms of Boolean polynomials.

(25 Hours)

Unit- 2:
Karnaugh maps, Design of switching circuits, Logic gates, Half adder, Full Adder, Logic circuits.

(20 Hours)

Reference Books:

1. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
2. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), SpringerVerlag, New York, Inc., 1989.
3. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
4. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.
5. G.F.Simmons, Differential Equations, Tata Mcgraw Hill.
6. T. Apostol, Calculus, Volumes I and II.
7. S. Goldberg, Calculus and mathematical analysis.
8. B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.
9. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P. Ltd., Indian

Reprint 2003.
10. Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
11. J. G. Chakraborty and P. R. Ghosh, Advanced Higher Algebra, U. N. Dhur and Sons.

Second Year, Semester – 3, Course: Major – 4
Paper Name: Complex Analysis and Partial Differential Equation
Paper Code: MATMAJ - 4
Full Marks: 100 (50 =Written, 25=Practical, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Program Objectives:

Students will grasp the idea of complex functions, its derivatives and integrations. Also, in the practical classes, they will learn how to represent the complex numbers, to find the line integrals, contour integration, plotting of complex functions etc by using mathematical software.

From the second part of the course, the students will learn to formulate, classify and transform the first order PDEs into canonical forms. They will also learn about the method of characteristics and separation of variables to solve the first and second order linear PDEs. Through practical classes, the students will get the idea of integral surfaces, solution of wave equation, heat equation and Laplace's equation.

Program Outcomes:

After studying this course, the student will be able to:

- understand the analytic function as a mapping on the plane,
- grasp the idea of Mobius transformation,
- understand the Cauchy's theorem and integral formula on open subsets of the plane,
- understand how to count the number of zeros of analytic functions,
- know about the kind of singularities of meromorphic functions,
- formulate, classify and transform the first order PDEs into canonical form,
- learn about method of characteristics and separation of variables
- solve and classify the first and second order PDEs.

Complex Analysis (45 Hours)

Unit -1:

Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Milne's method.

(12 Hours)

Unit-2:

Analytic functions, examples of analytic functions, derivatives of functions, definite integrals of functions. Contours, Contour integrals and its examples, Cauchy integral formula, consequences of Cauchy integral formula. Taylor series, Power series representation of analytic functions, Zeroes of an analytic function.

(10 Hours)

Unit-3:

Cauchy's theorem and integral formula, Classification of singularities, Laurent series, Residues, Cauchy Residue theorem, Contour integration.

(8 Hours)

Unit-4: List of Practical (Using any Software)

(i) Declaring a complex number e.g. $z_1 = 3 + 4i, z_2 = 4 - 7i$ Discussing their algebra $z_1 + z_2, z_1 - z_2,\ z_1 * z_2 and \frac{z_1}{z_2}$and then plotting them.
(ii) Finding conjugate, modulus and phase angle of an array of complex numbers.
(iii) Compute the integral over a straight line path between the two specified end points e.g.,$\int f(z)dzc$ where C is the straight line path from $a\ +\ ib\ to\ c\ +\ id$.
(iv) Perform contour integration e.g. $f(z)dz$ where C is the contour given by $g(x, y)\ = 0$.
(v) Plotting of the complex functions like $f\ (z) = z\bar{z}, f\ (z) =\ z_3, f\ (z) = (z_4 - 1)$etc.
(vi) Finding the residues of the complex function.

(15 Hours)

Partial Differential Equation (45 Hours)

Unit-1:

Partial Differential Equations – Basic concepts, definitions, formations, Geometrical Interpretation. First order Partial Differential Equations: Classification, Construction and. Solution by Lagrange's method, Charpit's method. Method of Characteristics for obtaining General Solution of Quasi Linear Equations, Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.

(15 Hours)

Unit-2:

Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order Linear Equations to canonical forms. Solution of linear partial differential equations with constant coefficients.

(15 Hours)

Unit-3: List of Practical (Using any Software)

1. Plotting of a 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. Plotting of a solution of wave equation for different initial and boundary conditions.
5. Plotting of a solution of heat equation for different initial and boundary conditions.
6. Plotting of a solution of Laplace's equation for different initial and boundary conditions.

