St. Xavier's College (Autonomous), Mumbai

Syllabus of the courses offered by the Department of Mathematics

(2017-18)

St. Xavier's College – Autonomous Mumbai

Syllabus
For ODD Semester Courses in
MATHEMATICS
(2017-2018)

Contents:

Theory Syllabus for Courses:

F.Y.B.Sc. – Mathematics **Course Code: S.MAT.1.01**

Title: CALCULUS – I

Learning Objectives: To learn about (i) lub axiom of R and its consequences.
(ii) Convergence of sequences in R.
(iii) Limit and continuity of real valued functions of one variable.

Number of lectures : 45

Unit-I: Real Number System and Sequence of Real Numbers (15 Lectures)

Real Numbers: Real number system and order properties of R, Absolute value properties AM-GM inequality, Cauchy-Schwarz inequality, Intervals and neighbourhood, Hausdorff property, Bounded sets, Continuum property (l.u.b.axiom–statement, g.l.b.) and its consequences, Supremum and infimum, Maximum and minimum, Archimedean property and its applications, Density theorem.

Sequences: Definition of a sequence and examples, Convergence of a sequence, every convergent sequence is bounded, Limit of a sequence, uniqueness of limit if it exists, Divergent sequences, Convergence of standard sequences like $\{n^{1/n}\}$, $\{a^n\}$ Sequential version of Bolzano-Weierstrass theorem.

Unit II: Sequences (contd.) (15 Lectures)

Algebra of convergent sequences, Sandwich theorem for sequences, Monotone sequences, Monotone Convergence theorem and its consequences such as convergence of $\left(1+\frac{1}{n}\right)^n$.

Subsequences: Definition, Subsequence of a convergent sequence is convergent and converges to the same limit.

Cauchy sequence: Definition, every convergent sequence is a Cauchy sequence and converse.

Unit III: Limits and Continuity of real valued functions of one variable (15 Lectures)

Limit of Functions: Graphs of some standard functions such as |x|, e^x, log x, $\frac{1}{x}$, ax^2+bx+c, x^3, x⌋ (Flooring function), ┌x┐ (Ceiling function), sin x, cos x, tan x, x sin(1/x), x^2 sin(1/x) over
suitable intervals, Graph of a bijective function and its inverse, Limit of a function, evaluation of limit of simple functions using $\in -\delta$ definition, uniqueness of limit if it exists, Algebra of limits (with proof), Limit of a composite functions, Sandwich theorem (only statement), Left hand and right hand limits, non–existence of limits, Limit as $x \to \pm\infty$.

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, $\in -\delta$ definition of continuity, Sequential continuity, Algebra of continuous functions, Continuity of composite functions. Discontinuous functions, examples of removable and essential discontinuity.

Recommended Books:

1. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964.
2. Binmore, Mathematical Analysis, Cambridge University Press, 1982.
3. Robert G. Bartle and Donald R. Sherbet : Introduction to Real Analysis, Springer Verlag.
4. Howard Anton, Calculus - A new Horizon, Sixth Edition, John Wiley and Sons Inc,1999.

Additional Reference Books

1. T. M. Apostol, Calculus Vol I, Wiley & Sons (Asia) Pte. Ltd.
2. Courant and John, A Introduction to Calculus and Analysis, Springer.
3. Ajit and Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
4. James Stewart, Calculus, Third Edition, Brooks/cole Publishing Company,1994.
5. Sudhir R. Ghorpade and Balmohan V. Limaye, A Course in Calculus and Real Analysis, Springer International Ltd, 2000.

Assignments (Tutorials)

1. Application based examples of Archimedean property, intervals, neighbourhood.
2. Consequences of continuum property, infimum and supremum of sets.
3. Calculating limits of sequence.
4. Cauchy sequence, monotone sequence.
5. Limit of a function and Sandwich theorem.
6. Continuous and discontinuous functions.

