BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. MATHEMATICS **CLASS:** F.Y.B.Sc. **SEM:** I
COURSE NAME: CALCULUS I **COURSE CODE:** USMT101 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 2)
The objective of this course is to teach the learner basic concepts of Calculus with rigour

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
Unit 1: Real Number System						
I	Real Number System: Order properties of R, Absolute value and its properties	To understand basic composition of set of real numbers and to give clarity about its properties like order relation and related concepts, use of absolute value.	Chalk & Talk	Learner becomes confident about handling real numbers.	S.S.CHOKHANI	5
	Intervals & neighbourhoods. AM-GM inequality, Cauchy-Schwartz Inequality,Intervals and neighbourhoods, Hausdorff Property	Exposure to most useful inequlities in Mathematics, Structure and separatedness of real numbers, intervals & nbds. Explained.	Chalk & Talk	Learner able to see use of inequalities and Hausdorff property in context of more general structures like R^2	S.S.CHOKHANI	5
	Bounded Sets, Statements of LUB Axiom & its consequences, Supremumn & Infimum, Maximum & Minimum, Archimedean property and its applications, density of rationals.	To learn about boundedness and strucue of set real numbers	Chalk & Talk	Density theorem gives total clarity about the way RATIONAL AND RATIONAL NUMBERS OCCUR IN REAL NUMBER SYSTEM	S.S.CHOKHANI	5
Unit 3:Limits & Continuity						
	Graphs of some	To familiarize	Chalk &	Learner able to	S.S.CHOKHANI	5

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	standard functions such as IxI,e^x,ax^2+bx+c,1/x,x^n, Sin x, Cos x, tan x,Sin(1/x),x^2Sin(1/x) over suitable intervals of R.	learner with different behaviour of graphs of functions	Talk	visualize behaviour of many basic functions as listed here		
	Definition of Limit lim f(x) x→a of a function f(x), evaluation of limit of simple functions using the definition, uniqueness of limit if it exists, algebra of limits, limits of composite function, sandwich theorem, left-hand-limit lim x→a- f(x), right-hand-limit lim x→a+ , non-existence of limits, lim f(x) x→∞, lim f(x) x→-∞	To give learner proper basics of limits	Chalk & Talk	Learner here uses all results, intervals, neighbourhood and inequalities here and uses them to analyze limits rigorously.	S.S.CHOKHANI	5
	Continuous functions: Continuity of a real valued function on a set in terms of limits, examples, Continuity of a real valued function at end points of domain, Sequential continuity, Algebra of continuous functions, discontinuous functions, examples of removable and essential discontinuity.	To give learner proper basics of continuity	Chalk & Talk	Concepts of limits is effectively used along with other results to understand basics of Continuous functions, which is immensely useful in Mathematics.	S.S.CHOKHANI	5
II	**SEQUENCE:** Definition of a sequence and examples, Convergence of	To understand the definition of sequence , To understand the definition of convergent sequence	Chalk n Talk	Learners are able to determine convergence and divergence of sequence	Seeta Vishwakarma	5

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	sequences, every convergent sequences is bounded. Limit of a convergent sequence and uniqueness of limit, Divergent sequences.	in terms of $\epsilon - n_0$. To understand the definition of divergent sequence in terms of $\epsilon - n_0$.		Learners are able to prove that sequence is convergent to its limit or divergent by $\epsilon - n_0$ definition.		
5	Convergence of standard sequences like $\left(\frac{1}{1+na}\right), \forall a > 0$ $(b)^n, \forall b, 0 < b < 1.$ $\left(c^{\frac{1}{n}}\right), \forall c, c > 0$ $\left(n^{\frac{1}{n}}\right)$	To learn the convergence of standard sequences which is often used at various stage while solving many maths problems	Chalk n Talk	Learners are able to solve problems involving such sequences.	Seeta Vishwakarma	5
	Algebra of convergent sequences, sandwich theorem, monotone sequences, monotone convergence theorem and consequences as convergence of $\left(1+\frac{1}{n}\right)^n$ Definition of subsequence, subsequence of a convergent sequence is convergent and converges to the same limit, definition of a Cauchy sequences, every convergent sequences is a Cauchy sequence and converse.	To learn that if two sequence are convergent then their sum,product and quotient(provided sequence in denominator is non zero) is also convergent. To learn that if sequence is monotonically increasing/decreasing and bounded then it is convergent and using this useful result proving that sequence $\left(1+\frac{1}{n}\right)^n \to e$ To learn that subsequence of convergent sequence converge to same limit. To learn that every	Chalk n Talk	Learners are able to find limit of standard sequences and use it to solve many problems involving such sequences.	Seeta VIshwakarma	5

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		Cauchy sequence in $\mathbb{R}$ is convergent in $\mathbb{R}$				

BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. MATHEMATICS **CLASS:** F.Y.B.Sc. **SEM:** II
COURSE NAME: CALCULUS II **COURSE CODE:** USMT201 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 2)
The objective of this course is to teach the learner basic concepts of Calculus with rigour

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
UNIT - II: Continuity and differentiability of functions						
	Continuous function: Continuity of a real valued function on a set in terms of limits,	To digress continuity and give further exposure to continuity	Chalk & Talk	Learner able to understand and appreciate the utility of	S.S.CHOKHANI	5

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	examples, Continuity of a real valued function at end points of domain,Sequential continuity, Algebra of continuous functions, Discontinuous functions ,examples of removable and essential discontinuity.	which is used in further study of subject		continuity in showing existence of solutions of equations and also find approximate solution in many cases.		
	Intermediate Value theorem and its applications, Bolzano-Weierstrass theorem (statement only): A continuous function on a closed and bounded interval is bounded and attains its bounds. Di_erentiation of real valued function of one variable: De_nition of di_erentiation a point of an open interval, examples of di_erentiable and non di_erentiable functions, di_erentiable functions are continuous but not conversely, algebra of di_erentiable functions.		Chalk & Talk	Learner able to understand idea behind differentiability and use it for later results.	S.S.CHOKHANI	5
	Chain rule, Higher order derivatives, Leibnitz rule, Derivative of inverse functions, Implicit dif-ferentiation (only examples)	To introduce methods of computing derivatives and higher order derivatives.	Chalk & Talk	Learner able to find higher order derivatives of functions in various situations.	S.S.CHOKHANI	5
UNIT - III: Applications of differentiation						
	Definition of local	To introduce	Chalk &	Learner able to	S.S.CHOKHANI	5

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	maximum and local minimum, necessary condition, stationary points, second derivative test, examples, Graphing of functions using first and second derivatives, concave, convex functions, point of inflection.	nature of function to learner w.r.t. maximum and minimum values.	Talk	find maximum, minimum of functions and apply it to various situations.		
	Rolle's Theorem, Lagranges's and Cauchy's Mean Value Theorems, applications and examples, Monotone increasing and decreasing functions,examples.	Basics of useful Mean Value Theorems		Learner able to apply Mean Value Theorems to various problems and solve problems.	S.S.CHOKHANI	5
	L-Hospital rule without proof, examples of indeterminate forms, Taylor's theorem with Lan-grange's form of remainder with proof, Taylor polynomial and applications.	To explain learner about basic expansions and representations of functions in various forms .		The learner is able to apply results in various problem solving and approximations and evaluating limits.	S.S.CHOKHANI	5
I	**INFINITE SERIES:** Definition of Series $\sum_{n=1}^{\infty} a_n$ of real numbers, simple examples of series, Sequence of partial sums of a series, convergence of a series, convergent series, divergent series.	To understand the series,meaning of convergent series and divergent series. To be able to prove if series is convergent with the help of sequence of partial sums of series.	Chalk n Talk	Learners able to determine if series is convergent with the help of sequence of partial sums of series.	SEETA VISHWAKARMA	3

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	Necessary condition: $\sum_{n=1}^{\infty} a_n$ converges $\Rightarrow$ $a_n \to 0$; but converse not true, algebra of convergent series, Cauchy Criterion, divergence of harmonic series.	To learn the basic theorem for convergence of series so that it can be applied to determine if series is convergent.	Chalk n Talk	Lerners able to use this these theorem in order to determine convergence and divergence of infinite series.	SEETA VISHWAKARMA	3
	convergence of $\sum_{n=1}^{\infty} \frac{1}{n^p}, p > 1$ Compar-ison test, limit comparison test, alternating sereis,	To know the convergence of the series of type $\sum_{n=1}^{\infty} \frac{1}{n^p}, p > 1$ To familiarize with comparison test and limit comparison test to determine whether series is convergent or divergent.	Chalk n Talk	Learners able to use these test to determine if series is convergent.	SEETA VISHWAKARMA	3
	Leibnitz's theorem (alternating series test) convergence of $\sum_{n=1}^{\infty} \frac{(-1)^n}{n}$; absolute convergence, conditional convergence, absolute conver-gence implies convergence but not conversely.	To learn the Leibnitz theorem in order to determine the convergence of alternate series. To learn the definition of absolute convergence and conditional convergence 3) To learn that absolutely convergent series is	Chalk n Talk	Learners able to determine convergence of alternate series and able to find examples of series which is convergent but not absolutely convergent. Learners are also able to determine if series is convergent absolutely convergent or	SEETA VISHWAKARMA	3

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		convergent but converse is not true.		conditionally convergent.		
	Ratio test (without proof), root test (without proof) and examples.	To familiarize with ratio test and root test to determine whether series is convergent or divergent	Chalk n Talk	Learners able to use ratio test and root teat to determine if series is convergent.	SEETA VISHWAKARMA	3

BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. **CLASS:**F.Y.B.Sc.MAthematics **SEM:** **I**
COURSE NAME: Algebra II **COURSE CODE:** USMT102 **CREDITS:** 2.

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner fundamentals in algebra ,good concept required for higher mathematics
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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	Statements of well-ordering property of non-negative integers, Principle of finite induction (First and second) as a consequence of well-ordering property, Binomial theorem for non-negative ex-	Student to understand induction steps 2 Students to understands binomial theorem 3. to understand properties of Pascal Triangle	Chalk and talk	Student able to understand induction steps 2 Students understands binomial theorem 3. Students understand properties of Pascal Triangle	Rajendra .Y .Chavan	5

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	ponents, Pascal Triangle.					
	Statements of well-ordering property of non-negative integers, Principle of Finite induction (First and second) as a consequence of well-ordering property, Binomial theorem for non-negative ex- ponents, Pascal Triangle. Divisibility in integers, division algorithm, greatest common divisor (GCD) and least common multiple (L.C.M) of two integers	Students to understand Steps in finite induction and use the result to prove statement defined in natural numbers. Students to understands Binomial theorem and results	Chalk and Talk Chalk and Talk	Students to understand Steps in finite induction and use the result to prove statement defined in natural numbers. Students find theorem useful in application purpose.	Rajendra .Y .Chavan	5
	basic properties of GCD such as existence and uniqueness of GCD of integers a & b and that the GCD. can be expressed as ma + nb for some m; nZ ,	To understand basic Arithmetic results	Chalk and Talk	Students find g.c.d and its problems.	Rajendra .Y .Chavan	2
	Euclidean algorithm,	To understand	Chalk and Talk	Students understand	Rajendra .Y .Chavan	3

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	Primes, Euclids lemma, Fundamental Theorem of arithmetic, The set of primes is infinite.	Euclids theorem and its Applications.		the results.		