(15 Hours)

References books:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.

2. Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

3. L.V. Ahlfors, Complex Analysis, McGraw Hill Book Company, 1966.

4. J.B. Conway, Functions of Complex Variable I, Springer Verlag, New York Inc, 1978.

5. Murray R. Spiegel, Complex Variables, Schaum's Outline Series, New York, 1964.

6. Reinhold Remmert, Theory of Complex Functions, Springer Verlag, 1991.

7. Walter Rudin, Real and Complex Analysis, McGraw Hill, New York, 1997.

8. George E. Shilov, Elementary Real and Complex Analysis, The MIT Press, Massachusetts, 1973. 9. Dennis G. Zill and Patrick D. Shanahan, A First Course in Complex Analysis wit Applications, Jones & Bartlett, India, 2010.

10. James W. Brown and R.V. Churchill, Complex Variables and Applications, 8th Ed., McGrawHill International Edition, 2009.

11. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th Ed., Springer, Indian reprint, 2006.

12. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.

13. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.

14. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.

15. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co.

16. Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley.

17. G. F. Simmons, Differential Equations, Tata McGraw Hill

Second Year, Semester – 4, Course: Major – 5
Paper Name: Dynamics of a Particle and Group Theory
Paper Code: MATMAJ - 5
Full Marks: 100 (75 =Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Program Objectives: In this course of study, students grab the basic knowledge of the behaviour of objects in motion. Motion in a straight line, expressions of velocity and acceleration in different coordinate systems, central orbit, motion of a particle with varying mass and particle motion in a resisting medium are the key topics of this course. Also, the course aims to provide the students with a comprehensive understanding of the fundamental concepts of Group theory, including the definition of group, subgroup properties, and various group operations. Exploring advanced group concepts, students will delve into advanced topics such as cyclic groups, normal subgroups, quotient groups, homomorphisms, and Isomorphisms, enabling them to grasp the deeper structures and properties of abstract algebraic systems. By studying abstract algebraic structures and theorems, students will develop problem-solving skills and gain the ability to apply algebraic concepts in various mathematical contexts, laying a solid foundation for further study in mathematics and related fields.

Program Outcomes:

Student will able to find the acceleration, force and equation of motion in various situations like simple harmonic motion, resisting medium and when the particle is moving in a plane. They will also know the equation of central orbit, planetary motion and its implementation in various problems. They will able to do solve practical problems for the case of the artificial satellites, on falling raindrop, projected rockets and varying mass.

After completion of this course, the students will able to know about the algebraic structure on sets, relations and mapping. They will be capable of to identify the symmetric structures of different shape and formation of group structures and to find the generator of cycle group, the order of element of a finite group and factor group. They will be able to identify the properties of homomorphism and isomorphism.

Dynamics of a Particle (45 Hours)

Unit-1 **(10 Hours)**

Motion in straight line under variable acceleration. Simple Harmonic Motion. Hooke's law. Problems on elastic string. Expressions for velocity and acceleration of a particle moving on a plane in Cartesian and Polar coordinates. Motion of a particle moving on a plane with reference to a set of rotating axes.

Unit-2: **(27 Hours)**

Central forces and central orbit. Tangential and normal accelerations. Circular motion. Simple cases of constrained motion of a particle. Motion of a particle in a plane under different laws of resistance. Motion of a projectile in a resisting medium.

Trajectories in a resisting medium where resistance varies as some integral power of velocity. Terminal velocity. Motion under the inverse square law in a plane.

Kepler's law and planetary motion. Escape velocity, time of describing an arc of an orbit, motion of artificial satellites.

Unit- 3 **(8 Hours)**

Equation of motion of a particle of varying mass. Problems of motion of varying mass such as those of falling raindrops and projected rockets.

Group Theory (45 Hours)

Unit-1: **(10 Hours)**

Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups. Subgroups and examples of subgroups, centralizer, normaliser, centre of a group, product of two subgroups.

Unit-2: (13 Hours)

Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

Unit-3: (10 Hours)

External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

Unit-4: (12 Hours)

Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of Isomorphisms, First, Second and Third Isomorphism theorems.