F.Y.B.Sc. – Mathematics **Course Code: S.MAT.1.02**

Title: ALGEBRA - I

Learning Objectives: To learn about (i) divisibility of integers.
(ii) properties of equivalence relations and partitions.
(iii) roots of polynomials.

Number of lectures : 45

Prerequisites:

Set Theory: Set, subset, union and intersection of two sets, empty set, universal set, complement of a set, De Morgan's laws, Cartesian product of two sets, Relations, Permutations and combinations.

Complex numbers: Addition and multiplication of complex numbers, modulus, amplitude and conjugate of a complex number.

Unit I: Integers and divisibility **(15 Lectures)**

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 exponents, Pascal Triangle. Divisibility in integers, division algorithm, greatest common divisor (g.c.d.) and least common multiple (l.c.m.) of two integers, basic properties of g.c.d. such as existence and uniqueness of g.c.d. of integers a and b and that the g.c.d. can be expressed as ma + nb where m, n are in Z, Euclidean algorithm, Primes, Euclid's lemma, Fundamental theorem of arithmetic, the set of primes is infinite. Congruences, definition and elementary properties, Euler's □ function, Statements of Euler's theorem, Fermat's theorem and Wilson theorem, Applications.

Unit II: Functions and Equivalence relations **(15 Lectures)** Definition of a function, domain, codomain and range of a function, composite functions, examples, Direct image f [A] and inverse image $f^{-1}[A]$ of a function. Injective, surjective, bijective functions, Composite of injective, surjective, bijective functions, Invertible functions, Bijective functions are invertible and conversely, Examples of functions including constant, identity, projection, inclusion, Binary operation as a function, properties, examples. Equivalence relations, Equivalence classes, properties such as two equivalences classes are either identical or disjoint. Definition of partition, every partition gives an equivalence relation and vice versa, Congruence an equivalence relation on Z, Residue classes, Partition of Z, Addition modulo n, Multiplication modulo n, examples, conjugate classes.

Unit III: Polynomials **(15 Lectures)**
Definition of polynomial, polynomials over F where F = Q , R ,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), Euclidean algorithm (without proof), applications, Roots of a polynomial, relation between roots and coefficients, multiplicity of a root, Remainder theorem, Factor theorem, A polynomial of degree n over F has at most n roots. Complex roots of a polynomial in R[X] occur in conjugate pairs, Statement of Fundamental Theorem of Algebra, A polynomial of degree n in R[X] has exactly n complex roots counted with multiplicity. A non-constant polynomial in R[X] can be expressed as a product of linear and quadratic factors in C[X]. Necessary condition for a rational number to be a root of a polynomial with integer coefficients, simple consequences such as $\sqrt{p}$ is an irrational number where p is a prime number, n^{th} roots of unity, sum of n^{th} roots of unity.

Recommended Books

1. David M. Burton, Elementary Number Theory, Seventh Edition, McGraw Hill Education
(India) Private Ltd.
2. Norman L. Biggs, Discrete Mathematics, Revised Edition, Clarendon Press, Oxford 1989.

Additional Reference Books

1. I. Niven and S. Zuckerman, Introduction to the theory of numbers, Third Edition, Wiley Eastern, New Delhi, 1972.
2. G. Birkoff and S. Maclane, A Survey of Modern Algebra, Third Edition, Mac Millan, New York, 1965.
3. N. S. Gopalkrishnan, University Algebra, Ne Age International Ltd, Reprint, 2013.
4. I .N. Herstein, Topics in Algebra, John Wiley, 2006.
5. P. B. Bhattacharya S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, New Age International, 1994.
6. Kenneth Rosen, Discrete Mathematics and its applications, Mc-Graw Hill International Edition, Mathematics Series.

Assignments (Tutorials)

1. Mathematical induction (The problems done in F.Y.J.C. may be avoided).

2. Division Algorithm and Euclidean algorithm, in Z, Primes and the Fundamental Theorem of Arithmetic.
3. Functions (direct image and inverse image). Injective, surjective, bijective functions, finding inverses of bijective functions.
4. Congruences and Euler's function, Fermat's little theorem, Euler's theorem and Wilson's theorem.
5. Equivalence relation.
6. Factor Theorem, relation between roots and coefficients of polynomials, factorization and reciprocal polynomials.