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
II	**Functions** Definition of function, domain, co-domain and range of a function, composite functions, exam-ples, Direct image f(A) and inverse image f□1(B) for a function f, injective, surjective, bijective functions, Composite of injective, surjective, bijective functions when de_ned, invertible func-tions, bijective functions are invertible and conversely examples of functions including constant, identity, projection, inclusion, Binary operation as a function, properties, examples.	Learners able to understand the concept of Functions.	Chalk n talk	Identify the types of functions.	MS. Shital Warbhe	7

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	Equivalence relation: Equivalence realtion,Equivalence classes, properties such as two equivalences classes are either identical or disjoint, De_nition of partition, every partition gives an equivalence relation and vice versa.	Learners able to understand ,how to make a partition of set and types of relation.	Chalk n talk	Identify the types of relation.	Ms. Shital Warbhe.	6
	Congruence is an equivalence relation on Z, Residue classes and partition of Z, Addition modulon, Multiplication modulo n, examples.	Learners able to understand addition modulo and multiplication modulo n .	Chalk n talk	Identify a partition of z.	Ms. Shital Warbhe.	2

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
III	Definition of a polynomial, polynomials over the field F where IF = Q;R or C, Algebra of polynomials, degree of polynomial, basic properties. Division algorithm in F[X] (without proof), and g.c.d of two polynomials and its basic properties (without proof),	Students to understand Division algorithm and consequence results	Chalk and Talk	Students understand Division algorithm and consequence results	R.Y.Chavan	5

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	Euclidean algorithm (without proof), applications					
	Roots of a polynomial, re- lation between roots and coefficients, multiplicity of a root, Remainder theorem, Factor theorem. A polynomial of degree over n has at most n roots roots,	1.Students to understand remainder and Factor theorem. 2. Student to understand roots of polynomials	Chalk and Talk Diagram	1.Students are able to understand remainder and Factor theorem. 2. Student can find roots of polynomials	R.Y.Chavan	3
	Complex roots of a polynomial in R[X] occur in conjugate pairs, Statement of Fundamental Theorem of Algebra, A polynomial of degree in C[X] has exactly n complex roots counted with multiplicity,	Students to understand the Complex plane and algebra of complex numbers students to train to find root of the polynomial and multiple roots	Chalk and Talk and Diagram. chalk and Talk	Students able to understand the Complex plane and algebra of complex numbers students are able to find root of the polynomial and multiple roots	R.Y.Chavan	2
	A non-constant polyno- mial in R[X] can be expressed as a product of linear and quadratic factors in R[X], necessary condition for a rational number $\frac{p}{q}$ to be a root a polynomial	1.students to understand polynomials over F and its algebra. 2.students to understand rational root theorem and its results	Chalk and Talk	students understand polynomials over F and its algebra. 2.students to understand rational root theorem and its results	R.Y.Chavan	5

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	with integer coefficients, simple consequences such as p is a irrational number where p is a prime number, roots of unity, sum of all the roots of unity.					

BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. **CLASS:** F.Y.B.Sc. **SEM:** **II**
COURSE NAME:Algebra II **COURSE CODE:** USMT202 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 3)
Course is designed to teach learner the system of equation and its solution and its representation in matrix form

UNIT	**TOPIC**	**OBJECTIVE**	**TEACHING AIDS used**	**OUTCOME**	**Faculty Engaging Lecture**	**No of lectures if defined**
I	Parametric Equation of Lines and Planes , System of homogeneous and non-homogeneous linear Equations, The solution of m homogeneous linear equations in n unknowns by elimination and	1.student to learn homogeneous and non homogeneous System 2.students to teach solving system	diagram chalk and talk	student to learn homogeneous and non homogeneous System 2. students can under stand geometrically	Rajendra .Y .Chavan	5

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	their geometrical interpretation for (m; n) = (1; 2); (1; 3); (2; 2); (2; 2); (3; 3); De_nition of n-tuple of real numbers, sum of n-tuples and scalar multiple of n-tuple.					
	Matrices with real entries; addition, scalar multiplication of matrices and multiplication of ma- trices, transpose of a matrix, types of matrices: zero matrix, identity matrix, scalar matrix,	students to learn to transform system into matrix students to learn different types of Matrix and operation	chalk and Talk	student can solve homogeneous and non homogeneous System students learn different types of Matrix and operation	Rajendra .Y .Chavan	5
	diagonal matrix, upper and lower triangular matrices, symmetric matrix, skew symmetric matrix, invertible matrix; Identities such as $(AB)^t = A^tB^t$; $(AB)^{-1} = A^{-1}B^{-1}$. System of linear equations in matrix form, Elementary row operations, row echelon matrix,	to teach transpose and properties of matrix	chalk and talk	student learn all properties of Matrices	Rajendra .Y .Chavan	3
	Gaussian	Students to	chalk and	Students able	Rajendra	2

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	elimination method. Deduce that the system of m homogeneous linear equations in n unknowns has a non-trivialsolution if m < n:	understand Gaussian elimination method	Talk	to solve Gaussian elimination method	.Y .Chavan	

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
II	**Vector Spaces.:** Definition of real vector space, Examples such as R^n, R[X],M_{mxn}(R), space of real valued functions on a non-empty set.	Learners able to understand the concept of vector spaces.	Chalk n talk	Identify a spaces	MS. Shital Warbhe .	3
	Subspaces: definition, examples: lines , planes passing through origin as subspaces of respectively; upper triangular matrices, diagonal matrices, symmetric matrices, skew symmetric matrix as subspaces of M_n(R) (n = 2, 3); $P_n(X) = a_0 + a_1x + a_2x^2 + \_ \_ \_ + a_nx^n$; a_i ε R; for1 = i.., n as subspace of R[X] , the space of all solutions of the system of m homogeneous linear	Learners able to understand Concept of subspaces	Chalk n talk	Identify the Subset of given vector space	Ms. Shital Warbhe.	4

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	equations in n unknowns as a subspace of R^n.					
	Properties of a subspace: properties of a subspaces such as necessary and sufficient conditions for a non-empty subset to be a subspace of a vector space, arbitrary intersection of subspaces of a vector space is a subspace, union of two subspaces is a subspace if and only if one is the subset of other. .	Learners able to understand Properties of subspaces.	Chalk n talk	Implement for any subspaces.	Ms.Shital Warbhe.	4
	Linear depedent and independent of vectors : Finite linear combination of vectors in a vector space; linear span L(S) of a non-empty subset S of a vector space, S is a generating set for L(S);L(S) is a vector subspace of V ; Linearly independent/ Linearly Dependent subsets of a vector space, a subset $\{v_1,v_2,\ldots, v_k\}$is linearly dependent if and only v_i is a linear combination of other vectors v_j's	Learners able to understand ,how to write the linear combination of vectors .	Chalk n talk	Compare the set of vectors are linearly dependent and independent.		4
UNIT	**TOPIC**	**OBJECTIVE**	**TEACHING AIDS used**	**OUTCOME**	**Faculty Engaging Lecture**	**No of lectures if defined**
III	Basis of a vector space, dimension of a vector space, maximal linearly independent subset	students to understand vector space	chalk and Talk	student understand vector space	Rajendra .Y .Chavan	5

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	of a vector space is a basis of a vector space, minimal generating set of a vector space is a basis of a vector space, any two basis of a vector space have same number of elements, any set of n linearly independent vectors in an n-dimensional vector space is a basis					
	any collection of n + 1 vectors in an n-dimensional vector space is linearly dependent. Extending any basis of a subspace W of a vector space V to a basis of the vector space V. If $W_1;W_2$ are two subspaces of a vector space V then $W_1 + W_2$ is a subspace of the vector space	students to understand union and addition of subspace	chalk and Talk	Student understand union and addition of subspaces	Rajendra .Y .Chavan	5
	LinearTransformations Kernel, Image of a Linear Transformation T , Rank T , Nullity T, and properties such as: kernel T is a subspace of domain space of T and Img T is a subspace of co-domain space of T.	Student to understand linear transformation , nullity rank	chalk and Talk	students understand concept of linear transformation ,basis.	R .Y .Chavan	3
	If $V = \{v_1\ v_2,\ldots,v_n\}$ is a basis of V and $W = \{w_1,w_2\ldots w_n\}$ any vectors in W then there exists a unique linear transformation $T : V \rightarrow W$ such that $T(v_j) = w_j$ for j= 1 to n, Rank nullity theorem	student to understand rank nullity theorem	chalk and Talk	students verify rank nullity theorem	R. Y .Chavan	2

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	(statement only) and examples.					

BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. MATHEMATICS **CLASS:** S.Y.B.Sc. **SEM:** **III**
COURSE NAME: CALCULUS III **COURSE CODE:** USMT301 **CREDITS:** 2

COURSE Objectives: (L/WEEK:3)
The objective of this course is to teach the learner concepts of Calculus with rigour

UNIT	**TOPIC**	**OBJECTIVE**	**TEACHING AIDS used**	**OUTCOME**	**Faculty Engaging Lecture**	**No of lectures if defined**
Unit I: Functions of several variables (15 Lectures)						
I	The Euclidean inner product on R^n and Euclidean norm function on R^n, distance between two points, open ball in R^n; definition of an open subset of R^n; neighbourhood of a point in R^n; sequences in R^n, convergence of sequences-	To understand basic composition of set R^n and to give clarity about its properties.	Chalk & Talk	Learner understands utility of R^n, important operations and its utility.	S.S.CHOKHANI	5

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	these concepts should be specifically discussed for n = 3 and n = 3:					
	Functions from R_n to R (scalar fields) and from R_n to R_m (vector fields), limits, continuity of functions, basic results on limits and continuity of sum, difference, scalar multiples of vector fields, continuity and components of a vector fields.	To expose basic concepts like limits and continuity in several variables.	Chalk & Talk	Learner able to generalize and use limits, continuity with several VARIABLES.	S.S.CHOKHANI	5
	Directional derivatives and partial derivatives of scalar fields. Mean value theorem for derivatives of scalar fields.	To learn about derivatives and partial derivatives of scalar fields. Mean value theorem for derivatives of scalar fields.	Chalk & Talk	Learner comes to know of Mean Value Theorems and its corollaries.	S.S.CHOKHANI	5
Unit II: Differentiation (15 Lectures)						
	Differentiability of a scalar field at a point of R_n (in terms of linear transformation) and on an open subset of R_n; the total derivative, uniqueness of total derivative of a differ-entiable function at a point, simple examples of finding total derivative of	To familiarize learner with differentiability of functions of several variables and its comparison with properties like continuity, partial derivatives.	Chalk & Talk	Learner able to understand differentiability of functions of several variables and its comparison with properties like continuity, partial derivatives.	S.S.CHOKHANI	5

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	functions such as $f(x; y) = x^2 + y^2$; $f(x; y; z) = x + y + z$;, differentiability at a point of a function f implies continuity and existence of direction derivatives of f at the point, the existence of continuous partial derivatives in a neighbourhood of a point implies differentiability at the point.					
	Gradient of a scalar field, geometric properties of gradient, level sets and tangent planes.	To give learner proper basics of gradient, level sets and tangent planes, chain rule	Chalk & Talk	Learner able to understand gradient, level sets and tangent planes, chain rule.	S.S.CHOKHANI	4
	Chain rule for scalar fields.		Chalk & Talk		S.S.CHOKHANI	1
	Higher order partial derivatives, mixed partial derivatives, suffcient condition for equality of mixed partial derivative.	To teach basics of higher derivatives and its properties.	Chalk & Talk	All related concepts learned and used by learner.	S.S.CHOKHANI	5
Unit III: Applications (15 lectures)						
	Second order Taylor's formula for scalar fields.	To explain various applications of concepts learned in Units I & II.	Chalk & Talk	All related applications learned and used by learner.	S.S.CHOKHANI	2
	Differentiability of vector fields, definition of		Chalk & Talk	All related applications	S.S.CHOKHANI	5

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	differentiability of a vector field at a point, Jacobian matrix, differentiability of a vector field at a point implies continuity. The chain rule for derivative of vector fields (statements only)			learned and used by learner..		
	Mean value inequality.		Chalk & Talk	All related applications learned and used by learner.	S.S.CHOKHANI	1
	Hessian matrix, Maxima, minima and saddle points.		Chalk & Talk	All related applications learned and used by learner.	S.S.CHOKHANI	3
	Second derivative test for extrema of functions of two variables.		Chalk & Talk	All related applications learned and used by learner.	S.S.CHOKHANI	2
	Method of Lagrange Multipliers.		Chalk & Talk		S.S.CHOKHANI	2

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. MATHEMATICS **CLASS:** S.Y.B.Sc. **SEM:** **IV**
COURSE NAME: CALCULUS IV **COURSE CODE:** USMT401 **CREDITS:** 2

COURSE Objectives: (L/WEEK:3)
The objective of this course is to teach the learner concepts of Calculus with rigour

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
Unit I: Riemann Integration (15 Lectures)						
I	Approximation of area, Upper/Lower Riemann sums and properties, Upper/Lower integrals, Definition of Riemann integral on a closed and bounded interval, Criterion of Riemann in-tegrability, if $a < c < b$ then f is in R[a; b]; if and only Z if f is in R[a; c] and R[c; b] If f is bounded	To understand concept of Riemann integration and study its properties.	Chalk & Talk	Learner grasps concept of Riemann integration and its properties like addition, monotonicity etc.	S.S.CHOKHANI	8 3 4

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	with finite number of discontinuities then f is in R[a; b], generalize this if f is monotone then f is in R[a; b]:					
Unit II: Indefinite and improper integrals (15 lectures)						
	Continuity of indefinite integral of 'f', Fundamental theorem of calculus, Mean value theorem, Integration by parts, Leibnitz rule, Improper integrals-type 1 and type 2, Abso- lute **convergence** of improper integrals, Comparison tests, Abel's and Dirichlet's tests. of a point implies di_erentiability at the point.	To familiarize learner with above concepts and properties.	Chalk & Talk	Learner able to visualize behaviour of integral under different conditions.	S.S.CHOKHANI	5 5 5
Unit III: Applications (15 lectures)						
	Beta and Gamma functions and their properties, relationship between these functions (without proof).	To introduce Beta and Gamma Functions	Chalk & Talk	Leaner able to grasp Beta and Gamma functions and see its utility .	S.S.CHOKHANI	4
	Applications of definite Integras: Area between curves, finding volumes by sicing, volumes	To explain various applications of concepts learned in Units I & II.	Chalk & Talk	All related applications learned and used by learner.	S.S.CHOKHANI	11

Note:
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	of solids of revolution-Disks and Washers, Cylindrical Shells, Lengths of plane curves, Areas of surfaces of revolution					

BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. Mathematics **CLASS:** S.Y.B.Sc. **SEM:** **III**
COURSE NAME: Algebra **COURSE CODE:** USMT 302 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner how to develop skill of Algebra and understand the concepts of linear transformation ,determinants , inner product space.

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	**Linear Transformations :** Review of linear transformations,Kernel and image of a linear transformation, Rank-Nullity theorem (with proof), Linear isomorphisms, inverse of a linear isomorphism, Any n-dimensional real vector space is isomorphic to $\mathbb{R}^n$.	Learners able to understand the concept Rank and nullity of transformations	Chalk n talk.	Find the dimension of null space of transformation and dimension of Image of transformation	Ms. Shital Warbhe.	4
	Matrices: The matrix units, row operations, elementary matrices, elementary matrices are invertible	Learners able to understand the concept of row rank n Column rank.	Chalk n talk .	Find the rank of matrix.	Ms. Shital Warbhe	6

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	and an invertible $m \times n$ matrix is a product of elementary matrices. 3. Row space, column space of an m n matrix, row rank and column rank of a matrix, Equivalence of the row and the column rank, Invariance of rank upon elementary row or column operations.					
	System of linear equation: Equivalence of rank of an m ×n matrix A and rank of the linear transformation L_A : $\mathbb{R}^n \rightarrow \mathbb{R}^m$($L_A$(X) = AX). The dimension of solution space of the system of linear equations AX = 0 equals n - rank(A). 5. The solutions of non-homogeneous systems of linear equations represented by AX = B; Existence of a solution when rank(A)= rank(A;B), The general solution of the system is the sum of a particular solution of the system and the solution of the associated homoge-neous system.	Learners able to understand the concept of solution of system of linear equation.	Chalk n talk .	Differentiate Between the solution of homogeneous and non homogeneous equation .	Ms. Shital Warbhe	5

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II	**Determinants:** Definition of determinant as an n−linear skew-symmetric function from $f:\mathbb{R}^n \times \mathbb{R}^n \times \mathbb{R}^n \times \dots \mathbb{R}^n \times\to \mathbb{R}$ such that determinant of $(E^1, E^2, \dots, E^n)$ is 1, where Ej denotes the jth column of the n × n identity matrix In. Determinant of a matrix as determinant of its column vectors (or row vectors).	Learner able to understand the concept of determinant.	Chalk and Talk	Determine the determinant of matrix .	Ms. Shital Warbhe.	4
	Properties of determinant: Existence and uniqueness of determinant function via permutations, Computation of determinant of 2 × 2, 3 × 3 matrices, diagonal matrices, Basic results on determinants such as det(A^t)= det(A), det(AB) = det(A) det(B), Laplace expansion of a	Learner able to understand the concept of properties of determinants.	Chalk n talk .	Implement the properties Of determinant.	Ms. Shital Warbhe.	5

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	determinant, Van-dermonde determinant, determinant of upper triangular and lower triangular matrices.					
	Linear dependence and independence of vectors in $\mathbb{R}^n$ Linear dependence and independence of vectors in $\mathbb{R}^n$using determinants, The existence and uniqueness of the system AX = B, where A is an n×_n matrix with det(A) ≠ 0, Co-factors and minors, Adjoint of an n×n matrix A, Basic results such as Aadj(A) = det(A)I_n: An n ×n real matrix A is invertible if and only if det(A) ≠ 0;A^{-1} = 1/det(A) adj(A) for an invertible matrix A, Cramer's rule.	Learners able to understand the concept linear dependence and independence Of vectors in $\mathbb{R}^n$ by using the determinant .	Chalk n talk .	Compare Linear dependence and independence of vectors **in** $\mathbb{R}^n$	Ms. Shital Warbhe	5
	Determinant as area and volume	Learner able to understand the concept of area and volume by using determinant .	Chalk n talk .	Find area and volume .	Ms. Shital Warbhe	1
III	**Inner Product Spaces:** Dot product in $\mathbb{R}^n$ Definition of general inner product on a vector space over R: Examples of inner product including the inner product < f; g >=	Learner able to understand the concept of Inner product spaces.	Chalk n talk .	Find the dot product of vectors.	Ms. Shital Warbhe	6

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	$\int_{-\pi}^{\pi} f(t)g(t)\ dt$ on C[$-\pi$, π]; the space of continuous real valued functions on [$-\pi$, π].					
	Orthogonality of vectors: Norm of a vector in an inner product space. Cauchy-Schwartz inequality, Triangle in-equality, Orthogonality of vectors, Pythagoras theorem and geometric applications in R_2; Projections on a line, The projection being the closest approximation, Orthogonal com-plements of a subspace, Orthogonal complements in R_2 and R_3. Orthogonal sets and orthonormal sets in an inner product space, Orthogonal and orthonormal bases. Gram-Schmidt orthogonalization process, Simple examples in R_3;R_4.	Learner able to understand the concept of orthogonality of vectors.	Chalk n talk .	Classify an orthogonal vectors and orthonormal vectors.	Ms. Shital Warbhe	9

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. Mathematics **CLASS:** S.Y.B.Sc. **SEM:** IV
COURSE NAME: Algebra **COURSE CODE:** USMT 402 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner how to develop skill of Algebra and understand the concepts of Groups and Subgroups.