Reference Books:

1. S.L.Loney, Dynamics of a Particle and of Rigid Bodies, Cambridge University Press, Indian Edition-Raddha Publishing House.

2. J.G.Chakravorty and P.R.Ghosh, Advanced Analytical Dynamics, U.N.Dhur and Sons.

3. S.Ganguly and S.Saha, Analytical Dynamics of a Particle, New Central Book Agency.

4. N.Datta and R.N.Jana, Dynamics of a Particle, Shreedhar Prakashani

5. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

6. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

7. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.

8. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.

9. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

10. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract

algebra.

Second Year, Semester – 4, Course: Major – 6
Paper Name: Analytical Geometry in Two Dimensions and Three Dimensions
Paper Code: MATMAJ - 6
Full Marks: 100 (75 =Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Programme Objectives:

From this course, the students will grasp the idea of different coordinate systems like Cartesian system, Polar system, Spherical system and Cylindrical system. The students will learn the concepts of the point, straight line, planes, different types of plane curve like circle, parabola, hyperbola and ellipse etc and some of the three dimensional standard shapes such as ellipsoid, paraboloid and hyperboloid.

Programme Outcomes:

Students will able to grip the idea of various coordinate systems. They will able to identify the equation of straight line, plane, circle, sphere, parabola, hyperbola, and ellipse. Also, they will be able to find the shortest distance between two skew lines, length of a point from a line and from a plane. Students will be capable of T to check the coplanarity of two skew lines and to check the parallelism of two planes. They will be familiar with the shape of some standard three dimensional shapes like ellipsoid, paraboloid and hyperboloid and be able to find the equation of tangent line, normal and enveloping cone.

Analytical Geometry in Two dimensions (40 Hours)

Unit-1: (10 Hours)
Transformation of Rectangular axes: Translation, Rotation and their combinations. Theory of Invariants. General Equation of second degree in two variables: Reduction into canonical form. Classification of conic.

Unit-2: (10 Hours)
Pair of straight lines: Condition that the general equation of second degree in two variable may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Angle bisector. Equation of two lines joining the origin to the points in which a line meets a conic.

Unit-3: (10 Hours)
Circle, Parabola, ellipse and Hyperbola: Equation of pairs of tangents from an

external point, chord of contact, poles and polars, conjugate points and conjugate lines.

Unit-4: **(10 Hours)**
Polar equation of straight lines and circles. Polar equation of a conic referred to a focus as pole. Equation of tangents, normal, chord of contact.

Analytical Geometry in Three dimensions (50 Hours)

Unit-1: **(10 Hours)**
Rectangular Cartesian co-ordinates in space. Halves and Octants. Concept of a geometric vector (directed line segment). Projection of a vector on a co-ordinate axis. Inclination of a vector with an axis. Co-ordinates of a vector. Direction cosines of a Vector. Distance between two points. Division of a directed line segment in a given ratio.

Unit-2: **(12 Hours)**
Equation of Plane. General form, Intercept and Normal form. Equation of a plane passing through the intersection of two planes. Angle between two intersecting planes. Bisectors of angles between two intersecting planes. Parallelism and perpendicularity of two planes.

Unit-3: **(12 Hours)**
Straight lines in space: Equation (Symmetric & Parametric form). Direction ratio and Direction cosines. Canonical equation of the line of intersection of two intersecting planes. Angle between two lines. Distance of a point from a line. Condition of co-planarity of two lines. Equations of skew-lines. Shortest distance between two skew lines.

Unit-4: **(16 Hours)**
Transformation of rectangular axes by translation, rotation and their combinations. General equation of second degree in three variables: Reduction to canonical forms. Classification of Quadrics. Ellipsoid, Hyperboloid, Paraboloid: Canonical equation and the study of their shape. Tangent planes, Normal, Enveloping cone. Generating lines of hyperboloid of one sheet and hyperbolic paraboloid.

Reference Books:

1. S.L. Loney, Co-ordinate Geometry.
2. J.T. Bell Dimensions, Co-ordinate Geometry of Three.
3. C. smith, Elementary Treatise on Conic Sections.