CIA I – 20 marks, 45 mins. (Objectives/Short questions, not more than 5 marks each)

CIA II – 20 marks, 45 mins. (Objectives/Short questions, not more than 5 marks each)

End Semester exam – 60 marks, 2 hours.

There will be three questions, one per unit. The Choice is internal- i.e. within a unit and could be between 50% to 100%

S.Y.B.Sc. – Mathematics **Course Code: S.MAT.3.01**

Title: CALCULUS – III

Learning Objectives: To learn about (i) Riemann Integration **(ii) Different coordinate systems, Sketching in Improper integrals, β and Γ functions R^2 and R^3, iii) double integrals and its applications**

Number of lectures : 45

Unit I: Riemann Integration **(15 Lectures)**

Approximation of area,Upper / Lower Riemann sums and properties, Upper / Lower integrals, Definition of Riemann integral on a closed and bounded interval, Criterion for Riemann integrability, For a < c < b, f ∈ R[a, b] if and only if f ∈ R[a, c] and f ∈ R[c, b] with $\int_a^b f = \int_a^c f + \int_c^b f$. Properties: f, g ∈ R[a, b] then λ f ∈ R[a, b] and f+g ∈ R[a, b] with $\int_a^b \lambda f = \lambda \int_a^b f$ and $\int_a^b f + g = \int_a^b f + \int_a^b g$ and; f ∈ R[a, b] $|f| \in R[a, b]$; $\left|\int_a^b f\right| \leq \int_a^b |f|$;

$f \geq 0 \int_a f \geq 0$; f ∈ C[a, b] f ∈ R[a, b]; if f is bounded with finite number of discontinuities then f ∈ R[a, b] ; generalize this if f is monotone then f ∈ R[a, b].

Unit II: Indefinite and improper integrals **(15 Lectures)**

Continuity of $F(x) = \int_a^x f(t)dt$ where f ∈ R[a, b], Fundamental theorem of calculus,Mean value theorem, Integration by parts, Leibnitz rule, Improper integrals – type 1 and type 2, Absolute convergence of improper integrals, Comparison tests, Abel's and Dirichlet's tests (without proof); β and Γ functions with their properties, relationship between β and Γ functions.

Unit III: Applications **(15 Lectures)**

Topics from analytic geometry – sketching of regions in R^2 and R^3 , graph of a function, level sets, Cylinders and Quadric surfaces, Cartesian coordinates, Polar coordinates, Spherical coordinates, Cylindrical coordinates and conversions from one coordinate system to another.

(a) Double integrals: Definition of double integrals over rectangles, properties, double integrals

over a bounded region.

(b) Fubini`s theorem (without proof) – iterated integrals, double integrals as volume.

(c) Application of double integrals: average value, area, moment, center of mass.

(d) Double integral in polar form.

(Reference for Unit III: Sections 5.1, 5.2, 5.3 and 5.5 from Marsden-Tromba-Weinstein).

References:

1. Goldberg, Richard R.: Methods of real analysis. (2nd ed.) New York. John Wiley & Sons, Inc., 1976. 0-471-31065-4--(515.8GOL)

2. Goldberg, Richard R.: Methods of real analysis. (1st ed. Indian Reprint) New Delhi. Oxford & IBH Publishing Co., 1964(1975).--(515.8GOL)

3. Kumar, Ajit & Kumaresan, S.: A basic course in real analysis. (Indian reprint)

4. Boca Raton. CRC Press, 2015. 978-1-4822-1637-0--(515.8Kum/Kum)

5. Apostol, Tom M.: Calculus, Vol.-II. [Multi-variable calculus and linear algebra, with applications to differential equations and probability] (2nd ed.) New York. John Wiley & Sons, Inc., 1969. 0-471-00008-6--(515.14APO)