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	**Groups:** Definition of a group, abelian group, order of a group, finite and infinite groups. Examples of groups including: i) Z;Q;R;C under addition. ii) Q_(= Q n f0g);R_(= R n f0g);C_(= C n f0g):Q+(= positive rational numbers) under multiplication. iii) Z_n; the set of residue classes modulo n under addition. iv) U(n); the group of prime residue classes modulo n under multiplication. v) The symmetric group S_n: vi) The group of symmetries of a plane figure. The Dihedral group D_n as the group of symmetries of a regular polygon of n sides (for n = 3; 4). vii) Klein 4-group. viii) Matrix groups M_{n_n}(R) under	Learners able to understand the concept Of groups.	Chalk n talk.	Identify the types of group.	Ms. Shital Warbhe.	4

Note:
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	addition of matrices, $GL_n(R)$; the set of invertible real matrices, under multiplication of matrices. ix) Examples such as S_1 as subgroup of C; _n the subgroup of n□th roots of unity.					
	Properties: Properties such as 1) In a group (G; :) the following indices rules are true for all integers n; m: i) $a^n a^m = a^{n+m}$ for all a in G: ii) $(a^n)^m = a^{nm}$ for all a in G: iii) $(ab)^n = a^n b^n$ for all ab in G whenever ab = ba: 2) In a group (G; :) the following are true: i) The identity element e of G is unique. ii) The inverse of every element in G is unique. iii) $(a^{□1})^{□1} = a$ for all a in G: iv) $(a:b)^{□1} = b^{□1}a^{□1}$ for all a; b in G: v) If $a^2 = e$ for every a in G then (G; :) is an abelian group. vi) $(aba^{□1})^n = ab^n a^{□1}$ for every a; b in G and for every integer n: vii) If $(a:b)^2 = a^2:b^2$ for every a; b in G then (G; :) is an abelian group. viii) (Z_ n; :) is a group if and only if n is a prime. 3) Properties of order of an element	Learners able to understand the properties of group.	Chalk n talk .	Implement for any group .	Ms. Shital Warbhe	6

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	such as: (n and m are integers.) i) If o(a) = n then am = e if and only if n=m. ii) If o(a) = nm then o(an) = m. iii) If o(a) = n then o(am) = n (n;m) ;. where (n;m) is the GCD of n and m. iv) o(aba□1) = o(b) and o(ab) = o(ba). v) If o(a) = m and o(b) = m; ab = ba; (n;m) = 1 then o(ab) = nm.					
	Subgroups: i) Definition, necessary and sufficient condition for a non-empty set to be a Subgroup. ii) The center Z(G) of a group is a subgroup. iii) Intersection of two (or a family of) subgroups is a subgroup. iv) Union of two subgroups is not a subgroup in general. Union of two subgroups is a subgroup if and only if one is contained in the other. v) If H and K are subgroups of a group G then HK is a subgroup of G if and only if HK = KH.	Learners able to understand the concept Of sub groups.	Chalk n talk .	Compare the union and intersection properties of subgroup.	Ms. Shital Warbhe	5
II	**Cyclic groups and cyclic subgroups :** Cyclic subgroup of a group, cyclic groups, (examples including Z;Zn	Learners able to understand the concept of cyclic groups.	Chalk n talk .	Differentiate Between cyclic and non cyclic groups.	Ms. Shital Warbhe	7

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	Properties : (i) Every cyclic group is abelian. (ii) Finite cyclic groups, infinite cyclic groups and their generators. (iii) A finite cyclic group has a unique subgroup for each divisor of the order of the group. (iv) Subgroup of a cyclic group is cyclic. (v) In a finite group G;G =< a > if and only if o(G) = o(a). (vi) If G =< a > and o(a) = n then G =< a_m > if and only if (n;m) = 1: (vii) If G is a cyclic group of order p_n and H < G;K < G then prove that either H ⊆ K or K ⊆ *H*	Learners able to understand the properties of cyclic group.	Chalk n talk .	Implement for any cyclic group	Ms. Shital Warbhe	8
III	**Lagrange's Theorem :** Definition of Coset and properties such as : 1) IF H is a subgroup of a group G and x 2 G then (i) xH = H if and only if x 2 H. (ii) Hx = H if and only if x 2 H: 2) If H is a subgroup of a group G and x; y 2 G then (i) xH = yH if and only if x□1y 2 H: (ii) Hx = Hy if and only if xy□1 2 H: 12Lagrange's theorem and consequences such as Fermat's Little	Learners able to understand the concept of Cosets	Chalk n talk .	Implement for any group and it make partition of group.	Ms. Shital Warbhe	8

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	theorem, Euler's theorem and if a group G has no nontrivial subgroups then order of G is a prime and G is cyclic.					
	Group homomorphism and isomorphism, auto morphisms : i) Definition. ii) Kernel and image of a group homomorphism. iii) Examples including inner automorphisms	Learners able to understand the concept of Homomorphism and isomorphism, automorphisms	Chalk n talk .	Discriminate Homomorphism and isomorphism, automorphisms	Ms. Shital Warbhe	4
	Properties such as: (1) f : G → G' a group homomorphism then ker f < G. (2) f : G → G' is a grouphomomorphism then ker f = {e} if and only if f is 1-1 (3)f : G → G' is a group homomorphism then (i) G is abelian if and only if G' is abelian. (ii) G is cyclic if and only if G' is cyclic.	Learners able to understand the properties of group homomorphism.	Chalk n talk .	Implement for any group.	Ms. Shital Warbhe.	3

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. **CLASS:** S.Y.B.Sc. **SEM:** **III**
COURSE NAME:Discrete Mathematics **COURSE CODE:** USMT303 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner topics on permutation and recurrence relation

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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	Permutations and Recurrence :. Permutation of objects, S_n, composition of permutations, results such as every permutation is a product of disjoint cycles, every cycle is a product of transpositions, even and odd permutation, rank and signature of a permutation, cardinality of S_n;A_n	1.To understand permutation and recurrence relation problems. 2.To understand concept of cycles ,transposition 3 .To understand the concept of cardinality of permutataion	Examples in natures. Talk and chalk	1.Students can solve problems on permutation and recurrence relation 2. students understand concept of cycles ,transposition. 3. Students can find cardinality of permutation.	Rajendra .Y .Chavan	5
	2. Recurrence Relations, definition of non-homogeneous, linear , non-linear recurrence relation, obtaining recurrence relation in counting problems,	1.To train students in problem solving of homogeneous and non homogeneous recurrence relation.	Chalk and talk	Students can solve problems on homogeneous and non homogeneous linear recurrence relation	Rajendra .Y .Chavan	3

Note:
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	solving homogeneous	To understand difference between homogeneous and non homogeneous	Chalk and talk	Students are able to differentiate between homogeneous and non homogeneous linear recurrence		2
	Non homogeneous recurrence relations by using iterative methods .	To understand iterative method	Chalk and talk	Able to solve the problems by iterative methods.	Rajendra .Y .Chavan	3
	solving a homogeneous recurrence relation of second degree using algebraic method proving the necessary result	To understand algebraic method in solving recurrence relation	Chalk and talk	Students are able to solve by algebraic method	Rajendra .Y .Chavan	2

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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
II	Preliminary Counting : 1. Finite and infinite sets, countable and uncountable sets examples such as N;Z;N _ N;Q;(0; 1);R	Students to understand countable and uncountable set and different examples	Talk and chalk	Students tounderstand countable and uncountable set and different examples	Rajendra .Y .Chavan	5
	2. Addition and multiplication Principle, counting sets of pairs, two ways counting. .	Students to understand two ways counting	Talk and chalk	Students tounderstand two ways counting	Rajendra .Y .Chavan	5
	3. Stirling numbers of second kind. Simple recursion formulae satisfied by S(n,k)	students to understand stirking number and recursive formulae	Talk and chalk	students to understand stirking number and recursive formulae	Rajendra .Y .Chavan	3
	4. Pigeonhole principle and its strong form, its applications to geometry, monotonic sequences etc	students to understand Pigeonhole principle and demonstration	Talk and chalk	students understand Pigeonhole principle and demonstration	Rajendra .Y .Chavan	2

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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
III	1. Binomial and Multinomial Theorem, Pascal identity, examples of standard identities such as the following with emphasis on combinatorial proofs. . .	To understand different identities based on combinatorics	Talk and chalk	Students are able to write different identities based on combinatorics	Rajendra .Y .Chavan	5
	2. Permutation and combination of sets and multi-sets, circular permutations, emphasis on solving problems.	To understand the concept of circular permutation and problem solving	Talk and chalk	Studentsunderstand the concept circular permutation and can solve problem solving	Rajendra .Y .Chavan	5
	3. Non-negative and positive solutions of equation $x_1 + x_2 + \_\,\_\,\_ + x_k = n$	Students to train problem solving in equation	Talk and chalk	Students can solve equation in n variable.	Rajendra .Y .Chavan	3
	4. Principal of inclusion and exclusion, its applications, derangements, explicit formula for d_n, deriving formula for Euler's function	Problems on inclusion and exclusion principle,derangement and results	Talk and chalk	Students are able to solve problem and identify use of Eulers formula	Rajendra .Y .Chavan	2

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. **CLASS:** S.Y.B.Sc. **SEM:** **IV**
COURSE NAME: ORDINARY DIFFERENTIAL EQUATIONS **COURSE CODE:** USMT403 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner to identify differential equation and skills in finding the solutions to the problems.
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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	Definition of a differential equation, order, degree, ordinary differential equation and partial differential equation, linear and non linear ODE. (2) Existence and Uniqueness Theorem for the solution of a second order initial value problem (statement only), Definition of Lipschitz function, Examples based on verifying the conditions of existence and uniqueness theorem (3) Review of Solution of homogeneous and non-homogeneous differential equations of first order and first degree. Notion	1.to identify order and degree of differential equation. 2.to identify exact and non exact condition 3.solve integration to obtain in the complete solution.	Talk and chalk	1.students can identify order and degree of differential equation. 2.Students can identify exact and non exact condition 3. Students are able to solve integration to obtain in the complete solution.	Rajendra .Y .Chavan	5

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	of partial derivatives. Exact Equations: General solution of Exact equations of first order and first degree.		Chalk and talk			
	Necessary and sufficient condition for Mdx + Ndy = 0 to be exact. Non-exact equations: Rules for finding integrating factors (without proof) for non exact equations, such as : i)M x + N y is an I.F. if M x + N y≠0 and Mdx+Ndy = 0 ishomogeneous. ii)1/M x-N y is an I.F. if M x - N y ≠0 and Mdx + Ndy = 0 is of the form $f_1(x; y)$ y dx + $f_2(x; y)$ x dy = 0	Students to understand when to use accurate I.F. to solve non homogeneous differential non exact differential equation.	Chalk and talk	Students understand when to use accurate I.F. to solve non homogeneous differential non exact differential equation.	Rajendra .Y .Chavan	5
	iv) Linear and reducible linear equations of first order, finding solutions of first order differential equations of the type for	Student to learn to find the solution to first order first degree solution.	Chalk and Talk	Student learn to find the solution to first order first degree solution.	Rajendra .Y .Chavan	3
	applications to orthogonal trajectories, population growth, and finding the current at a given time.	Students to understand the different applications of first order first degree DE.	Chalk and talk	Students to understand the different applications of first order first degree DE.	Rajendra .Y .Chavan	2