4. C. Smith, Solid Analytical.
5. Chakravorty, J.G. & Ghosh, P.R., Advanced Analytical Geometry.
6. N. Datta & R. N. Jana, Analytical Geometry and Vector Algebra.
7. Das, A. N., Analytical Geometry of two and three dimensions.
8. R. M. Khan, Analytical Geometry of two and three dimensions & Vector analysis.

Third Year, Semester – 5, Course: Major – 7
Paper Name: Linear Programming Problem and Theory of Games
Paper Code: MATMAJ - 7
Full Marks: 100 (75 =Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Programme Objectives:

In this course, the students will learn about various optimization techniques pertaining to linear programming and apply it to problems arising from the real life. Also, the students will learn the basic concepts of game theory through a problem solving approach.

Programme Outcomes:

This course will enable the students to

- find the graphical solution of linear programming problems with two variables,
- understand the relation between basic feasible solutions and extreme points,
- utilize the simplex method, two-phase method and Big-M method for solving linear programming problems,
- understand the relationship between the primal and dual problems,
- comprehend the theory of games.
- solve the two-person zero sum game , games with mixed strategies etc.

Linear Programming Problem (60 Hours)

Unit-1: (20 Hours)

Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two phase method. Big-M method and their comparison.

Unit-2: (15 Hours)

Duality, formulation of the dual problem, primal dual relationships, economic interpretation of the dual.

Unit-3: **(25 Hours)**
Transportation problem and its mathematical formulation, northwest corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem, Travelling salesman problem.

Theory of Games (30 Hours)

Concept of game problem. formulation of two person's zero-sum game, solving two-person zero sum game, games with mixed strategies, graphical solution procedure, dominance property, linear programming solution of games.

Reference Books:

1. Suresh Chandra, Jayadeva, Aparna Mehra, Numerical optimization with applications, Alpha Science.
2. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
3. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.
4. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
5. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Third Year, Semester – 5, Course: Major – 8
Paper Name: Real Analysis-2 and Ordinary differential Equation-2
Paper Code: MATMAJ - 8
Full Marks: 100 (50 =Written, 25 = Practical, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Programme Objectives:
Students will be able to grasp the various aspects of real functions like existence

and importance of limits of functions at a certain point of the domain, continuity and differentiability of real functions. Mean Value Theorems of various forms of remainder and its applications are discussed in this course. Also, the course aims to introduce some advance concepts of ODE to individuals from all academic backgrounds. Participants will develop better understanding to solve differential equations, their implications, and their potential applications in various fields. The course will emphasize practical examples and real-world case studies to facilitate comprehension and inspire innovative thinking. Also, the students will learn various aspects of real analysis and ordinary differential equation through practical point of view using some mathematical software.

Programme Outcomes:

This course will enable the students to:

- have a rigorous understanding of the concept of limit of a function, continuity and uniform continuity of functions defined on some intervals,
- understand the geometrical properties of continuous functions on closed and bounded intervals,
- know about the concept of differentiability using limits, leading to a better understanding for applications,
- grasp the idea of mean value theorems and Taylor's theorem with different forms of remainder,
- understand the Sturm−Liouville problem and their solutions,
- undertake any advanced course on ordinary differential equations.
- understand the various aspects of real analysis and ordinary differential equation through practical classes by using some mathematical software.

Real Analysis - 2 (50 Hours)

Unit-1: **(10 Hours)**

Limits of functions $(\varepsilon - \delta)$ approach, sequential criterion for limits, divergence criteria. Limit theorems, one sided limit. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity, Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, theorems on uniform continuity.

Unit-2: **(10 Hours)**

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions, Relative extrema, interior extremum theorem. Rolle 's Theorem, Mean value theorem, intermediate value property of derivatives, Darboux's theorem, Applications of mean value theorem to inequalities and approximation of polynomials.

Unit-3: **(10 Hours)**
Cauchy's mean value theorem, Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema, Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\log(1+x)$, $\frac{1}{ax+b}$, $(x+1)^n$. Application of Taylor's theorem to inequalities.

Unit-4: **(5 Hours)**
Functions of bounded variation, Variation function, Positive variation, negative variation.

Unit-5: Practical (Using any Software) **(15 Hours)**
1. Plotting of recursive sequences.

2. Study the convergence of sequences through plotting.

3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequence from the plot.

4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.