6. Stewart, James: Multivariable calculus:concepts & contexts. Pacific Grove.Brooks/Cole Publishing Company, 1998. 0-534-35509-9--(515STE)

7. Marsden, Jerrold E.;Tromba, Anthony J. & Weinstein, Alan: Basic multivariablecalculus.

(Indian reprint) New Delhi. Springer (India) Private Limited, 1993(2004). 81-8128-186-1--(515.84MAR)

8. Robert G. & Sherbert, Donald R.: Introduction to real analysis. (3rd ed.) New Delhi. Wiley India (P) Ltd, 2005(2007). 81-265-1109-5--(515.8Bar/She)

Suggested Tutorials:

1. Calculation of upper sum, lower sum and Riemann integral.
2. Problems on properties of Riemann integral.
3. Problems on fundamental theorem of calculus, mean value theorems, integration by parts, Leibnitz rule.
4. Convergence of improper integrals, applications of comparison tests, Abel's and Dirichlet's tests.
5. Sketching of regions in R^2 and R^3 , graph of a function, level sets, Cylinders and Quadric surfaces, conversions from one coordinate system to another.
6. Double integrals, iterated integrals, applications to compute average value, area, moment, center of mass.

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S.Y.B.Sc. – Mathematics **Course Code: S.MAT.3.02**

Title: ALGEBRA - III

Learning Objectives: (i) To understand linear maps and isomorphism between vector spaces

(ii) To study determinant function via permutations and its Laplace expansion,

Inverse of a matrix by adjoint method, Cramer`s rule,
(iii) To study Gram–Schmidt orthogonalization process in an inner product space.

Number of lectures : 45

Unit I: Linear Transformations and Matrices (15 Lectures)

1. Review of linear transformations and matrix associated with a linear transformation: Kernel and image of a linear transformation, Rank– Nullity theorem (with proof), Linear isomorphisms and its inverse. Any n–dimensional real vector space is isomorphic to R^n Matrix of sum, scalar multiple, composite and inverse of Linear transformations, Sum and scalar multiple of a linear transformation, spaceL(U,V) of Linear transformation from U to V where U and V are finite dimensional vector spaces over R , the dual space V*, linear functional, linear operator.

2. Elementary row operations, elementary matrices, elementary matrices are invertible and an invertible matrix is a product of elementary matrices.

3. Row space, column space of an $m\times n$ 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.

4. Equivalence of rank of an $m\times n$ matrix and rank of the linear transformation $L_A: R^n \rightarrow R^m$ $L_A(X) = AX$ where A is an $m\times n$ matrix. The dimension of solution space of the system of linear equation $AX = O$ 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 homogeneous system.

Unit II: Determinants (15 Lectures)

1. Definition of determinant as an n–linear skew–symmetric function from $R^n\times R^n \times \ldots\times R^n \rightarrow R$ such that determinant of $(E_1, E_2,\ldots,E_n)$ is 1 where E_j denotes the j^{th}

column of the identity matrix I_n. Determinant of a matrix as determinant of its column vectors (or row vectors).

2. of 2 Existence and uniqueness of determinant function via permutations, Computation of determinant × 2, 3× 3 matrices, diagonal matrices, Basic results on determinants such as det(A)=det(A^t),

det(AB) = det(A) det(B). Laplace expansion of a determinant, Vandermonde determinant, determinant of upper triangular and lower triangular matrices, finding determinants by row reduction method.

3. Linear dependence and independence of vectors in R^n using determinants. The existence and uniqueness of the system AX = B where A is an n × n matrix with det(A) ≠ 0. Cofactors and minors, Adjoint of an n× n matrix. Basic results such as A (adj A) = det(A) I_n. An n× n real matrix is invertible if and only if det(A) ≠ 0. Inverse (if exists) of a square matrix by adjoint method, Cramer's rule.