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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
II	1.Homogeneous and non-homogeneous second order linear differentiable equations: The space of solutions of the homogeneous equation as a vector space. Wronskian and linear independence of the solutions. The general solution of homogeneous differential equations. The general solution of a non-homogeneous second order equation. Complementary functions and particular integrals.	1.Students to understand solution space of homogeneous differential equation is vector space. 2.Student understand to find the solution to homogeneous and non homogeneous. 3. students to understand Wronskian	Talk and chalk	1.Students understand that solution space of homogeneous differential equation is vector space 2.Student are able to find the solution to homogeneous and non homogeneous. 3. students can find Wronskian	Rajendra .Y .Chavan	5
	2. The homogeneous equation with constant coefficients. auxiliary equation. The general solution corresponding to real and distinct roots, real and equal roots and complex roots of the auxiliary equation.	Students to learn to find solution in various root cases. And complete solution	Chalk and Talk	Students are able to find solution in various root cases and complete solution	Rajendra .Y .Chavan	5

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	Non-homogeneous equations: The method of undetermined coefficients. .	To understand method of undermined coefficients.	Chalk and Talk	Student can solve by undetermined coefficient methods.	Rajendra .Y .Chavan	3
	method of variation of parameters	To understand method of variation of parameters	Chalk and Talk	Students understand and solve by method of variation of parameters	Rajendra .Y .Chavan	2

UNIT	**TOPIC**	**OBJECTIVE**	**TEACHING AIDS used**	**OUTCOME**	**Faculty Engaging Lecture**	**No of lectures if defined**
III	Existence and uniqueness theorems homogeneous linear system of ODEs in two variables: Let $a_1(t)$; $a_2(t)$; $b_1(t)$; $b_2(t)$ be continuous real valued functions defined on [a; b]. Fix t in [a; b]. Then there exists a unique solution $x = x(t)$; $y = y(t)$ valid throughout [a; b]	1.Students to understand homogeneous linear system of equations. 2.to develop the skill in solving system of first order differential equations.	Talk and chalk.	1.Students understand homogeneous linear system of equations. 2.Students are able in solving system of first order differential equations.	Rajendra .Y .Chavan	5
	satisfying the initial conditions $x(t_0) = x_0$&$y(t_0) = y_0$: The Wronskian W(t) of two solutions of a homogeneous linear system of ODEs in	Students to understand initialise problems. 2.student to develop skill in solving problems	Talk and chalk	Students able to understand initialise problems. 2..student to develop skill in solving problems	Rajendra .Y .Chavan	5

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	two variables, result: W (t) is identically zero or nowhere zero on [a, b]. Two linearly independent solutions and					
	general solution of a homogeneous linear system of ODEs in two variables.	Students to understand transformation from system to homogeneous system to homogeneous differential equation	Talk and chalk	Students can transform system to homogeneous differential equation	Rajendra .Y .Chavan	3
	Explicit solutions of Homogeneous linear systems with constant coefficients in two variables,	Students to train to find explicit solution to Homogeneous linear System		Students are able to find explicit solution to Homogeneous linear System	Rajendra .Y .Chavan	2

BHAVAN'S COLLEGE, ANDHERI(WEST)

<u>Course Learning Objective and Outcome</u>

PROGRAMME NAME: B.Sc. MATHEMATICS **CLASS:** T.Y.B.Sc. **SEM:** V

COURSE NAME: TOPOLOGY OF METRIC SPACES **COURSE CODE:** USMT503 **CREDITS:** 2.5

COURSE Objectives: (L/WEEK:3)

The objective of this course is to teach the learner the concepts of Metric Topology.

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined

Note:

HOD/Coordinators are requested to submit above details for every syllabus revision/ restructuring of syllabus/change in subject distribution.

Unit I: Metric spaces (15 L)						
	Definition, examples of metric spaces R;R_2 ,Euclidean space R_n with its Euclidean, sup and sum metric, C (complex numbers), the spaces l_1 and l_2 of sequences and the space C[a; b], of real valued continuous functions on [a; b]. Discrete metric space.3:	To introduce concept of Metric , Metic space and various concepts associated with it like open sets, closed sets, limit points, etc.	Chalk & Talk	Learner understands and is equipped to use it for further studies.	S.S.CHOKHANI	5
	Distance metric induced by the norm, translation invariance of the metric induced by the norm. Metric subspaces, Product of two metric spaces. Open balls and open set in a metric space, examples of open sets in various metric spaces. Hausdorff property. Interior of a set. Properties of open sets. Structure of an open set in IR. Equivalent metrics.		Chalk & Talk	Learner understands and is equipped to use it for further studies	S.S.CHOKHANI	5
	Distance of a point from a set, between sets ,diameter of a set in a metric space and bounded sets. Closed ball in a metric space, Closed sets- definition, examples. Limit point of a set, isolated point, a closed set contains all its limit points, Closure of a set and boundary of a set.		Chalk & Talk	Learner understands and is equipped to use it for further studies	S.S.CHOKHANI	5

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Unit II: Sequences and Complete metric spaces (15L)						
	Sequences in a metric space, Convergent sequence in metric space, Cauchy sequence in a metric space, subsequences, examples of convergent and Cauchy sequence in finite metric spaces, R^n with different metrics and other metric spaces.	To familiarize learner with sequences in Metric Space and its various properties like boundedness in more general context.	Chalk & Talk	Learner able to understand sequences in Metric Space and its various properties like boundedness in more general context.	S.S.CHOKHANI	5
	Characterization of limit points and closure points in terms of sequences, Definition and exam- ples of relative openness/closeness in subspaces. Dense subsets in a metric space and Separability Definition of complete metric spaces, Examples of complete metric spaces, Completeness prop- erty in subspaces, Nested Interval theorem in R, Cantor's Intersection Theorem, Applications of Cantors Intersection Theorem: (i) The set of real Numbers is uncountable. (ii) Density of rational Numbers(Between any two real numbers there	To familiarize learner with sequences in Metric Space and its various properties like separability.	Chalk & Talk	Learner able to understand sequences in Metric Space and its various properties like separability.	S.S.CHOKHANI	10

Note:
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	exists a rational number) (iii) Intermediate Value theorem: Let : [a; b]R be continuous, and assume that f(a) and f(b) are of di_erent signs say, f(a) < 0 and f(b) > 0. Then there exists c in (a; b) such that f(c) = 0.					
Unit III: Compact sets 15 lectures						
	Definition of compact metric space using open cover, examples of compact sets in different metric spaces $R;R_2;R_n$, Properties of compact sets: A compact set is closed and bounded, (Converse is not true). Every infinite bounded subset of compact metric space has a limit point. A closed subset of a compact set is compact. Union and Intersection of Compact sets. Equivalent statements for compact sets in R:	To introduce learner with concept of Compactness and its various properties like boundedness, closed, their union and intersection etc.	Chalk & Talk	Learner becomes familiar with concept of Compactness and its various properties like boundedness, closed, their union and intersection etc.	S.S.CHOKHANI	7
	(i) Sequentially compactness property. (ii) Heine-Borel property: Let be a closed and bounded interval. Let be a family of open intervals such that Then there exists a finite subset such that that is, is contained in the union of a _nite		Chalk & Talk	All related applications learned and used by learner..	S.S.CHOKHANI	8

Note:
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	number of open intervals of the given family. (iii) Closed and boundedness property. (iv) Bolzano-Weierstrass property: Every bounded sequence of real numbers has a convergent subsequence.					

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. MATHEMATICS **CLASS:** T.Y.B.Sc. **SEM:** VI
COURSE NAME: TOPOLOGY OF METRIC SPACES & REAL ANALYSIS **COURSE CODE:** USMT603 **CREDITS:** 2.5

COURSE Objectives: (L/WEEK:3)
The objective of this course is to teach the learner the concepts of Metric Topology & Real Analysis.

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
Unit I: Continuous functions on metric spaces (15 L)						

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	Epsilon-delta definition of con- tinuity at a point of a function from one metric space to another. Characterization of continuity at a point in terms of sequences, open sets and closed sets and examples, Algebra of continuous real valued functions on a metric space. Continuity of composite continuous function. Con- tinuous image of compact set is compact, Uniform continuity in a metric space, definition and examples (emphasis on R). Let (X; d) and (Y; d) be metric spaces and f : X to Y be continu- ous. If (X; d) is compact metric, then f : X to Y is uniformly continuous. Contraction mapping and fixed point theorem, Applications.	To understand continuity in more general context and study its equivalent definitions.	Chalk & Talk	Learner understands continuity in more general context and study its equivalent definitions.	S.S.CHOKHANI	15
Unit II: Connected sets: (15L)						
	Separated sets- Definition and examples, disconnected sets, disconnected and connected metric spaces, Connected subsets of a metric space, Connected subsets of R. A subset of R is	To familiarize learner with concept of connectedness and path connectedness and apply it to cases of Euclidean metric spaces in particular.	Chalk & Talk	Learner able to understand concept of connectedness and path connectedness and apply it to cases of Euclidean metric spaces in particular	S.S.CHOKHANI	15

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	connected if and only if it is an interval. A continuous image of a connected set is connected. Character- ization of a connected space, viz. a metric space is connected if and only if every continuous function from X to R is a constant function. Path connectedness in Rn, de_nition and examples. A path connected subset of Rn is connected, convex sets are path connected. Con- nected components. An example of a connected subset of Rn which is not path connected.			and derive properties like IVP.		
Unit III : Sequence and series of functions:(15 lectures)						
	Sequence of functions - pointwise and uniform convergence of sequences of real-valued func- tions, examples. Uniform convergence implies pointwise convergence, example to show converse not true, series of functions, convergence of series of functions, Weierstrass M-test. Examples. Properties of uniform convergence: Continuity of the uniform limit of a	To explain pointwise and uniform convergence of sequences and series of functions, study their behaviour wrt continuity, term by term integration, term by term differentiation, continuity.	Chalk & Talk	All related applications like pointwise and uniform convergence of sequences and series of functions, study their behaviour wrt continuity, term by term integration, term by term differentiation, continuity are learned by learner.	S.S.CHOKHANI	15

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	sequence of continuous function, conditions under which integral and the derivative of sequence of functions converge to the integral and derivative of uniform limit on a closed and bounded interval. Examples. Conse- quences of these properties for series of functions, term by term differentiation and integration. Power series in R centered at origin and at some point in R , radius of convergence, region (interval) of convergence, uniform convergence, term by-term differentiation and integration of power series, Examples. Uniqueness of series representation, functions represented by power series, classical functions defined by power series such as exponential, cosine and sine functions, the basic properties of these functions.					