5. Cauchy's root test by plotting n^{th} roots.

6. Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

Ordinary Differential equations-2 (40 Hours)

Unit-1: **(5 Hours)**
Existence and Uniqueness theorem and related problems.

Unit-2: **(5 Hours)**
Homogeneous linear systems with constant coefficients, The matrix method for homogeneous linear systems with constant coefficients: 2 equations in 2 unknown functions, n equations in n unknown functions.

Unit-3: **(5 Hours)**
Power series solution of second order homogeneous ODE, ordinary points,

singular points, Frobenius series solution, Legendre and Bessel's equation through examples

Unit-4: **(10 Hours)**
Definition, Construction of Green's function for an important special case, Linear integral equations in cause and effect, The influence function, Applications of Green's function, Self-adjoint form, Sturm-Liouville problem and its applications.

Unit-5: Practical (Using any Software) **(15 Hours)**
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).
8. Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two prey one predator).
9. Epidemic model of influenza (basic epidemic model, contagious for life, disease carriers).
10. Battle model (basic battle model, jungle warfare, long range weapons).

Reference Books:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
2. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones& Bartlett.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall.
4. S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York.
5. T. Apostol, Mathematical Analysis, Narosa Publishing House.
6. Courant and John, Introduction to Calculus and Analysis, Vol I, Springer.
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
8. V. Karunakaran, Real Analysis, Pearson.
9. Terence, Tao, Analysis I, Hindustan Book Agency.
10. S. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing.

11. Simmons, G. F., “Differential Equations”, McGraw-Hill, 2nd Edition 1991.
12. Hildebrand F. B., "Methods of Applied Mathematics", Courier Dover Publications 1992.
13. Tenenbaum, M. and Polard, H., “Ordinary Differential Equations”, Dover Publications 1985.
14. Sneddon, I. N., “Elements of Partial Differential Equations”, McGraw-Hill Book Company 1988.
15. Rao, K. S., “Introduction to Partial Differential Equations", PHI Learning Pvt. Ltd. (2nd Edition) 2010.
16. Amarnath, T., “An Elementary Course in Partial Differential Equations”, Narosa Publishing House (2nd Edition) 2012.

Third Year, Semester – 5, Course: Major – 9
Paper Name: Metric Spaces and Ring Theory
Paper Code: MATMAJ - 9
Full Marks: 100 (75 =Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Programme Objectives:

Introduction of Ring theory should be the next step when the concepts of group theory have been built up. Thus, the basics as well as the advanced concepts of Ring theory and Metric spaces have been introduced in this course.

Programme Outcomes:

The course will enable the students to:

- learn various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces,
- analyze how a theory advances from a particular frame to a general frame,
- appreciate the mathematical understanding of various geometrical concepts, viz. balls or connected sets etc. in an abstract setting,
- know about Banach fixed point theorem, whose far-reaching consequences have resulted into an independent branch of study in analysis, known as fixed point theory,
- learn about the two important topological properties, namely connectedness and its basic properties,
- understand the fundamental concept of rings, integral domains and fields,
- grip the idea of ring homomorphism and isomorphism theorems of rings,
- appreciate the significance of unique factorization in rings and integral

domains and identification & construct the examples of fields.

Metric Spaces (45 Hours)

Unit-1: **(15 Hours)**
Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set.

Unit-2: **(10 Hours)**
Sequences in metric spaces, Cauchy sequences. Complete metric spaces, Cantor's intersection theorem (statement only), subspaces, dense sets.

Unit-3: **(10 Hours)**
Continuous mappings, sequential criterion, and other characterizations of continuity. Uniform continuity, Connectedness in metric space and its basic properties.

Unit-4: **(10 Hours)**
Cover, Lindelof Space, Compact Spaces, Compactness and Total boundedness.

Ring Theory (45 Hours)

Unit-1: **(20 Hours)**
Ring theory: Definition and examples of rings, properties of rings, sub rings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, prime and maximal ideals, ring isomorphism (Statement only)

Unit-2: **(25 Hours)**
Fields, Sub Fields, Polynomial Rings, Euclidean Domains, Prime and Irreducible elements, Unique Factorization Domains, Factorization of Polynomials over a UFD.

