Rayat Shikshan Sanstha's

Karmaveer Bhaurao Patil College Vashi, Navi Mumbai

Autonomous College

[University of Mumbai]

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of Course	T.Y.B.Sc. Mathematics
2	Eligibility for Admission	S.Y.B.Sc. (with Mathematics as one of the subject)
3	Passing Marks	40%
4	Ordinances/Regulations (if any)	
5	No. of Years/Semesters	One year/Two semester
6	Level	U.G.
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic year	2020-2021

Date: ________________

Signature: __________________

Name of BOS Chairman: ____

AC- 27/09/ 2019
Item No- 3.15

Rayat Shikshan Sanstha's
KARMAVEER BHAURAO PATIL COLLEGE, VASHI.
NAVI MUMBAI
Sector-15- A, Vashi, Navi Mumbai - 400 703

(AUTONOMOUS COLLEGE)

Syllabus for Mathematics

Program: B.Sc.

Course: T.Y.B.Sc. Mathematics

(Choice Based Credit, Grading and Semester System with effect from the academic year 2020-2021)

SEMESTER V

Course Code	UNIT	TOPICS	Credits	L/Week
Integral Calculus				
UGMT501	I	Multiple Integrals	2.5	3
	II	Line Integrals		
	III	Surface Integrals		
Linear Algebra				
UGMT502	I	Quotient spaces and Orthogonal Linear Transformations	2.5	3
	II	Eigen values and Eigen vectors		
	III	Diagonalization		
Topology of Metric Spaces				
UGMT503	I	Metric spaces	2.5	3
	II	Sequences and Complete metric spaces		
	III	Compact Sets		
Numerical Analysis I (Elective A)				
UGMT504A	I	Errors Analysis and Transcendental & Polynomial Equations	2.5	3
	II	System of Linear and Non-linear equations		
	III	Eigen Value Problem and ODE		
Number Theory and Its applications I (Elective B)				
UGMT504B	I	Congruences and Factorization	2.5	3
	II	Diophantine equations and their & solutions		
	III	Primitive Roots and Cryptography		
Graph Theory (Elective C)				
UGMT504C	I	Basics of Graphs	2.5	3
	II	Trees		
	III	Eulerian and Hamiltonian graphs		
	II	Properties of Distribution function, Joint Density function		
	III	Weak Law of Large Numbers		
PRACTICALS				
UGMTP501		Practicals based onUGMT501 and UGMT 502	3	6
UGMTP502		Practicals based on UGMT503 and UGMT504A OR UGMT504B OR UGMT504C	3	6

SEMESTER VI

Course Code	UNIT	TOPICS	Credits	L/Week
Basic Complex Analysis				
UGMT601	I	Introduction to Complex Analysis	2.5	3
	II	Cauchy Integral Formula		
	III	Complex power series, Laurent series and isolated singularities		
Algebra				
UGMT602	I	Group Theory	2.5	3
	II	Ring Theory		
	III	Polynomial Rings and Field theory Homomorphism		
Topology of Metric Spaces and Real Analysis				
UGMT603	I	Continuous functions on Metric spaces	2.5	3
	II	Connected sets		
	III	Sequences and series of functions		
Numerical Analysis II (Elective A)				
UGMT604A	I	Interpolation	2.5	3
	II	Polynomial Approximations and Numerical Differentiation		
	III	Numerical Integration		
Operations Research (Elective B)				
UGMT604B	I	Linear Programming I		
	II	Linear Programming II		
	III	Transportation and Assignment model		
Graph Theory and Combinatorics (Elective C)				
UGMT604C	I	Colorings of Graphs	2.5	3
	II	Planar graph		
	III	Combinatorics		
PRACTICALS				
UGMTP601		Practicals based on UGMT601 and UGMT 602	3	6
UGMTP602		Practicals based on UGMT603 and UGMT604A OR UGMT604B OR UGMT604C	3	6

Note: 1. Blue Highlighted Topic / Course has focused on employability/ entrepreneurship/skill development

2. Yellow Highlighted Topic / Course is related to professional ethics, gender, human values, Environment & sustainability
3. Green Highlighted Topic / Course is related to local/national/regional & global development needs.

Note: 1. UGMT501, UGMT502, UGMT503 are compulsory courses for Semester V.
2. Candidate has to opt one Elective Course from UGMT504A, UGMT504B and UGMT504D for Semester V.
3. UGMT601, UGMT602, UGMT603 are compulsory courses for Semester VI.
4. Candidate has to opt one Elective Course from UGMT604A, UGMT604B, and UGMT604C for Semester VI.

One practical of three periods per week per course (1 lecture/period is of 48 minutes duration).

SEMESTER V

Course: Integral Calculus
Course Code: UGMT501

Course Outcome of Multivariable Calculus II:
Students will be able to:

1. Define double and triple integral and explain geometrically area and volume.
2. Explain Fubini's theorem and basic properties of double and triple integrals.
3. Solve examples by converting it to polar, cylindrical and spherical coordinates.
4. Find and interpret the gradient curl, divergence for a function at a given point.
5. Interpret line, surface and volume integrals.
6. Evaluate integrals by using Green's Theorem, Stokes theorem, Gauss's Theorem.
7. Define surface integral over scalar and vector field.
8. Prove Stoke's theorem.

ALL Results have to be done with proof unless otherwise stated.

UNIT I: Multiple Integrals (15 lectures)

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. Basic properties of double and triple integrals proved using the Fubini's theorem such as integrability of the sums, scalar multiples, products, and (under suitable conditions) quotients of integrable functions. Formulae for the integrals of sums and scalar multiples of integrable functions.
Integrability of continuous functions.
Domain Additivity of the integral. Integrability and the integral over arbitrary bounded domains. Change of variables formula. 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.