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: T.Y.B.Sc. Mathematics **CLASS:** T.Y.B.Sc. **SEM:** **V**
COURSE NAME: Linear Algebra **COURSE CODE:** USMT502 **CREDITS:** 2.5

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner how to develop skill of Linear Algebra and understand the concepts of Quotient Spaces and Orthogonal Linear Transformations

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	**Review of vector spaces over R , sub spaces and linear transformation.**	Learners able to understand the concept of vector spaces .	Chalk n talk	Identify the Spaces	MS. Shital Warbhe	7
	Quotient Spaces: For a real vector space V and a subspace W, the cosets v +W and the quotient space V=W ,		Chalk n talk		MS. Shital Warbhe	
	First Isomorphism theorem of real vector spaces (fundamental theorem of homomorphism of vector spaces), Dimension and basis of the quotient when V is finite dimensional.space V=W ,		Chalk n talk		MS. Shital Warbhe	
	Orthogonal transformations Isometries of a real _finite dimensional inner		Chalk n talk		MS. Shital Warbhe	

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	product space. Translations and Reflections with respect to a hyperplane, Orthogonal matrices over R Equivalence of orthogonal transformations and isometries fixing origin on a finite dimensional inner product space, Orthogonal transformation of R_2, Any orthogonal transformation in R_2 is a reflection or a rotation, Characterization of isometries as composites of orthogonal transformations and translation. Characteristic polynomial of an n×n real matrix.					
	Cayley Hamilton Theorem: Cayley Hamilton Theorem and its Applications (Proof assuming the result A(adjA) = I_n for an n × n matrix over the polynomial ring R[t].		Chalk n talk		MS. Shital Warbhe	
II	**Eigenvalues and eigen vectors:** Eigen values and eigen vectors of a linear transformation T : V → V , where V is a finite dimensional real vector space and examples, Eigen values and Eigen		Chalk n talk		MS. Shital Warbhe	

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	vectors of n× n real matrices, The linear independence of eigenvectors corresponding to distinct eigenvalues of a linear transformation and a Matrix. The characteristic polynomial of an n real matrix and a linear transformation of a finitedimensional real vector space to itself, characteristic roots, Similar					
	The characteristic polynomial of an n real matrix and a linear transformation of a finitedimensional real vector space to itself, characteristic roots, Similar matrices, Relation with change of basis, Invariance of the characteristic polynomial and (hence of the) eigen values of similar matrices, Every square matrix is similar to an upper triangular marix.		Chalk n talk		MS. Shital Warbhe	
	Minimal Polynomial : Minimal Polynomial of a matrix, Examples like minimal polynomial of		Chalk n talk		MS. Shital Warbhe	

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	scalar matrix, diagonal matrix, similar matrix, Invariant subspaces.					
III	**Diagonalisation :** Geometric multiplicity and Algebraic multiplicity of eigen values of an $n \times n$ real matrix, An $n \times n$ matrix A is diagonalizable if and only if has a basis of eigenvectors of A if and only if the sum of dimension of eigen spaces of A is n if and only if the algebraic and geometric multi-plicities of eigen values of A coincide,Examples of non diagonalizable matrices, Diagonalisation of a linear transformation $T : V \to V$, where V is a finite dimensional real vector space and examples.		Chalk n talk		MS. Shital Warbhe	

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	Orthogonal diagonalisation and Quadratic Forms: Orthogonal diagonalisation and Quadratic Forms. Diagonalisation of real Symmetric matrices,Examples, Applications to real Quadratic forms, Rank andSignature of a RealQuadratic form, Classification of conics in R_2 and quadric surfaces in R_3. Positive definite and semi definite matrices, Characterization of positive definite matrices in terms of principal minors.		Chalk n talk		MS. Shital Warbhe	

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: T.Y.B.Sc. Mathematics **CLASS:** T.Y.B.Sc. **SEM:** VI
COURSE NAME: Algebra **COURSE CODE:** USMT602 **CREDITS:** 2.5

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner how to develop skill of Algebra and understand the concepts of Quotient Spaces and Orthogonal Linear Transformations

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	**Group Theory:** Review of Groups, Subgroups, Abelian groups, Order of a group, Finite and infinite groups, Cyclic groups, The Center Z(G) of a group G, Cosets, Lagrange's theorem, Grouphomomorphism, isomorphism's, auto morphisms, inner automorphisms.	Learners able to understand the concept Group Subgroup.	Chalk n talk	Identify group, subgroup	MS. Shital Warbhe	7
	Normal subgroups: Normal subgroups of a group, definition and examples including center of a group, Quotient group, Alternating group A_n, Cycles. Listing normal subgroups of A_4; S_3. First Isomorphism theorem (or Fundamental Theorem of homomorphism's of groups), Second Isomorphism theorem, third Isomorphism theorem, Cayleys theorem, External direct product of a group, Properties of external	Learners able to understand the concept Cosets, Normal Subgroup.	Chalk n talk	Implement isomorphism of group and partition of group.	MS. Shital Warbhe	8

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	direct products, Order of an element in a direct product, criterion for direct product to be cyclic, Classification of groups of order ≤ 7.					
II	**Ring Theory:** Definitions of a ring (The definition should include the existence of a unity element), zero divisor, unit, the multiplicative group of units of a ring. Basic Properties & examples of rings, including Z;Q;R;C;Mn(R);Q[X]; R[X];C[X]; Z[i]. Definitions of Commutative ring, integral domain (ID), Division ring, examples. Theorem such as: A commutative ring R is an integral domain if and only if for a; b; c 2 R with a 6= 0 the relation ab = ac implies that b = c. Definitions of Subring, examples.	Learners able to understand the concept Ring ,unit , Zero divisor, integral domain.	Chalk n talk	Identify Ring. Discriminat e unit , Zero divisor, integral domain.	MS. Shital Warbhe	7
	Ring homomorphisms: Properties of ring homomorphisms, Kernel of ring homomorphism, Ideals, Operations on ideals and Quotient rings, examples. Factor theorem and First and second Isomorphism theorems for rings, Correspondence Theorem for rings: (If f : R → R' is a surjective ring	Learners able to understand the concept ring homomorphi sms, Quotient rings, Isomorphis m	Chalk n talk	Implement Homomorp hism ,isomorphis m of Ring	Ms. Shital Warbhe.	8

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	homomorphism,then there is a 1-1 correspondence between the ideals of R containing the ker f and the ideals of R. Definitions of characteristic of a ring, Characteristic of an ID.					
III	**Polynomial Rings:** Principal ideal, maximal ideal, prime ideal, the characterization of the prime and maximal ideals in terms of quotient rings. Polynomial rings, R[X] when R is an integral domain/ Field. Divisibility in Integral Domain, Definitions of associates, irreducible and primes. Prime (irreducible) elements in R[X];Q[X]; Z_p[X]. Eisensteins criterion for irreducibility of a polynomial over Z. Prime and maximal ideals in polynomial rings.	Learners able to understand the concept Maximal ideal and prime ideal	Chalk n talk	Discriminat-e Maximal ideal and prime ideal.	MS. Shital Warbhe	8
	Field theory: Definition of field, subfield and examples, characteristic of fields. Any field is an ID and a finite ID is a field.Characterization of fields in terms of maximal ideals, irreducible polynomials. Construction of quotient field of an integral domain (Emphasis on Z;Q). A	Learners able to understand the concept Field.	Chalk n talk	Identify field. Construct Quotient field.	MS. Shital Warbhe	7

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	field contains a subfield isomorphic to Z_p or Q.					

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. Mathematics **CLASS:** F.Y.B.Sc. **SEM:** I
COURSE NAME: Algebra-I **COURSE CODE:** USMT102 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner how to develop skill of Algebra and understand the concepts of Functions and equivalence relation.

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
II	**Functions** Definition of function, domain, co-domain and range of a function, composite functions, exam- ples, Direct image f(A) and inverse image f□1(B) for a function f, injective, surjective, bijective functions, Composite of injective, surjective, bijective functions when de_ned, invertible func- tions, bijective functions are invertible and conversely examples of functions including constant, identity, projection, inclusion, Binary operation as a function, properties, examples.	Learners able to understand the concept of Functions.	Chalk n talk	Identify the types of functions.	MS. Shital Warbhe	7
	Equivalence relation:	Learners able to	Chalk n talk	Identify the types of	Ms. Shital Warbhe.	6

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	Equivalence realtion,Equivalence classes, properties such as two equivalences classes are either identical or disjoint, De_nition of partition, every partition gives an equivalence relation and vice versa.	understand ,how to make a partition of set and types of relation.		relation.		
	Congruence is an equivalence relation on Z, Residue classes and partition of Z, Addition modulon, Multiplication modulo n, examples.	Learners able to understand addition modulo and multiplication modulo n .	Chalk n talk	Identify a partition of z.	Ms. Shital Warbhe.	2

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. Mathematics **CLASS:** F.Y.B.Sc. **SEM:** **II**
COURSE NAME: Algebra-II **COURSE CODE:** USMT202 **CREDITS:** 2

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner how to develop skill of Algebra and understand the concepts of Vector Spaces.

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
II	**Vector Spaces.:** Definition of real vector space, Examples such as R_n;R[X];M_{m_n}(R), space of real valued func- tions on a non- empty set.	Learners able to understand the concept of vector spaces.	Chalk n talk	Identify a spaces	MS. Shital Warbhe .	3
	Subspaces: definition, examples: lines , planes passing through origin as subspaces of respectively; upper triangular matrices, diagonal matrices, symmetric matrices, skew symmetric matrix as subspaces of M_n(R)(n = 2; 3); $P_n(X) = a_0 + a_1x + a_2x_2 + \_ \_ \_ + a_nx_n$; a_i 2 R; 81 _ i _ n as subspace of R[X] , the space of all solutions of the system of m homogeneous linear equations	Learners able to understand Concept of subspaces	Chalk n talk	Identify the Subset of given vector space	Ms. Shital Warbhe.	4

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	in n unknowns as a subspace of R^n.					
	Properties of a subspace: properties of a subspaces such as necessary and sufficient conditions for a non-empty subset to be a subspace of a vector space, arbitrary intersection of subspaces of a vector space is a subspace, union of two subspaces is a subspace if and only if one is the subset of other. .	Learners able to understand Properties of subspaces.	Chalk n talk	Implement for any subspaces.	Ms.Shital Warbhe.	4
	Linear depedent and independent of vectors : Finite linear combination of vectors in a vector space; linear span L(S) of a non-empty subset S of a vector space, S is a generating set for L(S);L(S) is a vector subspace of V ; Linearly independent/ Linearly Dependent subsets of a vector space, a subset fv_1; v_2; : : : ; v_kg is linearly dependent if and only 9i 2 f1; 2; : : : kg such that v_i is a linear	Learners able to understand ,how to write the linear combination of vectors .	Chalk n talk	Compare the set of vectors are linearly dependent and independent.		4

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	combination of other vectors v_js					

BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. **CLASS:** T.Y.B.Sc. **SEM:** V
COURSE NAME: MULTIPLE INTEGRAL **COURSE CODE:** USMT501 **CREDITS:**2.5

COURSE Objectives:(L/WEEK: 3)
The objective of this course is to provide the concept of higher order integration also to provide the concept of integration integrate over line,surface in plane and surface in space and deriving useful results to make integration solving comparatively easier.