4. Determinant as area and volume.

Unit III: Inner Product Spaces (15 Lectures)

1. Dot product in R^n, Definition of general inner product on a vector space over R. Examples of inner product including the inner product $\langle f, g\rangle = \int_{-\pi}^{\pi} f(t)g(t)dt$ on $C[-\pi, \pi]$, the space of continuous real valued functions on $[-\pi, \pi]$.

2. Norm of a vector in an inner product space. Cauchy–Schwarz inequality, Triangle inequality, Orthogonality of vectors, Pythagoras's theorem and geometric applications in R^2, Projections on a line, The projection being the closest approximation, Orthogonal complements 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^2, R^3, R^4.

References:

1. Lang, Serge: Introduction to linear algebra. (2nd ed. 3rd Indian reprint) New Delhi. Springer (India) Private Limited, 2005(2009). 81-8128-260-6--(512.5Lan)

2. Kumaresan, S.: Linear algebra : a geometric approach. New Delhi. Prentice-Hall Of India Private Limited, 2001. 81-203-1628-2--(512.5KUM)

3. Krishnamurthy, V.; Mainra, V.P. & Arora, J.L: Introduction to linear algebra. New Delhi.Affiliated East-West Press Pvt. Ltd., 1976. 81-85095-15-9--(512.5KRI)

4. Lay, David C.: Linear algebra and its applications. (3rd ed.) Noida. Pearson Education Inc., 2016. 978-81-775-8333-5--(512.5Lay)

5. Artin, Michael: Algebra. (2nd ed. Indian Reprint) New Delhi. Prentice-Hall Of India Private Limited, 1994. 81-203-0871-9--(512ART)

6. Hoffman, Kenneth and Kunze, Ray: Linear algebra. (2nd ed.) Noida. Pearson India Education Services Pvt. Ltd, 2015. 978-93-325-5007-0--(512.5Hof)

7. Strang, Gilbert: Linear algebra and its applications. (3rd ed.) Fort Worth. Harcourt Brace Jovanovich College Publishers, 1988. 0-15-551005-3--(512.5STR)

8. Smith, Larry: Linear algebra. (3rd ed.) New York. Springer-Verlag, 1978.0-387-98455-0-- (512.5SMI)

9. Rao, Ramachandra A. and Bhimasankaran, P.: Linear Algebra. New Delhi. Tata Mcgraw- Hill Publishing Co. Ltd., 1992. 0-07-460476-7--(512.5RAO)

10. Banchoff, Thomas & Wermer, John: Linear algebra through geometry. (2nd ed.) New York. Springer-Verlag, 1984. 0-387-97586-1--(512.5BAN/WER)

11. Axler, Sheldon: Linear algebra done right. (2nd ed.) New Delhi. Springer (India) Private Limited, 2010. 81-8489-532-2--(512.5Axl)

12. Janich, Klaus: Linear algebra.New Delhi. Springer (India) Private Limited, 1994. 978-81- 8128-187-6--(512.5Jan)

13. Bretscher, Otto: Linear algebra with applications.(3rd ed.) New Delhi. Dorling Kindersley (India) Pvt. Ltd, 2008. 81-317-1441-6--(512.5Bre)

14. Williams, Gareth: Linear algebra. New Delhi. Narosa Publishing House, 2009. 81-7319- 981-3--(512.9Wil)

Suggested Tutorials:

1. Rank–Nullity Theorem.
2. System of linear equations.

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3. Calculating determinants of matrices, diagonal and upper / lower triangular matrices using definition, Laplace expansion and row reduction method, Linear dependence / independence of vectors by determinant concept.
4. Finding inverses of square matrices using adjoint method, Examples on Cramer's rule.
5. Examples of Inner product spaces, Orthogonal complements in R^2 , R^3, R^4. [2] and R^3 .

6. Examples on Gram–Schmidt process in R

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S.Y.B.Sc. – Mathematics **Course Code: S.MAT.3.03**

Title: FINITE MATHEMATICS

Learning Objectives: To learn about (i) Advanced counting

(ii) Permutation and Recurrence Relation

(iii) Introductory Graph theory.