UNIT II: Line Integrals (15 lectures)

Review of Scalar and Vector fields on R^n.
Vector Differential Operators, Gradient, Curl, Divergence.
Paths (parameterized curves) in R^n (emphasis on R^2 and R^3), Smooth and piecewise smooth paths. Closed paths. Equivalence and orientation preserving equivalence of paths. Definition of the line integral of a vector field over a piecewise smooth path. 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 Integrals, Necessary and sufficient conditions for a vector field to be conservative. Greens Theorem (proof in the case of rectangular domains). Applications to evaluation of line integrals.

UNIT III: Surface Integrals (15 lectures)

Parameterized surfaces. Smoothly equivalent parameterizations. Area of such surfaces.
Definition of surface integrals of scalar-valued functions as well as of vector fields defined on a surface.
Curl and divergence of a vector field. Elementary identities involving gradient, curl and divergence.
Stokes Theorem (proof assuming the general from of Greens Theorem) and applications.Gauss Divergence Theorem (proof only in the case of cubical domains) and applications

References:

1. Apostol, Calculus, Vol. 2, Second Ed., John Wiley, New York, 1969 Section 1.1 to 11.8
2. 2. James Stewart , Calculus with early transcendental Functions - Section 15
3. 3. J.E.Marsden and A.J. Tromba, Vector Calculus, Fourth Ed., W.H. Freeman and Co., New York, 1996.Section 5.2 to 5.6.
4. Lawrence Corwin and Robert Szczarba ,Multivariable Calculus, Chapter 12.

Other References:

1. R. Courant and F.John, Introduction to Calculus and Analysis, Vol.2, Springer Verlag, New York, 1989.
2. W. Fleming, Functions of Several Variables, Second Ed., Springer-Verlag, New York, 1977.
3. M.H. Protter and C.B.Morrey Jr., Intermediate Calculus, Second Ed., Springer-Verlag, New York, 1995.
4. G.B. Thomas and R.L Finney, Calculus and Analytic Geometry, Ninth Ed. (ISE Reprint), Addison-Wesley, Reading Mass, 1998.
5. D.V.Widder, Advanced Calculus, Second Ed., Dover Pub., New York. 1989.
6. A course in Multivariable Calculus and Analysis., Sudhir R.Ghorpade and Balmohan Li-maye, Springer International Edition.

Course: Linear Algebra

Course Code: UGMT502

Course Outcome of Linear algebra:
Students will be able to:

1. Define Vector Space, Quotient space Direct sum, linear span and linear independence, basis and inner product.
2. Prove first isomorphism theorem.
3. Define orthogonal transformation, Isometries, reflections and rotations.
4. Find characteristic polynomial of a given matrix.
5. Find the eigen values and eigen vectors of a matrix.
6. Prove Cayley- Hamilton theorem, Schwartz inequality.
7. Calculate algebraic and geometric multiplicity and deduce if a matrix is diagonalizable.
8. Find quadratic forms.

UNIT I: Quotient Spaces and Orthogonal Linear Transformations (15 Lectures)

Review of linear transformations & inner product spaces.

Orthogonal transformations: Isometries of a real finite dimensional inner product space, Translations and Reflections with respect to a hyperplane, Orthogonal matrices over □ , Equivalence of orthogonal transformations and Isometries fixing origin on a finite dimensional inner product space, Orthogonal transformation of □^{2}, Any orthogonal transformation in □^{2} is a reflection or a rotation, Characterization of isometries as composites of orthogonal transformations and translation.

Quotient Spaces: For a real vector space V and a subspace W , the cosets v + W and the quotient space V /W , First Isomorphism theorem of real vector spaces (fundamental theorem of homomorphism of vector spaces), Dimension and basis of the quotient space V/W .

UNIT II: Eigen values and Eigen vectors (15 Lectures)

Eigen values and Eigen vectors of a linear transformation,T: $V \to V$, where V is a finite dimensional real vector space and examples, Eigen values and Eigen vectors of $n \times n$ real matrices, The linear independence of eigen vectors corresponding to distinct eigenvalues of a linear transformation and a Matrix. ,

The characteristic polynomial of an $n \times n$ real matrix and a linear transformation of a finite dimensional real vector space to itself, characteristic roots,

Cayley Hamilton Theorem and its Applications.

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 matrix. Minimal Polynomial of a matrix, Examples like minimal polynomial of scalar matrix, diagonal matrix, similar matrix.

UNIT III: Diagonalisation (15 Lectures)

Invariant subspaces and block diagonal matrices.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 it 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 multiplicities of eigen values of A coincide, Examples of non diagonalizable matrices, Diagonalization of a linear transformation $T : V \to V$, where V is a finite dimensional real vector space and examples. Orthogonal diagonalisation and Quadratic Forms. Diagonalisation of real Symmetric matrices, Examples, Applications to real Quadratic forms, Rank and Signature of a Real Quadratic form, Classification of conics inR^2 and quadric surfaces inR^3. Positive definite and semi definite matrices, Characterization of positive definite matrices in terms of principal minors.

References:

1. S. Kumaresan, Linear Algebra: A Geometric Approach.
2. Ramachandra Rao and P. Bhimasankaram, Tata McGraw Hill Publishing Company.

Other References:

1. T. Bancho and J. Wermer, Linear Algebra through Geometry, Springer.
2. L. Smith, Linear Algebra, Springer.
3. M. R. Adhikari and Avishek Adhikari, Introduction to linear Algebra, Asian Books Private Ltd.
4. Kenneth Hoffman and Ray Kunze, Linear Algebra, Prentice Hall of India, New Delhi.
5. Inder K Rana, Introduction to Linear Algebra, Ane Books Pvt. Ltd.

Course: Topology of Metric Spaces

Course Code: UGMT503

Course Outcome of Topology of metric spaces:
Students will be able to:

1. Define metric spaces, discrete metric space, metric subspace.
2. Explain properties of metric space, open set, Hausdroff property.
3. Find distance of a point from a set.
4. Define sequences, convergent sequences and Cauchy sequences in a metric space and solve examples.
5. Characterize limit points and closure in terms of sequences.
6. Define complete metric spaces and explain nested interval theorem and Cantor's
7. Define compact metric space, sequentially compact metric space and solve examples.
8. Explain properties of compact metric space.
9. Prove Heine Borel property, closed and boundedness property and Bolzano-weierstrass property.