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	**MULTIPLE INTEGRALS:** Definition of double (resp: triple) integral of a function and bounded on a rectangle (resp:box). Geometric interpretation as area and volume. Fubini's Theorem over rectangles and any closed bounded sets, Iterated Integrals.	To provide the concept of double and triple integration over bounded region R in $\mathbb{R}^2$ &$\mathbb{R}^3$. To provide the concept that integration of scalar function $Z = f(x, y) \geq 0$ over a bounded region R in plane gives the volume of region whose upper surface is $Z = f(x, y)$ and lower surface is R. To provide the	Chalk and Talk	Learners are able to find the area of region bounded by curves. Learners are able to derive the formula of volume of sphere,cone,cylinder.	Seeta Vishwakarma	5

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		concept of fubini's theorem which is helpful in solving some double integration which appears to be difficult at first glance.				
	Basic properties of double and triple integrals proved using the Fubini's theorem such as (i) Integrability of the sums, scalar multiples, products, and (under suitable conditions) quo-tients of integrable functions. Formulae for the integrals of sums and scalar multiples of integrable functions. (ii) Integrability of continuous functions. More generally, Integrability of functions with a \small set of (Here, the notion of \small sets should include finite unions of graphs of continuous	To provide the concept of double or triple integration of finite sum of continuous scalar field is equal to finte sum of integration of scalar field. To provide the concept that if scalar field is having set of discontinuity with content zero then that function is integrable .	Chalk and Talk	Learners learn the concept of double or triple integration of finite sum of continuous scalar field is equal to finite sum of integration of scalar field and they are able to apply this concept while solving integration problem. Learns the concept that if scalar field is having set of discontinuity with content zero then that function is integrable and they are able to apply this concept while solving integration problem also able to identify whether given function is integrable or not just looking at the problem.	Seeta Vishwakarma	5

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	functions.)					
	Domain additivity of the integral. Integrability and the integral over arbitrary bounded domains. Change of variables formula (Statement only).Polar, cylindrical and spherical coordinates, and integration using these coordinates. Differentiation under the integral sign. Applications to finding the center of gravity and moments of inertia.	To provide concept of dividing the domain and then integrating to make problem solving easier. To provide the concept of changing of variable from one co-ordinate system to another co-ordinate system to make problem solving easier.	Chalk and Talk.	By knowing the concept of dividing the domain learners are able to solve problem with less efforts. By knowing the concepts of change of variable learners are able to convert highly complicated integration to easiest one they are also able to find center of gravity and moment of inertia of solid region.	Seeta Vishwak arma	5
II	**LINE INTEGRALS:-** Review of Scalar and Vector Fields on $\mathbb{R}^n$, Vector Differential Operators, Gradient, Curl, Divergence. Paths (parametrized curves) in (emphasis on $\mathbb{R}^2$and $\mathbb{R}^3$), Smooth and piecewise smooth paths. Closed paths. Equivalence	To provide the concept of Parametrized smooth curve in $\mathbb{R}^n$, $n = 2 \; or \; 3$ To provide the concept of line integration. To provide the concept of vector differential operators,gradient,curls,divergence. To provide concept of line integration of vector field.	chalk and talk.	Learners are able to parametrise the curves in $\mathbb{R}^n$, $n = 2 \; or \; 3$ By knowing the concept of line integration learners are able to find the length of curve in $\mathbb{R}^n, n = 2 \; or \; 3$ By knowing the concept of line integration of vector field(force field) ,learners are able to find work done by force in moving partical along the curve in	Seeta Vishwak arma	

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	and orientation preserving equivalence of paths. Definition of the line integral of a vector field over a piecewise smooth path.			space.		
	Basic properties of line integrals including linearity, path-additivity and behavior under a change of parameters. Examples. Line integrals of the gradient vector field, Fundamental Theorem of Calculus for Line Inte-grals,	To familiarize with the concept that line integral of gradient field is path independent. To familiarize with the fact that if line integration of a vector field over closed path is zero then it is conservative.	Chalk and Talk	Learners learn that line integral of gradient field is path independent and using this result able to solve problems. Learners learn that If line integration of a vector field over closed path is zero then it is conservative.	Seeta Vishwak arma	5
	Necessary and sufficient conditions for a vector field to be conservative. Green's Theorem (proof in the case of rectangular domains). Applications to evaluation of line integral.	To provide the concept of Greens theorem which is useful in converting line integration to double integration	Chalk and Talk	By using green's theorem leraners are able to find area of region in plane.	Seeta Vishwak arma	5
III	**<u>SURFACE INTEGRALS:-</u>** Parameterized surfaces. Smoothly equivalent parameterizati ons. Area of such surfaces. Definition of	To provide the concept of surface integral of scalar field and vector field. To provide concept of	Chalk and Talk	Learners are able to interprete surface integration of vector field as flux. By parametrising the surface learners are able to find normal and		5

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	surface integrals of scalar-valued functions as well as of vector fields defined on a surface.	parametrized surface.		tangent plane to surface.		
	Curl and divergence of a vector field. Elementary identities involving gradient, curl and divergence.	To provide concept of curl and divergence	Chalk and Talk	Learners are able to find rotational effect of vector field.		5
	Stoke's Theorem (proof assuming the general from of Green's Theorem). Examples. Gauss Divergence Theorem (proof only in the case of cubical domains). Examples.	To provide concept of stoke's theorem and divergence theorem.	Chalk and Talk	By using stoke's theorem learners able to solve line integral converting it into surface integral and vice versa. By using Divergence theorem learners are able to solve surface integral by converting it into volume integral and vice versa.		5

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BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. **CLASS:** T.Y.B.Sc. **SEM:** VI
COURSE NAME: BASIC COMPLEX ANALYSIS **COURSE CODE:** USMT601 **CREDITS:**2.5

COURSE Objectives:(L/WEEK: 3)
The objective of this course is the exposure of complex number and complex analysis extending the concept of real analysis including limit,continuity and differentiation.
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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	**INTRODUCTION TO COMPLEX ANALYSIS:-** Review of complex numbers,Complex plane, polar coordinates, exponential map, powers and roots of complex numbers, De Moivres formula, $\mathbb{C}$ as a metric space, bounded and unbounded sets, point at infinity,extended complex plane, sketching of set in complex plane (No questions to be asked). Limit at a point, theorems on limits, convergence	To familiarize the learner with complex number,sketching the region,complex valued function and its real and imaginary part. To familiarize with sequence of complex number,limits and continuity of complex function	Chalk and talk	Learners learns the represention of complex number in polar form and exponential form which problem solving comparatively easier. Learners are able to compare complex plane with $\mathbb{R}^2$,identify real function and complex function	Seeta vishwakarma	5

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	of sequences of complex numbers and results using properties of real sequences. Functions $f\colon \mathbb{C} \to \mathbb{C}$, real and imaginary part of functions, continuity at a point and algebra of continuous functions.					
	Derivative of $f\colon \mathbb{C} \to \mathbb{C}$ compar-ison between differentiability in real and complex sense, Cauchy-Riemann equations, sufficient conditions for differentiability, analytic function, f, g analytic then $f + g, fg, f/g (g \neq 0)$are analytic,	To familiarize with differentiability of complex valued func tion,analytic function	Chalk and talk	Learners are able to find derivative of complex valued function. Learners know when the complex function is analytic and differentiable at a point. find some complex function which is differential when it is real valued but nowhere differentiable when it is complex valued		5
	Theorem: If f(z) = 0 everywhere in a domain D, then f(z) must be constant throughout D, Harmonic functions and harmonic conjugate.	To learn that if derivative of complex valued function is zero in connected domain D then function is constant. To learn that real and imaginary part	Chalk and talk	Learners know that if derivative of complex valued function is zero in connected domain D then function is constant,also know that real and imaginary part of complex function are harmonic.		5

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		of complex function are harmonic				

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
II	**CAUCHY INTEGRSL FORMULA:-** Explain how to evaluate the line integral $\int f(z)dz$ over $\|z-z_0\|=r$ and prove the Cauchy integral formula : If f is analytic in $B(z_0,r)$ then for any w in $B(z_0,r)$ we have $f(w)=\frac{1}{2\pi i}\int \frac{f(z)}{z-w}dz$ over $\|z-z_0\|=r$	To familiarize with Cauchy integral formula which is very useful in evaluating some integration,	Chalk and talk	Using Cauchy integral formula able to solve many complex integration.		5
	Taylors theorem for analytic function, trigonometric function, hyperbolic functions.	To familiarize that if f is analytic at a point then f can be expressed in form of series which is valid or convergent in some nbd of that point.	Chalk and talk	Using this useful result learners are able to express analytic function including trigonometric function(sinZ ,cosZ) and hyperbolic function(sinhZ coshZ) in taylor series form.		5
	Mobius transformations: definition and examples Exponential function, its properties	To familiarize with mobius transformation.	Chalk and talk	Learners know that image of circle under mobius transformation is circle or straight line.		5

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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
III	**<u>COMPLEX POWER SERIES,LAURENT SERIES,ISOLATED SINGULARITY:-</u>** Power series of complex numbers and related results following from Unit I, radius of conver-gences, disc of convergence, uniqueness of series representation, examples.	To learn power series,its radius of convergence, To provide the concept that power series is analytic function in its radius of convergence.	Chalk and talk	Learners are able to find domain of convergence of power series. Also able to find value of derived series of power series.		5
	Definition of isolated singularity, statement (without proof) of ex-istence of Laurent series expansion in neighbourhood of an isolated singularity,	To provide concept of Laurent series. To provide concept of singularity and isolated singularity and types of singularity.. To provide concept of finding Laurent series of a function about its singularity.	Chalk and talk	Learners are able to find Laurent expansion of function in different domain. Learners are able to find singularity point of a function,also able to determine whether singularity is isolated or non isolated. .		5
	type of isolated singularities viz. removable, pole and essential defined using	To provide the concept of determining types of singularity by using Laurent	Chalk and talk	Students are able to identify types of singularity(removable,pole,essential) of function by observing its		5

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	Laurent series expansion, examples Statement of Residue theorem and calculation of residue.	expansion of function. To provide concept of residue.		laurents expansion about singular point. Learners are able to find residue of pole of function.		