(iv) Introduction to probability measure

Number of lectures : 45

Unit I: Counting (15 Lectures)

1. Finite and infinite sets, Countable and uncountable sets, examples such as N, Z, $N\times N$, Q, $(0,1)$, R .
2. Addition and multiplication principle, Counting sets of pairs, two ways counting.
3. Stirling numbers of second kind, Simple recursion formulae satisfied by $S(n,k)$ and direct formulae for $S(n,k)$ for $k = 1,2,\cdots,n$.
4. Pigeon hole principle and its strong form, its applications to geometry, monotonic sequences.
5. Binomial and Multinomial Theorem, Pascal identity, examples of standard identities
6. Permutation and combination of sets and multi-sets, circular permutations, emphasis on solving problems.
7. Non-negative and positive integral solutions of equation $x_1 + x_2 + \cdots + x_k = n$.

8. Principle of Inclusion and Exclusion, its applications, derangements, explicit formula for d_n, various identities involving d_n, deriving formula for Euler's phi function $\varphi(n)$.
9. Permutation of objects, s_n composition of permutations, results such as every permutation is product of disjoint cycles; every cycle is product of transpositions, even and odd permutations, rank and signature of permutation, cardinality of S_n, A_n.

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10. Recurrence relation, definition of homogeneous, non-homogeneous, linear and non-linear recurrence relation, obtaining recurrence relation in counting problems, solving (homogeneous as well as non-homogeneous) recurrence relation by using iterative method, solving a homogeneous recurrence relation of second degree using algebraic method proving the necessary result.

Unit II: Graph Theory (15 Lectures)

1. Definition, examples and basic properties of graphs, pseudographs, complete graphs, bipartite graphs.
2. Isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, The adjacency matrix, weighted graph.
3. Travelling salesman's problem, shortest path, Floyd-Warshall algorithm, Dijkstra's algorithm.

Unit III: Probability Theory (15 Lectures)

1. Finitely Additive Probability Measure.
2. Sigma Fields.
3. Discrete Random Variables.
4. Joint Distribution of Random Variables as a Probability Measure.
5. Expectation and Variance of Discrete Random Variables.
6. Conditional Expectation.
7. Chebyshev's Inequality, Weak Law of Large Numbers and Central Limit Theorem.

Recommended books:

1. Biggs, Norman L.: Discrete mathematics. (Revised ed.) Oxford. Oxford University Press, 1993. 0-19-853427-2--(510BIG)

2. Brualdi, Richard A.: Introductory combinatorics. (3rd Ed.) Upper Saddle River. Prentice-Hall, Inc., 1999. 0-13-181488-5--(511.6BRU)

3. Goodaire, Edgar and Michael Parmenter, Michael: Discrete Mathematics with Graph Theory, Pearson.(3rd ed.)

4. Rosen, Kenneth H.: Discrete mathematics and its applications. (5th ed.) New Delhi. Tata Mc-Graw Hill Publishing Company Limited, 2003. 0-07-242434-6--(511ROS)

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5. Marek Capinski and Tomasz Zastawniak : Probability through Problems, Springer.

Reference Books:

1. Krishnamurthy, V.: Combinatorics: Theory and applications. New Delhi. Affiliated East-West Press Pvt. Ltd., 1985. 81-85336-02-4--(510KRI)

2. Rosen, Kenneth H.: Discrete mathematics and its applications. (5th ed.) New Delhi. Tata Mc-Graw Hill Publishing Company Limited, 2003. 0-07-242434-6--(511ROS)

3. Lipschutz, Seymour & Lipson, Marc Lars: Theory and problems of discrete mathematics.
(2nd ed. Indian reprint) New Delhi. Tata Mcgraw-Hill Publishing Co. Ltd., 1997(1999). 0-07-463710-X--(512LIP/LIP)

4. Allen Tucker, Allen: Applied Combinatorics, (6th ed.), John Wiley and Sons.

5. Grimaldi, Ralph P.: Discrete and combinatorial mathematics : an applied introduction. (3rd ed.) Reading. Addison-Wesley Publishing Company, 1994.
0-201-54983-2--(510GRI)