UNIT I: Metric spaces (15 Lectures)

Definition, examples of metrics in R and R^2 , R^n with its Euclidean, sup and sum metric, C (complex numbers), the spaces l^1 andl^2 of sequences and the space C[a, b], of real valued continuous functions on [a, b]. Discrete metric space.

Distance metric induced by the norm and its translation invariance.

Metric subspaces, Product of two metric spaces. Open balls and open set in a metric space, examples of open sets in various metric spaces. Hausdroff property. Interior of a set. Properties of open sets. Structure of an open set in$R$. Equivalent metrics.

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.

UNIT II: Sequences and Complete metric spaces (15 Lectures)

Sequences in a metric space, Convergent sequence in metric space, Cauchy sequence in a metric space, subsequences, examples of convergent and Cauchy sequence in metric spaces, $□^n$ with different metrics and other metric spaces.

Characterization of limit points and closure points in terms of sequences, Definition and examples 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 property in subspaces, Cantor's Intersection Theorem and its Applications. Density of rational Numbers, Intermediate Value theorem.

UNIT III: Compact sets (15 Lectures)

Definition of compact metric space using open cover, examples of compact sets in different metric spaces in□,$□^2$ and $□^n$, Properties of compact sets: closed and boundedness, Existence of limit points for infinite bounded subset. Compactness of closed subsets. Union and Intersection of Compact sets. Equivalent statements for compact sets in □. Sequentially compactness property.Heine-Borel property. Bolzano-Weierstrass's property.

Reference books:

1. S. Kumaresan, Topology of Metric spaces.

2. E. T. Copson. Metric Spaces. Universal Book Stall, New Delhi, 1996.
3. Expository articles of MTTS programme

Other references :

1. W. Rudin, Principles of Mathematical Analysis.
2. T. Apostol. Mathematical Analysis, Second edition, Narosa, New Delhi, 1974
3. E. T. Copson. Metric Spaces. Universal Book Stall, New Delhi, 1996.
4. R. R. Goldberg Methods of Real Analysis, Oxford and IBH Pub. Co., New Delhi 1970.
5. P.K.Jain. K. Ahmed. Metric Spaces. Narosa, New Delhi, 1996.
6. W. Rudin. Principles of Mathematical Analysis, Third Ed, McGraw-Hill, Auckland, 1976.
7. D. Somasundaram, B. Choudhary. A first Course in Mathematical Analysis. Narosa, New Delhi
8. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hi, New York, 1963. Sutherland. Topology.

Course: Numerical Analysis I (Elective A)

Course Code: UGMT504A

Course Outcome of Numerical Analysis I:
Students will be able to:

1. Express system of linear equation in matrix representation and find solution to the system using appropriate methods.
2. Have knowledge of iterative methods based on second degree equations.
3. Find relative, absolute and percentage errors. Find errors in different iterative methods.
4. Find rate of convergence of various iterative methods.

N.B. Derivations and geometrical interpretation of all numerical methods have to be covered.

UNIT I: Errors Analysis and Transcendental & Polynomial Equations (15 Lectures)

Measures of Errors: Relative, absolute and percentage errors. Types of errors: Inherent error, Round-off error and Truncation error. Taylor's series example. Significant digits and numerical stability.
Concept of simple and multiple roots. Iterative methods, error tolerance, use of intermediate value theorem.
Iteration methods based on first degree equation: Newton-Raphson method, Secant method, Regula-Falsi method, Iteration Method. Conditions for convergence and Rate of convergence of all above methods.
Iteration methods based on second degree equation: Muller method, Chebyshev method, Multipoint iteration method. Iterative methods for polynomial equations; Birge-Vieta method, Bairstow method.

UNIT II: System of linear and non-linear equations (15 Lectures)

Methods for multiple roots. Newton- Raphson method for System of non-linear equations and for complex roots. Conditions for convergence and Rate of convergence of all above methods.
Matrices: Pivot element, Partial and complete pivoting, Forward and backward substitution method, LU decomposition: Doolittle and Crout's method, Cholesky method. Error analysis of direct methods.
Iteration methods: Jacobi iteration method, Gauss-Seidel method, Relaxation method. Convergence analysis of iterative method.

UNIT III: Eigen value problem and ODE (15 Lectures)

Eigen value problem, Jacobi's method for symmetric matrices Power method to determine largest eigenvalue and eigenvector. Solution of Initial value problem of an ordinary first order differential equation:

One step methods; Taylor’s series method, Picard's method, Euler's method, Heun's method, Polygon method, Runge-Kutta method of second and fourth order; Accuracy of one-step methods. Numerical solution of system of first order Initial value problems.

Recommended Books

1. Kendall E. and Atkinson, An Introduction to Numerical Analysis, Wiley.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publications.
3. S.D. Comte and Carl de Boor, Elementary Numerical Analysis, An algorithmic approach, McGrawHillll International Book Company.
4. S. Sastry, Introductory methods of Numerical Analysis, PHI Learning.
5. Hildebrand F.B., Introduction to Numerical Analysis, Dover Publication, NY.
6. Scarborough James B., Numerical Mathematical Analysis, Oxford University Press, New Delhi.

Course: Number Theory and its applications I (Elective B)

Course Code: UGMT504B

Course Outcome of Number theory and its applications I:
Students will be able to:

1. Define congruences and state its elementary properties.
2. Define Euler’s function and its properties.
3. State Fermat’s little theorem, Euler’s generalization of the same.
4. Define linear Diophantine equation.
5. Explain the results such as Pythagorean triples, primitive solutions.
6. Define basic notations and encryption, decryption, etc.,
7. Explain RSA algorithm, concept of public key cryptosystem.