BHAVAN'S COLLEGE, ANDHERI(WEST)

Course Learning Objective and Outcome

PROGRAMME NAME: B.Sc. **CLASS:** T.Y.B.Sc. **SEM:** V
COURSE NAME:Graph Theory **COURSE CODE:** USMT5C4 **CREDITS:** 2.5

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner Graphs and Trees and shortest path algorithm And Hamiltonian and Eulerian graphs
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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	Basics Of Graphs: graphs , matrix ,simple and multiple graph, types of graphs- Complete graph, Null graph, Complementary graphs, Regular Graphs sub graphs of a graph Vertex and edge induce subgraphs, spanning subgraphs ,	1.To understand Graph structure ,types of graphs 2.to understand different types of graphs and properties 3.to learn to apply hand shaking lemma 4. to able to find spanning sub graphs of a simple graph 5.to understand to find complementary graph of a given graph	Diagrams, Model ,chalk and talk	1. students able to understand Graph structure ,types of graphs 2.able to solve problems on hand shaking lemma 3. able to apply hand shaking lemma for graphs 4. able to differentiate types of graphs. 5.able to find complementary graph of a given graph	Rajendra .Y .Chavan	5

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	Basic terminology: degree of a vertex, walk, trail path, cycle circuit.hand shaking Lemma.isomorphism between graphs and its consequences, self complementary and characterisation in terms of a cycle lengths.	1 to understand Walk,trail,path and cycle and circuit. 2.to train to identify graphs are isomorphic or not 3.to understand bipartite graph	Diagrams,model, chalk and talk	1. able to differentiate Walk,trail,path and cycle and circuit. 2. student can find graphs are isomorphic or not 3 students understand bipartite graph and properties	Rajendra .Y .Chavan	5
	graphs and connected graphs connected components and matrices associated with graphs Adjecency and incidence matrix of a graph	1 to understand connected and disconnected graphs 2.to find total components of graphs 3 .to understand matrix to graph and graph to matrix 4. Student understand the characterstics of graph from the adjacency and incidence matrix	Diagram, model, Chalk and talk	1.students differentiate between connected and disconnected graphs 2. able to find number of components. 3.Students are able to draw graphs from matrix and vice versa 4. Student understand the characterstics of graph from the adjacency and incidence matrix	Rajendra .Y .Chavan	3
	Degree sequence and havel -hakimi theorem ,distance in the graph shortest path problems Dijkstras's algorithm	1.to understand havel -hakimi theorem. 2. students Are trained to understand degree sequence and its properties	Chalk and talk	1. students are able to write theproof of the result. 2.using degree sequence students can determine whether graphical or not	Rajendra .Y .Chavan	2

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UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
II	Cut edge and cut vertices and relevant results Characterisation of cut edge	1.to understand cut vertex and characterstics 2.to understand cut edge. 3.to understand theorem on cut edge and cut vertex	Diagrams, Model ,chalk and talk	1.student understand cut edge of the graph. 2.student understand cut edge 3.student able to write the proof of theorem based on cut edge and cut vertex.	Rajendra .Y .Chavan	3
	Definition of tree and its characterizations spanning tree of graphs.	1.understand tree and properties 2.to able to draw tree graph and different types of trees	Diagram,model and chalk and talk	1students able to understand tree and properties 2.students can draw tree and understand different types	Rajendra .Y .Chavan	2
	Recurrence relation of spanning tree and cayley formula for spanning trees kn	.1 to understand the result recurrence relation on spanning tree. 2 to.train to find the spanning trees using recurrence	Diagram, model, Chalk and talk	1.student understand recurrence relation 2.student use caley result to find number of spanning trees 3.students can draw	Rajendra .Y .Chavan	5

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		3. to understand cayley result		minimal spanning trees		
	Algorithm for spanning trees BFS and DFS. prefix codes and Huffman coding, weightage graphs and minimal spanning tree,kruskal algorithm for minimal trees	1 to train Students in hufmann coding 2.to find minimal spanning tree using algorithms 3.to understand kruskal algorithm	Chalk and talk And diagrams	1.student can write coding. 2.student can perform rightly algorithm to find minimal spanning tree 3.students can perform kruskal algorithm	Rajendra .Y .Chavan	5

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
III	Eulerian graphs and its characterization-fluery algorithm	1.to understand eulerian graph and properties	Diagram, model. Chalk and talk	1 student understand eulerian graph and properties	R.Y. Chavan	02
	Hamiltonian graph.necessary condition for Hamiltonian graphs using G-S where s is proper subset Sufficient condition for Hamiltonian graphs	1students to understand Hamiltonian graph and its properties	Diagram, model. Chalk and talk	Student understand Hamiltonian graph and properties	Rajendra .Y .Chavan	5

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	Hamiltonian closure of a graph cube graph and its properties like regular ,bipartite ,connected	1to find the closure of Hamiltonian graph 2to understand the proof of Hamiltonian closure	Diagram,model Chalk and talk	1student find the closure of Hamiltonian graph 2students can write the proof of Hamiltonian closure	Rajendra .Y .Chavan	3
	Hamiltonian nature of cube graph,Line graph of a graph and simple results	1.to understand line graph and cube graph 2. students Are trained to draw line graph of a graph	Chalk and talk	1.students can write results on line graph and cube graph 2. students Are trained to draw line graph	Rajendra .Y .Chavan	5

BHAVAN'S COLLEGE, ANDHERI(WEST)

<u>Course Learning Objective and Outcome</u>

PROGRAMME NAME: <u>B.Sc.</u> **CLASS:** <u>T.Y.B.Sc.</u> **SEM:** <u>**VI**</u>
COURSE NAME:Graph Theory and Combinatorics **COURSE CODE:** <u>USMT6C4</u> **CREDITS:** <u>2.5</u>

COURSE Objectives: (L/WEEK: 3)
The objective of this course is to teach the learner Graphs and Trees and shortest path algorithm And Hamiltonian and Eulerian graphs
.

UNIT	TOPIC	OBJECTIVE	TEACHING AIDS used	OUTCOME	Faculty Engaging Lecture	No of lectures if defined
I	Vertex coloring-Evaluationof vertex chromatic number,critical graph, bounds of chromatic number. Statement brooks theorem	1to understand chromatic number and to find the chromatic number of known graph. 2To	Diagrams, Model ,chalk and talk	1studentunderstand chromatic number and can find the chromatic number of known graph. 2.student ableTo write the results on chromatic number.	Rajendra .Y .Chavan	5

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		understand the results on chromatic number				
	Edge coloring-Evaluation of edge coloring edge chromatic number , vizing theorem statement	1.to understand edge chromatic number and to find the edge chromatic number of known graph. 2.To understand the results on edge chromatic number	Diagrams, Model ,chalk and talk	1.Student can understand edge chromatic number and to find the edge chromatic number of known graph. 2.students able to edge chromatic number	Rajendra .Y .Chavan	5
	Chromatic polynomial,recurrence relation ,vertex and edge connectivity.	1.To understand chromatic polynomial 2. understand vertex connectivity		1.Students can find chromatic polynomial of a graph 2 able to find vertex connectivity	Rajendra .Y .Chavan	3
	Equality of a vertex and edge connectivity of cubic graphs.Whitney theorem on 2 vertex connected.	1 to understand result on edge connectivity of cubic graph	diagram and chalk and talk	1 to understand result on edge connectivity of cubic graph	Rajendra .Y .Chavan	2

UNIT	**TOPIC**	**OBJECTIVE**	**TEACHING AIDS used**	**OUTCOME**	**Faculty Engaging Lecture**	**No of lectures if defined**
II	Definition of planar graph. Euler formula and its consequences. Non planarity of K5;K(3; 3). Dual of a graph. Fulkerson theorem.	1.To Understand planer graph 2.To understand Euler theorem. 3.Ford Fulkerson algorithm	Digrams and model Talk and chalk	1student can draw planer graph and embedded in plane graph 2.able to write afford Fulkerson thm	Rajendra .Y .Chavan	5

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	Polyhedran in R3 and existence of exactl regular polyhedra-(Platonic solids)	To understand thm on regular polyhedra	Diagram and model Chalk and talk	1.able To prove thm on regular polyhedra	Rajendra .Y .Chavan	2
	Colorabilty of planar graphs- 5 color theorem for planar graphs, statement of 4 color theorem.	to understand theorem on planer graphs	Diagram and model Chalk and Talk	students are able to write theorem on planer graphs	Rajendra .Y .Chavan	3
	Networks and flow and cut in a network- value the capacity of cut in a network, relation between and cut. Maximal flow and minimal cut in a network and Ford-	To understand network flow To find maximum flow and minimum cut	Diagram ,and model Chalk and Talk	Students able to understand network flow To find maximum flow and minimum cut	Rajendra .Y .Chavan	5
UNIT	**TOPIC**	**OBJECTIVE**	**TEACHING AIDS used**	**OUTCOME**	**Faculty Engaging Lecture**	**No of lectures if defined**
III	Applications of Inclusion Exclusion Principle- Rook polynomial, Forbidden position alternating and M augmenting path, Berge theorem.Bipartite graphs.	1.To Understand Rook polynomial 2.understand application of inclusion exclusion	Diagram ,Model, Chalk and Talk	1.Students are able tom write Rook polynomial. 2.able to solve the problems on inclusion and exclusion.	Rajendra .Y .Chavan	5
	problems Introduction to partial fractions and using Newtonsbinomial theorem for real power nd series,	1.to understand catalan number and its proof.	Diagram ,Model, Chalk and Talk	Students are able to understand catalan number and its proof.	Rajendra .Y .Chavan	3
	expansion of some standard functions.	To understand recurrence	Diagram ,Model, Chalk and	Students are able solve recurrence	Rajendra .Y .Chavan	3

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	Forming recurrence relation and getting a generating function.	relation using generating function.	Talk	relation using generating function.		
	Solvingrecurrence relation using ordinary generating functions. System of Distinct Representatives and Hall's theorem of SDR. Introduction to matching, M	1.Understand theory SDR and examples 2.Understand Halls Marriage theorem	Diagram ,Model, Chalk and Talk	Students are Able to Understand theory SDR and examples Students are able Understand Halls Marriage theorem	Rajendra .Y .Chavan	2 2

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