6. Rosen, Kenneth H.: Discrete mathematics and its applications with combinatorics and graph theory. (7th ed.) New Delhi. McGraw Hill Education (India) Private Ltd., 2011(2015). 978-0-07-068188-0--(511Ros)

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PRACTICALS: Course Code :S.MAT.3.PR FINITE MATHEMATICS

1. Problems based on counting principles, Two way counting.

2. Stirling numbers of second kind, Pigeon hole principle.

3. Multinomial theorem, identities, permutation and combination of multi-set.

4. Inclusion-Exclusion principle, Euler phi function.
5. Derangement and rank signature of permutation, Recurrence relation
6. Drawing a graph, checking if a degree sequence is graphical. Representing a given graph by an adjacency matrix and drawing a graph having given matrix as adjacency matrix.
7. Problems on Discrete random variables, expectation and variance.
8. Problems Based on Chebyshev's Inequality, Weak Law of Large Numbers and Central Limit Theorem.

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EVALUATION:-

CIA- I: 20 marks, 45 mins.
Unit I: Objectives/Short questions, not more than 5 marks each

CIA- II : 20 marks, 45 mins.
Unit II: Short questions/Presentation/Assignment, not more than 5 marks each

End Semester Exam – 60 marks, 2 hours OR Additional Exam – 100 marks, 3 hours

T.Y. B.Sc. Maths **Course: S.Mat. 5.01**
Title: CALCULUS V

Learning Objectives:
1. To understand Riemann Integrability of bounded functions .
2. first and second Fundamental Theorem of Calculus and fubini's theorem of rectangles

Number of lectures: 45

UNIT 1
Riemann Integration, Double and Triple Integrals (12 lectures)
(a) Uniform continuity of a real valued function on a subset of R
(i) Definition.
(ii) a continuous function on a closed and bounded interval is uniformly continous (only statement).

(b) Riemann Integration.

(i) Partition of a closed and bounded interval [a; b], Upper sums and Lower sums of a bounded real valued function on [a; b]. Refinement of a partition, Definition of Riemann integrability of a function. A necessary and sufficient condition for a bounded function on [a; b] to be Riemann integrable.(Riemann's Criterion)

(ii) A monotone function on [a; b] is Riemann integrable.

(iii) A continuous function on [a; b] is Riemann integrable.

A function with only finitely many discontinuities on [a; b] is Riemann integrable.

Examples of a Riemann integrable function which is discontinuous at all rational numbers.

(c) Algebraic and order properties of Riemann integrable functions. (i) Riemann Integrability of sums, scalar multiples and products of integrable functions. The formulae for integrals of sums and scalar multiples of Riemann integrable functions.

(ii) If f is Riemann integrable on [a; b], and $a < c < b$, then f is Riemann integrable on [a; c] and [c; b]

Unit 2 **(11 lectures)**

(a) First and second Fundamental Theorem of Calculus.

(b) Integration by parts and change of variables formula.

(c) Mean Value Theorem for integrals.

(d) The integral as a limit of a sum, examples.

(e) Double and Triple Integrals

(i) The definition of the Double (respectively Triple) integral of a bounded function on a rectangle (respectively box).

(ii) Fubini's theorem over rectangles.

(iii) Properties of Double and Triple Integrals:

(1) Integrability of sums, scalar multiples, products of integrable functions, and formulae for integrals of sums and scalar multiples of integrable functions.

(2) Domain additivity of the integrals.

(3) Integrability of continuous functions and functions having only finitely (countably) many discontinuities.

(4) Double and triple integrals over bounded domains.

(5) Change of variables formula for double and triple integrals (statement only).

UNIT 3

Sequences and series of functions: **(11 lectures)**

(a) Pointwise and uniform convergence of sequences and series of real valued functions. Weierstrass M-test. Examples.