UNIT I: Congruences and Factorization (15 Lectures)

Divisibility, Primes and The fundamental theorem of Arithmetic. Congruences : Definition and elementary properties, Complete residue system modulo m, Reduced residue system modulo m , Euler's function and its properties, Fermat's little Theorem, Euler's generalization of Fermat's little Theorem, Wilson's theorem, Linear congruence, The Chinese remainder Theorem, Congruences of Hillgher degree, The Fermat-Kraitchik Factorization Method.

UNIT II: Diophantine equations and their solutions (15 Lectures)

The linear equations ax + by = c. The equations $x^2 + y^2 = p$; where p is a prime. The equation $x^2 + y^2 = z^2$, Pythagorean triples, primitive solutions, The equations $x^4 + y^4 = z^2$ and $x^4 + y^4 = z^4$ have no solutions (x, y, z) with $xyz \neq 0$. Every positive integer n can be expressed as sum of squares of four integers, Universal quadratic forms $x^2 +y^2 +z^2 +t^2$.

UNIT III: Primitive Roots and Cryptography (15 Lectures)

Order of an integer and Primitive Roots. Basic notions such as encryption (enciphering) and decryption (deciphering), Cryptosystems, symmetric key cryptography, Simple examples such as shift cipher, A ne cipher, Hill's cipher, Vigenere cipher. Concept of Public Key Cryptosystem; RSA Algorithm. An application of Primitive Roots to Cryptography.

Recommended Books:

1. Niven, H. Zuckerman and H. Montogomery, An Introduction to the Theory of Numbers, John Wiley & Sons. Inc.
2. David M. Burton, An Introduction to the Theory of Numbers. Tata McGraw Hill Edition.
3. G. H. Hardy and E.M. Wright. An Introduction to the Theory of Numbers. Low priced edition. The English Language Book Society and Oxford University Press, 1981.
4. Neville Robins. Beginning Number Theory. Narosa Publications.
5. S.D. Adhikari. An introduction to Commutative Algebra and Number Theory. Narosa Publishing House.
6. N. Koblitz. A course in Number theory and Cryptography, Springer.
7. M. Artin, Algebra. Prentice Hall.
8. K. Ireland, M. Rosen. A classical introduction to Modern Number Theory. Second edition, Springer Verlag.
9. William Stalling. Cryptology and network security.
10. Elementary number theory, David M. Burton.

Course: Graph Theory (Elective C)

Course Code: UGMT504C

Course Outcome of Graph theory:
Students will be able to:

1. Describe the origin of Graph Theory.
2. Illustrate different types of graph theory.
3. Explain independent sets and covering sets and some basic theorems.
4. Discuss degree sequences and operations on graphs.
5. Explain connectedness and components and some theorems.
6. Characterize tree.
7. Derive some properties of planarity and Euler’s formula.

UNIT I: Basics of Graphs (15 Lectures)

Definition of general graph, Directed and undirected graph, Simple and multiple graph, Types of graphs-Complete graph, Null graph, Complementary graphs, Regular graphs Sub graph of a graph, Vertex and Edge induced sub graphs, Spanning sub graphs. Basic terminology- degree of a vertex, Minimum and maximum degree, Walk, Trail, Circuit, Path, Cycle. Handshaking theorem and its applications, Isomorphism between the graphs and consequences of isomorphism between the graphs, Self complementary graphs, Connected graphs, Connected components. Matrices associated with the graphs Adjacency and Incidence matrix of a graph- properties, bipartite graphs and characterization in terms of cycle lengths. Degree sequence and Havel-Hakimi theorem, Distance in a graph- shortest path problems, Dijkstra's algorithm.

UNIT II: Trees (15 Lectures)

Cut edges and cut vertices and relevant results, Characterization of cut edge, Definition of a tree and its characterizations, Spanning tree, Recurrence relation of spanning trees and Cayley formula for spanning trees of K_n, Algorithms for spanning tree-BFS and DFS, Binary and m-ary tree, Pre x codes and Huffman coding, Weighted graphs and minimal spanning trees - Kruskal's algorithm for minimal spanning trees.

UNIT III: Eulerian and Hamiltonian graphs (15 Lectures)

Eulerian graph and its characterization- Fleury's Algorithm-(Chinese postman problem), Hamiltonian graph, Necessary condition for Hamiltonian graphs using G- S where S is a proper subset of V(G), Sufficient condition for Hamiltonian graphs- Ore's theorem and Dirac's theorem, Hamiltonian closure of a graph, Cube graphs and properties like regular, bipartite, Connected and Hamiltonian nature of cube graph, Line graph of graph and simple results.

Recommended Books.

1. Bondy and Murty Grapgh, Theory with Applications.
2. Balkrishnan and Ranganathan, Graph theory and applications.
3. West D G. Graph theory.

Additional Reference Book.

1. Behzad and Chartrand Graph theory.
2. Choudam S. A., Introductory Graph theory.

Course: Practicals (Based on UGMT501 and UGMT502)
Course Code: UGMTP501

Suggested Practicals (Based on UGMT501)

1. Evaluation of double and triple integrals.
2. Change of variables in double and triple integrals and applications
3. Line integrals of scalar and vector fields
4. Greens theorem, conservative field and applications
5. Evaluation of surface integrals
6. Stokes and Gauss divergence theorem
7. Miscellaneous theory questions on units 1, 2 and 3.