Reference Books:

1. Satish Shirali and Harikishan L. Vasudeva, *Metric Spaces,* Springer, 2009.
2. S. Kumaresan, *Topology of Metric Spaces,* 2nd Ed., Narosa Publishing House, 2011.
3. G.F. Simmons, *Introduction to Topology and Modern Analysis,* McGraw-Hill, 2004.
4. P.K.Jain, K.Ahmad, *Metric Spaces,* Narosa, 3rd Edition, 2019.

5. Mícheál O'Searcoid, *Metric Spaces,* Springer, 2008.
6. Bhattacharya P.B.,Jain S.K. and Hagpaul S.R., Basic Abstract Algebra Cambridge University Press, Second Edition.
7. D.S. Dummit and R.M. Foote, Abstract Algebra, John Wiley & Sons Inc., 3rd Ed., 2004.
8. W.W. Peterson and E.J. Weldon, Jr., Error-Correcting Codes. M.I.T. Press, Cambridge, Massachusetts, 1972.
9. S. Lang, Algebra, Springer (India) Pvt. Ltd., 2010
10. R. Lidl and H. Niederreiter, Introduction to Finite Fields and their Applications, Cambridge University Press, 1994.
11. Khanna, V.K., Bhambri, S.K., A Course in Abstract Algebra, 4th Edition, Vikas Publishing House Pvt. Ltd., 2013.
12. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
13. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
14. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.

Third Year, Semester – 6, Course: Major – 10
Paper Name: Probability and Logic & Sets
Paper Code: MATMAJ - 10
Full Marks: 100 (75 =Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Programme Objectives:

In this course the students will know about the basic concepts of probability, application of Bayes theorem, various probability functions and their applications in practical fields. Also, the students will learn the probability distribution functions (PDF), PDF of various distributions, expectation, Standard Deviation, Variance, Covariance, Moment, Moment Generating Function, law of large numbers, Central limit theorem, Convergence in probability, Markov chain and transition matrix. Also, in this course, mathematical logic and set theory has been discussed.

Programme Outcomes:

Students will able to learn the practical knowledge about probability and to estimate the probability of uncertain event. They will also able to find the Standard Deviation, Variance and Covariance between two variables, and to calculate the expectation and moment of random variable. The students can find the expression for characteristic function of a random variable and verify its properties. Applying stochastic process, they can solve the transition probability matrix. Also, the students will understand the basics of mathematical logic and set theory. They will learn about the truth table, different propositions, predicate, quantifiers, various operations between two sets and logical equivalences from this course.

Probability (65 Hours)

Unit-1: **(24 Hours)**
Random experiment, Sample space, probability as a set function, probability axioms, probability space. Finite sample spaces. Conditional probability, Bayes theorem, Real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, skewness, kurtosis, moment generating function, characteristic function. Discrete distributions uniform, binomial, Poisson, geometric, negative binomial, Continuous distributions : uniform, normal, exponential.

Unit-2: **(21 Hours)**
Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, moments, covariance, correlation coefficient, independent random variables, Conditional expectations, linear regression for two variables, regression curves.

Unit-3: **(10 Hours)**
Markov and Chebyshev's inequality, Convergence in Probability, statement and interpretation of weak law of large numbers and strong law of large numbers. Central limit theorem for independent and identically distributed random variables with finite variance.

Unit-4: **(10 Hours)**
Stochastic variable and stochastic process. Markov chain, Transition Probability Matrix, Communicating classes, Persistent and transient states. Closed set of States, Decompossible or reducible State, Closure of a set of States

Logic & Sets (25 Hours)

Unit-1: **(12 Hours)**
Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, bi-conditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence:

Logical equivalences. Predicates and quantifiers: Introduction, quantifiers, binding variables and negations.

Unit-2: **(7 Hours)**
Sets, subsets, set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Unit-3: **(6 Hours)**
Difference and Symmetric difference of two sets. Set identities, generalized union and intersections. Relation: Product set. Composition of relations, types of relations, partitions, equivalence Relations with example of congruence modulo relation. Partial ordering relations, n-ary relations.