Suggested Practicals (Based on UGMT502)

1. Quotient Spaces, Orthogonal Transformations.
2. Cayley Hamilton Theorem and Applications
3. Eigen Values & Eigen Vectors of a linear Transformation/ Square Matrices
4. Similar Matrices, Minimal Polynomial, Invariant Subspaces
5. Diagonalisation of a matrix
6. Orthogonal Diagonalisation and Quadratic Forms.
7. Miscellaneous Theory Questions

Course: Practicals
(Based on UGMT503 and UGMT504A OR UGMT504B OR UGMT504C)
Course Code: UGMTP502

Suggested Practicals (Based on UGMT503)

1. Examples of Metric Spaces, Normed Linear Spaces,
2. Sketching of Open Balls in R^2, Open and Closedsets, Equivalent Metrics
3. Subspaces, Interior points, Limit Points, Dense Sets and Separability, Diameter of a set, Closure.
4. Limit Points ,Sequences , Bounded , Convergent and Cauchy Sequences in a Metric Space
5. Complete Metric Spaces and Applications
6. Examples of Compact Sets

7. Miscellaneous Theory Questions

Suggested Practicals on UGMT504A

The Practicals should be performed using non-programmable scientific calculator. (The use of programming language like C or Mathematical Software like Mathematica, Matlab, MuPad, andMaple may be encouraged).

1. Newton-Raphson method, Secant method, Regula-Falsi method, Iteration Method
2. Muller method, Chebyshev method, Multipoint iteration method
3. Descarte rule of signs, Birge-Vieta method, Bairstrow method
4. Gauss elimination method, Forward and backward substitution method,
5. Triangularization methods-Dolittles and Crouts method, Choleskys method
6. Jacobi iteration method, Gauss-Siedal method
7. Eigen value problem: Jacobis method for symmetric matrices and Power method to determine largest eigenvalue and eigenvector

Suggested Practicals on UGMT504B

1. Congruences.
2. Linear congruences and congruences of Hilgher degree.
3. Linear diophantine equation.
4. Pythagorean triples and sum of squares.
5. Cryptosystems (Private Key).
6. Cryptosystems (Public Key) and primitive roots.
7. Miscellaneous theoretical questions based on full UGMT5B4.

Suggested Practicals on UGMT504C

1.Handshaking Lemma and Isomorphism.
2.Degree sequence and Djikstra's algorithm
3.Trees, Cayley Formula
4.Applications of Trees
5.Eulerian Graphs.
6.Hamiltonian Graphs.
7. Miscellaneous Problems.

SEMESTER VI

Course: Basic Complex Analysis

Course Code: UGMT601

Course Outcome of Basic complex analysis:
Students will be able to:

1. Explain limits and convergence of sequences of complex numbers and results using properties of real sequences.
2. Compare the difference between differentiability in real and complex sense.
3. Define harmonic functions, harmonic conjugate and find the same.
4. Prove the Cauchy integral formula.
5. State the Taylor’s theorem for analytic functions.
6. Define a mobius transformations and solve examples.
7. Define power series of complex numbers and uniqueness of series representation.

8. State residue theorem and calculate residues.

UNIT I: Introduction to Complex Analysis (15 Lectures)

Review of complex numbers: Complex plane, polar coordinates, exponential map, powers and roots of complex numbers, De Moivres formula, □as a metric space, bounded and unbounded sets, point at infinity-extended complex plane, sketching of set in complex plane.

Limit at a point, theorems on limits, convergence of sequences of complex numbers and results using properties of real sequences. Functions $f : C \to C,$ real and imaginary part of functions, continuity at a point and algebra of continuous functions. Derivative of $f : C \to C$, comparison between differentiability in real and complex sense, Cauchy-Riemann equations, sufficient conditions for differentiability, analytic function, f, g analytic then f + g; f - g; fg and f/g are analytic, chain rule. Theorem: If f(z) = 0 everywhere in a domain D, then f(z) must be constant throughout D. Harmonic functions and harmonic conjugate.

UNIT II: Cauchy Integral Formula (15 Lectures)

Explain how to evaluate the line integral $\int \quad f(z) dz over \, |z - z_0| = r$ 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 $f(w) = \frac{1}{2\pi i} \int \quad \frac{f(z)}{z-w} dz.$

Taylors theorem for analytic function, Exponential function, its properties, trigonometric function, hyperbolic functions. Mobius transformations: definition and examples.

UNIT III: Complex power series, Laurent series and isolated singularities (15 Lectures)

Power series of complex numbers and related results following from Unit I, radius of convergences, disc of convergence, uniqueness of series representation, examples. Definition of Laurent series , Definition of isolated singularity, statement (without proof) of existence of Laurent series expansion in neighborhood of an isolated singularity, type of isolated singularities viz. removable, pole and essential defined using Laurent series expansion, examples Statement of Residue theorem and calculation of residue.

Reference:

1. J.W. Brown and R.V. Churchill, Complex analysis and Applications : Sections 18, 19, 20, 21, 23, 24, 25, 28, 33, 34, 47, 48, 53, 54, 55 , Chapter 5, page 231 section 65, de ne residue of a function at a pole using Theorem in section 66 page 234, Statement of Cauchys residue theorem on page 225, section 71 and 72 from chapter 7.

Other References:

1. Robert E. Greene and Steven G. Krantz, Function theory of one complex variable

2. T.W. Gamelin, Complex analysis

Course: Algebra
Course Code: UGMT602

Course Outcome of Algebra:

Students will be able to:

1. Define normal subgroups, quotient groups and index of a subgroup.
2. Define homomorphism, kernel of a homomorphism, isomorphism.
3. Prove Cayley's theorem, the fundamental theorem of homomorphism for Groups, second and third isomorphism theorems.
4. Define rings, zero divisors of a ring, integral domain, field, ideals and prove theorems.
5. Define polynomial rings, prime and maximal ideals and prove theorems.
6. Define irreducible polynomials. State the irreducibility tests and use it to solve problems.

UNIT I: Group Theory (15 Lectures)

Groups and Group homomorphisms (Review), isomorphisms, automorphisms, inner automorphisms.

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 homomorphisms of groups), Second Isomorphism theorem, third Isomorphism theorem, Cayleys theorem, External direct product of a group, Properties of external direct products, Order of an element in a direct product, criterion for direct product to be cyclic, Classification of groups of order ≤ 7.

UNIT II: Ring Theory (15 Lectures)

` Examples of rings: Integers & Polynomials. Definitions of a ring (The definition should include the existence of a unit element), zero divisor, unit, the multiplicative group of units of a ring. Basic Properties & examples of rings, including Z; Q; R; C; $M_n(R)$; Q [X]; R [X]; C [X]; Z [i]; Z [$\sqrt{2}$]; Z [$\sqrt{-5}$]; Z_n.

Definitions of integral domain, Division ring and examples. Definitions of Subring, examples. 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 ideals in a quotient ring. Definition of characteristic of a ring, Characteristic of an Integral Domain.

UNIT III: Polynomial Rings and Field theory

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. Definition of field, sub field and examples, characteristic of fields. Characterization of fields in terms of maximal ideals, irreducible polynomials. Construction of quotient field of an integral domain (Emphasis on $Z$and$Q$). Prime subfield of a field.

Recommended Books

1. P. B. Bhattacharya, S. K. Jain, and S. R. Nagpaul, Abstract Algebra, Second edition, Foundation Books, New Delhi, 1995.
2. N. S. Gopalakrishnan, University Algebra, Wiley Eastern Limited.
3. N. Herstein. Topics in Algebra, Wiley Eastern Limited, Second edition.
4. M. Artin, Algebra, Prentice Hall of India, New Delhi.
5. J. B. Fraleigh, A First course in Abstract Algebra, Third edition, Narosa, New Delhi.
6. J. Gallian, Contemporary Abstract Algebra, Narosa, New Delhi.

Additional Reference Books:

1. S. Adhikari, An Introduction to Commutative Algebra and Number theory, Narosa Publishing House.
2. T.W. Hungerford. Algebra, Springer.
3. D. Dummit, R. Foote. Abstract Algebra, John Wiley & Sons, Inc.
4. I.S. Luthar, I.B.S. Passi. Algebra, Vol. I and II.
5. U. M. Swamy, A. V. S. N. Murthy Algebra Abstract and Modern, Pearson.
6. Charles Lanski, Concepts Abstract Algebra, American Mathematical Society
7. Sen, Ghosh and Mukhopadhyay, Topics in Abstract Algebra, Universities press

Course: Topology of Metric Spaces and Real Analysis

Course Code: UGMT603

Course Outcome of Topology of metric spaces and real analysis:
Students will be able to:

1. Define continuity of function from one metric space to another.
2. Solve examples on open and closed sets of a metric space.
3. Prove algebra of continuous real valued functions in a metric space.
4. Define connected, separable sets in metric space.
5. Properties of connected sets.
6. Define path connected sets and solve examples based on the topics and prove theorems.
7. Define point wise and uniform convergence and solve examples.
8. Find radius of convergence, region of convergence.

UNIT I: Continuous functions on metric spaces (15 Lectures)

Epsilon-delta definition of continuity 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. Continuous image of compact set is compact, Uniform continuity in a metric space, definition and examples (emphasis on R). Contraction mapping and fixed point theorem and applications.

UNIT II: Connected sets (15 Lectures)

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 connected if and only if it is an interval. A continuous image of a connected set is connected. Characterization of a connected space, Path connectedness in R^n, definition and examples. A path connected subset of R^n is connected, convex sets are path connected. Connected components. An example of a connected subset of R^n which is not path connected.

UNIT III: Sequence and series of functions (15 Lectures)

Sequence of functions - pointwise and uniform convergence of sequences of real- valued functions, 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 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. Consequences of these properties for series of functions, term by term differentiation and integration. Power series in □ centered at origin and at some point in □ , 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.

References for Units I, II, III:

1. S. Kumaresan, Topology of Metric spaces.
2. E. T. Copson. Metric Spaces. Universal Book Stall, New Delhi, 1996.
3. Robert Bartle and Donald R. Sherbert, Introduction to Real Analysis, Second Edition, John Wiley and Sons.
4. Ajit Kumar, S. Kumaresan, Introduction to Real Analysis
5. R.R. Goldberg, Methods of Real Analysis, Oxford and International Book House (IBH) Publishers, New Delhi.

Other references :

1. W. Rudin, Principles of Mathematical Analysis.
2. T. Apostol. Mathematical Analysis, Second edition, Narosa, New Delhi, 1974
3. E. T. Copson. Metric Spaces. Universal Book Stall, New Delhi, 1996.
4. R. R. Goldberg Methods of Real Analysis, Oxford and IBH Pub. Co., New Delhi 1970.
5. P.K.Jain. K. Ahmed. Metric Spaces. Narosa, New Delhi, 1996.
6. W. Rudin. Principles of Mathematical Analysis, Third Ed, McGraw-Hill, Auckland, 1976.
7. D. Somasundaram, B. Choudhary. A first Course in Mathematical Analysis. Narosa, New Delhi
8. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hi, New York, 1963.
9. Sutherland. Topology.

Course: Numerical Analysis II (Elective A)
Course Code: UGMT604A

Course Outcome of Numerical Analysis II:
Students will be able to:

1. Define Basic concepts of operators Δ, E, ∇
2. Find the difference of polynomial
3. Solve problems using Newton forward formula and Newton backward formula.
4. Derive Gauss's formula and Stirling formula using Newton forward formula and Newton backward formula.
5. Derive Simpson's 1/3 ,3/8 rules using trapezoidal rule, Simpson's rule.

N.B. Derivations and geometrical interpretation of all numerical methods with theorem mentioned have to be covered.

UNIT I: Interpolation (15 Lectures)

Interpolating polynomials, Uniqueness of interpolating polynomials. Linear, Quadratic and Higher order interpolation. Lagranges Interpolation. Finite difference operators: Shift operator, forward, backward and central difference operator, Average operator and relation between them. Difference table, Relation between difference and derivatives. Interpolating polynomials using finite differences Gregory-Newton forward difference interpolation, Gregory-Newton backward difference interpolation, Stirlings Interpolation. Results on interpolation error.