Reference Books:

1. S.C. Gupta and V.K. Kapoor, Fundamental of Mathematical Statistics.
2. A. Muhkerjee, Probability and Statistics.
3. William Feller, An introduction to Probability Theory and its Application, Volume 1,
4. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
5. Alexander M. Mood, Franklin A. Gray bill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007
6. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007
7. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.
8. A.M. Goon, M.K.Gupta and B.Dasgupta, Fundamental of Statistics, Vol 1 & Vol 2, World Press.
9. A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers
10. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
11. P.R. Halmos, Naive Set Theory, Springer, 1974.
12. E. Kamke, Theory of Sets, Dover Publishers, 1950.
13. D. Chakraborty, N. acharya and S.K. Bhandary Mathematical Logic and Set Theory.

Third Year, Semester – 6, Course: Major – 11
Paper Name: Statistics

Paper Code: MATMAJ - 11

Full Marks: 100 (50 =Written, 25 = Practical, 10 = Project, 10 = Internal, 5 = Attendance)

Total Credit: 6, Total Hours: 90

Programme Objectives:

In this course, the students will know about the basic concepts of statistics and its applications. Also, they will know the statistics distribution, estimation of parameter of population, the concepts of scatter diagram, principle of least regression coefficients, Maximum Likelihood Estimation, Hypothesis etc. The students will learn how to solve the practical problems in real life using mathematical statistics.

Programme Outcomes:

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

- understand the concept of population, sampling theory and sampling design by applying different sampling methods,
- analyze the data using mathematical software,
- gain knowledge in the descriptive statistics,
- know the components and need for time series,
- understand the correlation between the two variables, line fitting, estimation of different population parameter and testing of hypothesis.

Statistics (90 Hours with Practical)

Unit-1: **(15 Hours)**

Random sample. Concept of sampling and various types of sampling. Sample and Population. Collection, tabulation and graphical representation. Grouping of data, sample characteristics and their computations. Sampling distribution of a statistic. Estimates of a population characteristics or parameter. Unbiased and consistent estimates. Sample characteristics as estimates of the corresponding population characteristics. Sampling distribution of the sample mean and variance, Exact sampling distributions for normal populations.

Unit-2: **(15 Hours)**

Bivariate data, Scattered diagram, Principle of least squares, fitting of straight line, quadratic and power curves. Concept of correlation, computation of Karl-Pearson correlation coefficient for grouped and ungrouped data and its properties. Correlation ratio, Spearman's rank correlation coefficient and its properties. Simple linear regression, correlation verses regression, properties of regression coefficients.

Unit-3: **(10 Hours)**
Estimation of parameters. Method of Maximum likelihood. Application to binomial, Poisson and normal populations. Interval estimation of parameters for normal population.

Unit-4: **(10 Hours)**
Statistical hypothesis. Simple and composite hypothesis, Best Critical region of a test, two types of errors, Level of significance and Power of a test. One and two tailed tests, test function (non randomized and randomized). Statement of Neyman-Pearson's fundamental theorem and its application to normal population. Likely hood ratio testing and its application to normal population. Simple application of hypothesis testing.

Unit-5: **(10 Hours)**
Definition and component of time series, illustrations, additive, multiplicative and mixed model, analysis of times series, method of studying times series, method of moving averages, least square method.

List of Practical: (Using any software) **(30 Hours)**

1. Data Visualization - Frequency polygons and curves, Ogives, Histogram.
2. Data Visualization - Bar diagrams (simple, compound, percentage and multiple) and Pie diagram (single and multiple).
3. Computation of Descriptive Statistics (Measures of Central tendencies and Dispersion, Moments, Skewness and Kurtosis).
4. Computation of expected frequencies for Binomial, Poisson, Normal and Exponential distributions.
5. Computation of Karl Pearson's coefficient of correlation and rank correlation.
6. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit.
7. Large sample tests: Testing population means, proportions, variances based on single and two samples and tests based on Chi- distribution.
8. Fitting of regression line, parabola, curves by least square method.
9. Analysis of Variance of a one way classified data.
10. Analysis of Covariance of a one way classified data.
11. t-test for difference of means.
12. Time series Analysis: Computation of Secular trend by least squares and moving averages methods.
13. Testing population means, proportions, variances based on single and two samples.