UNIT II: Polynomial Approximations and Numerical Differentiation (15 Lectures)

Piecewise Interpolation: Linear, Quadratic and Cubic. Bivariate Interpolation: Lagranges Bivariate Interpolation, Newtons Bivariate Interpolation. Numerical differentiation: Numerical differentiation based on Interpolation, Numerical differentiation based on finite differences (forward, backward and central), Numerical Partial differentiation.

UNIT III: Numerical Integration (15 Lectures)

Numerical Integration based on Interpolation. Newton-Cotes Methods, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule. Determination of error term for all above methods. Convergence of numerical integration: Necessary and sufficient condition (with proof). Composite integration methods; Trapezoidal rule, Simpson's rule.

Reference Books

1. Kendall E, Atkinson, An Introduction to Numerical Analysis, Wiley.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain,, Numerical Methods for Scienti c and Engineering Computation, New Age International Publications.
3. S.D. Comte and Carl de Boor, Elementary Numerical Analysis, An algorithmic approach, McGrawHillll International Book Company.
4. S. Sastry, Introductory methods of Numerical Analysis, PHI Learning.
5. Hildebrand F.B, .Introduction to Numerical Analysis, Dover Publication, NY.
6. Scarborough James B., Numerical Mathematical Analysis, Oxford University Press, New Delhi.

Course: Operations Research (Elective B)

Course Code: UGMT064B

Course Outcome of Operations Research:
Students will be able to:

1. Form LPP graphically.
2. Find feasible solution to basic feasible region.
3. Explain simplex method with algorithm.
4. Solve transportation problems.
5. Find optimal solution by Modi method.
6. Define elements of Queuing model, pure birth and death model.
7. Solve problems using all the models.

UNIT I: Linear Programming-I (15 Lectures)

Prerequisites: Vector Space, Linear independence and dependence, Basis, Convex sets, Dimension of polyhedron, Faces. Formation of LPP, Graphical Method. Theory of the Simplex Method- Standard form of LPP, Feasible solution to basic feasible region, Improving BFS, Optimality Condition, Unbounded solution, Alternative optima, Correspondence between BFS and extreme points.

UNIT II: Linear programming-II (15 Lectures)

Simplex Method Simplex Algorithm, Simplex Tableau. Simplex Method Case of Degeneracy, Big-M Method, Infeasible solution, Alternate solution, Solution of LPP for unrestricted variable. Sensitivity analysis, integer programming.

UNIT III: Transportation and Assignment Model (15 Lectures)

Transportation Problem: Formation of TP, Concepts of solution, feasible solution, Finding Initial Basic Feasible Solution by North West Corner Method, Matrix Minima Method, Vogel's Approximation Method. Optimal Solution by MODI method, Unbalanced and maximization type of TP. Assignment model: Definitions, mathematical representations, solution of assignment problem, Hungarian method.

Reference for Unit III:

1. J. K. Sharma, Operations Research, Theory and Applications.
2. H. A. Taha, Operations Research, Prentice Hall of India.

Additional Reference Books:

1. Hillier and Lieberman, Introduction to Operations Research.
2. Richard Broson, Schaum Series Book in Operations Research, Tata McGrawHill Publishing Company Ltd.

Course: Graph Theory and Combinatorics (Elective C)

Course Code: UGMT604C

Course Outcome of Graph theory and Combinatorics:
Students will be able to:

1. Derive some properties of planarity and Euler's formula.
2. Find chromatic number and chromatic polynomials for graphs.
3. Prove Five colour theorem and state four colour theorem.
4. Define maximal flow and minimal cut in a network.
5. Apply principle of inclusion exclusion in various examples.
6. Form a recurrence relation and get a generating function.
7. Explain the concept of system of distinct representative and prove Hall's theorem.

Unit I. Colorings of graph (15L)

Vertex coloring- evaluation of vertex chromatic number of some standard graphs, critical graph. Upper and lower bounds of Vertex chromatic Number- Statement of Brooks theorem. Edge coloring- Evaluation of edge chromatic number of standard graphs such as complete graph, complete bipartite graph, cycle. Statement of Vizing Theorem. Chromatic polynomial of graphs-Recurrence Relation and properties of Chromatic polynomials. Vertex and Edge cuts vertex and edge connectivity and the relation between vertex and edge connectivity. Equality of vertex and edge connectivity of cubic graphs. Whitney's theorem on 2-vertex connected graphs.

Unit II. Planar graph (15L)

Definition of planar graph. Euler formula and its consequences. Non planarity of K_5; K(3; 3). Dual of a graph. Polyhedran in R^3 and existence of exactly five regular polyhedra- (Platonic solids) Colorabilty of planar graphs- 5 color theorem for planar graphs, statement of 4 color theorem. Networks and flow and cut in a network- value of a flow and the capacity of cut in a network, relation between flow and cut. Maximal flow and minimal cut in a network and Ford-Fulkerson theorem.

Unit III. Combinatorics (15L)

Applications of Inclusion Exclusion Principle- Rook polynomial, Forbidden position problems Introduction to partial fractions and using Newtons binomial theorem for real power and series, expansion of some standard functions. Forming recurrence relation and getting a generating function. Solving a recurrence relation using ordinary generating functions. System of Distinct Representatives and Hall's theorem of SDR. Introduction to matching, M alternating and M augmenting path, Berge theorem. Bipartite graphs.

Recommended Books.

1. Bondy and Murty Grapgh, Theory with Applications.
2. Balkrishnan and Ranganathan, Graph theory and applications. 3 West D G. , Graph theory.
3. Richard Brualdi, Introduction to Combinatorics.

Additional Reference Book.