Reference Books:

1. E-Book : https://onlinelibrary.wiley.com/doi/book/10.1002/9781118391686
2. V.K.Kapoor and S.C.Gupta : Fundamentals of Applied Statistics. Sultan Chand
3. Multivariate Analysis by Johnson and Wrichon
4. Pratirupa Sidhanthamulu – Telugu Academy, 4. Prayoga Rachana and Visleshana – Telugu Academy.
5. Parimal Mukhopadhyay : Applied Statistics . New Central Book agency.
6. M.R.Saluja : Indian Official Statistics. ISI publications.
7. B.L.Agarwal: Basic Statistics.New Age publications.
8. S.P.Gupta : Statistical Methods. Sultan Chand and Sons.
9. Gun, A M, Gupta, M K and Dasgupta, B, Fundamentals of Statistics (Volume One), World Press Private Ltd.
10. Gupta, S C and Kapoor, V K, Fundamentals of Mathematical Statistics, S Chand & Sons.
11. Das, N G, Statistical Methods, Combined edition: volume 1 & 2, McGraw Hill Education.
12. Bhattacharya, D and Roychowdhury, S, Statistics – Theory and Practice, U N Dhar Publications.
13. Mukherjee, A, Fundamental Treatise On Probability And Statistics, Shreetara Prakashani.
14. Kendall, M G and Stuart, A, Advanced Theory of Statistics, John Wiley & Sons Inc.
15. Gupta, S C, Fundamentals of Statistics, Himalaya Publishing House

Third Year, Semester – 6, Course: Major – 12
Paper Name: Multivariable Calculus and Vector Analysis
Paper Code: MATMAJ - 12
Full Marks: 100 (75 =Written, 10 = Project, 10 = Internal, 5 = Attendance)
Total Credit: 6, Total Hours: 90

Programme Objectives:

The aim of this course is to provide the fundamental concepts and techniques of multivariable calculus and vector analysis to the students. Also, the students will develop the understanding and skills of the subjects in such a way that they will be able to apply it to solve various types of problems in different branches of Mathematics.

Programme Outcomes:

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

- handle the mathematical formulae and methods of derivation of multivariable functions,
- state the integration techniques to calculate multiple integrals in different coordinate systems,
- perform differential calculus operations on functions of several variables including continuity, partial derivatives and directional derivatives,
- estimate multiple integrals in different coordinate systems including Cartesian, polar, cylindrical and spherical coordinates.
- perform calculus operations on vector-valued functions.
- use some most important theorems of vector calculus, such as the fundamental theorem of line Integrals, Green's theorem, the Divergence theorem and Stokes' theorem to simplify integration problems.

Multivariable Calculus and Vector Analysis (90 Hours)

Unit-1: **(20 Hours)**

Point set , open balls, open sets, closed set in R^2. Function of several variables, limit and continuity of functions of two or more variables, Partial differentiation, total differentiability, sufficient condition for differentiability. Homogeneous function, Euler's Theorem. Schwarz's Theorem and Young's Theorem.

Unit-2: **(25 Hours)**

Jacobians and their important properties. Implicit function, statement of Existence Theorem and its application in Two functional equation $F(x, y, u, v) = 0$ and $G(x, y, u, v) = 0$, to solve for u and v in term of x and y. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes. Statement and proof of Taylor's theorem for a function of Two variables. Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems.

Unit-3: **(20 Hours)**

Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals.

Unit-4: **(25 Hours)**

Definition of vector field, gradient, divergence and curl. Line integrals, applications of line integrals: mass and work. Fundamental theorem for line integrals, conservative vector fields, independence of path, Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stokes's theorem, The Divergence theorem and their application.

Reference Books:

1. S.C. Mallik and S. Arora, Mathematical Analysis, New Age International Limited, New Delhi.
2. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
3. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
4. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
5. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.
6. T. Apostol, Mathematical Analysis, Narosa Publishing House.
7. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer.
8. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
9. Marsden, J., and Tromba, Vector Calculus, McGraw Hill.
10. Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
11. Terence Tao, Analysis II, Hindustan Book Agency, 2006.
12. M.R. Speigel, Schaum's outline of Vector Analysis.