1. Behzad and Chartrand Graph theory.
2. Choudam S. A., Introductory Graph theory. 3 Cohen, Combinatorics.

Course: Practicals
(Based on UGMT601 and UGMT602)
Course Code: UGMTP601

Suggested Practicals (Based on UGMT601):

1. Limit continuity and derivatives of functions of complex variables,
2. Steriographic Projection , Analytic function, nding harmonic conjugate,
3. Contour Integral, Cauchy Integral Formula ,Mobius transformations
4. Taylors Theorem , Exponential , Trigonometric, Hyperbolic functions
5. Power Series , Radius of Convergence, Laurents Series
6. Finding isolated singularities- removable, pole and essential, Cauchy Residue theorem.
7. Miscellaneous theory questions.

Suggested Practicals (Based on UGMT602):

1. Normal Subgroups and quotient groups.
2. Cayleys Theorem and external direct product of groups.
3. Rings, Subrings, Ideals, Ring Homomorphism and Isomorphism
4. Prime Ideals and Maximal Ideals
5. Polynomial Rings
6. Fields.
7. Miscellaneous Theoretical questions on Unit 1, 2 and 3.

Course: Practicals
(Based on UGMT603 and UGMT604A OR UGMT604B OR UGMT604C)
Course Code: UGMTP602

Suggested practicals Based on UGMT603:

1. Continuity in a Metric Spaces
2. Uniform Continuity, Contraction maps, Fixed point theorem
3. Connected Sets , Connected Metric Spaces
4. Path Connectedness, Convex sets, Continuity and Connectedness
5. Pointwise and uniform convergence of sequence functions,
6. Properties Point wise and uniform convergence of series of functions and properties
7. Miscellaneous Theory Questions

Suggested Practicals based on UGMT604A:

The Practicals should be performed using non-programmable scientific calculator. (The use of programming language like C or Mathematical Software like Mathematica, Matlab, MuPad, and Maple may be encouraged).

1 Linear, Quadratic and Higher order interpolation, Interpolating polynomial by Lagranges Interpolation.

2 Interpolating polynomial by Gregory-Newton forward and backward difference Interpolation and Stirling Interpolation.

3 Bivariate Interpolation: Lagranges Interpolation and Newtons Interpolation

4 Numerical differentiation: Finite differences (forward, backward and central), Numerical Partial differentiation.

5 Numerical differentiation and Integration based on Interpolation

6 Numerical Integration: Trapezoidal rule, Simpsons 1/3rd rule, Simpsons 3/8th rule

7 Composite integration methods: Trapezoidal rule, Simpsons rule.

Suggested Practicals based on UGMT604B

All practicals to be done manually as well as using software TORA / EXCEL solver.

1. LPP formation, graphical method and simple problems on theory of simplex method
2. LPP Simplex Method
3. Big-M method, special cases of solutions.
4. Transportation Problem
5. Queuing Theory; single server models
6. Queuing Theory; multiple server models
7. Miscellaneous Theory Questions.

Suggested Practicals based on UGMT604C

1. Coloring of Graphs
2. Chromatic polynomials and connectivity.
3. Planar graphs
4. Flow theory.
5. Inclusion Exclusion Principle and Recurrence relation.
6. SDR and Matching.
7. Miscellaneous theoretical questions.

Scheme of Examination

Class: T.Y.B.Sc.

I. Semester End Examinations: There will be a Semester-end Theory examination of 60 marks for each of the courses UGMT501, UGMT502, UGMT503, UGMT504A or UGMT504B or UGMT504C of Semester V and UGMT601, UGMT602, UGMT603, UGMT604A or UGMT604B or UGMT604C of semester VI.

1. Duration: The examinations shall be of 2 Hours duration.
2. Theory Question Paper Pattern:

a) There shall be FOUR questions. The questions first three questions shall be of 15 marks each based on the units I, II, III respectively. The fourth question shall be of 15 marks based on the entire syllabus.

b) All the questions shall be compulsory. The questions shall have internal choices within. Including the choices, the marks for each question shall be 30.

c) The questions may be subdivided into sub-questions and the allocation of marks depends on the weightage of the topic.

II. Continuous Internal Assessment: There shall be internal evaluation of 40 marks.

Paper	20 Marks	10 Marks	10 Marks
Paper I	Unit Test	Assignment	Class Seminar/ Online Course (Certificate 5 marks, Viva 5 marks)
Paper II	Unit Test	Assignment	
Paper III	Unit Test	Assignment	
Paper IV	Unit Test	Assignment	
Paper V	Unit Test	Assignment	Project work

Question paper pattern for Unit Test of 20 marks:

Online Test.

III. Semester End Practical Examination:

There shall be a Semester-end practical examinations of three hours duration and 100 marks for each of the courses UGMTP501 and UGMTP502 of Semester V and UGMTP601 and UGMTP602 of semester VI.

Question Paper pattern:

Paper pattern: The question paper shall have two parts A, B. Each part shall have two Sections.

Section I Objective in nature: Attempt any Eight out of Twelve multiple choice questions. (8 × 3 = 24 Marks)

Section II Problems: Attempt any Two out of Three. (8 × 2 = 16 Marks)

Practical Course	Part A	Part B	Marks out of	Duration
UGMTP501	Questions from UGMT501	Questions from UGMT502	80	3 hours

UGMTP502	Questions from UGMT503	Questions from UGMT50A4/ UGMT50B4/ UGMT50C4/ UGMT50D4	80	3 hours
UGMTP601	Questions from UGMT601	Questions from UGMT602	80	3 hours
UGMTP602	Questions from UGMT603	Questions from UGMT60A4/ UGMT60B4/ UGMT60C4/ UGMT60D4	80	3 hours

Marks for Journals and Viva:

For each course UGMT501, UGMT502, UGMT503, UGMT504, UGMT601, UGMT602 UGMT603, and UGMT604:

1. Journals: 5 marks.

2. Viva: 5 marks.

Each Practical of every course of Semester V and VI shall contain 10 (ten) problems out of which minimum 05 (five) have to be written in the journal. A student must have a certified journal before appearing for the practical examination.

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