(b) Continuity of the uniform limit (resp: uniform sum) of a sequence (resp: series) of real-valued functions. The integral and the derivative of the uniform limit (resp: uniform sum) of a sequence (resp: series) of real-valued functions on a closed and bounded interval. Examples.

UNIT 4 **(11 lectures)**

(a) Power series in R. Radius of convergence. Region of convergence. Uniform convergence. Term-by-term differentiation and integration of power series. Examples.

(b) Taylor and Maclaurin series. Classical functions defined by power series: exponential, trigonometric, logarithmic and hyperbolic functions, and the basic properties of these functions.

List Of Recommended Reference Books

1. Real Analysis Bartle and Sherbet.
2. Calculus, Vol. 2: T. Apostol, John Wiley.
3. Richard G. Goldberg, Methods of Real Analysis, Oxford & IBHPublishing Co. Pvt. Ltd., New Delhi.

Practical:

I) Riemann Integration.
II) Fundamental Theorem of Calculus.

III) Double and Triple Integrals; Fubini's theorem, Change of VariablesFormula.
IV) Pointwise and uniform convergence of sequences and series of functions.
V) Illustrations of continuity, differentiability, and integrability for pointwise and uniform convergence.
VI) Power series in R. Term by term differentiation and integration.
VII) Miscellaneous Theoretical questions based on Unit 1. VIII) Miscellaneous Theoretical questions based on Unit 2.

T.Y. B.Sc. Maths Course: S.Mat. 5.02

Title: ALGEBRA **V**

Learning Objectives:

1. To understand Cyclic groups, Lagrange's theorem and Group homomorphisms and isomorphisms.

2. To understand Normal groups.

Number of lectures: 45

UNIT 1

Groups and subgroups **(12 lectures)**

(a) Definition and properties 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*, R* 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 symmetrices of a regular polygon of n sides.

(vii) Quaternion group.

(viii) Matrix groups $M_n(R)$ under addition of matrices, $GL_n(R)$, the set of invertible real matrices, under multiplication of matrices.

(b) Subgroups

Subgroups of $GL_n(R)$ such as $SL_n(R)$, $O_n(R)$, $SO_n(R)$, $SO_2(R)$ as group of 2 x 2 real matrices representing rotations, subgroup of n-th roots of unity.

Unit 2 **(11 lectures)**

(a)(i) Cyclic groups (examples of Z, Z_n) and cyclic subgroups.

(ii) Groups generated by a finite set, generators and relations.

Examples such as Klein's four group V_4, Dihedral group, Quaternion group.

(iii) The Center Z(G) of a group G, and the normalizer of an element of G as a subgroup of G.

(iv) Cosets, Lagrange's theorem.

(b) Group homomorphisms and isomorphisms. Examples and properties. Automorphisms of a group, inner automorphisms.

UNIT 3

Normal subgroups: (11 lectures)

(a) (i) Normal subgroups of a group. Definition and exmaples including center of a group. (ii) Quotient group.

(iii) Alternating group A_n, cycles. Listing normal subgroups of A_4, S_3.

(b) Isomorphisms theorems. (i) First Isomorphism theorem (or Fundamental Theorem of homomorphisms of groups). (ii) Second Isomorphism theorem. (iii) Third Isomorphism theorem.

Unit 4

(a) Cayley's theorem. **(11 lectures)**

(b) 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. The groups Z_n and U(n) as external direct product of groups.

(c) Classification of groups of order 7.

List Of Recommended Reference Books

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

Practical:

I) Groups Definitions and properties.
II) Subgroups, Lagrange's Theorem and Cyclic groups..
III) Groups of Symmetry and the Symmetric group S_n.
IV) Group homomorphisms, isomorphisms.
V) Normal subgroups and quotient groups.
VI) Cayley's Theorem and external direct product of groups.
VII) Miscellaneous Theoretical questions based on Unit 1 and 2.
VIII) Miscellaneous Theoretical questions based on Unit 3 and 4.

T.Y. B.Sc. Maths Course: S.Mat.5.03

Title: Topology of metric spaces.

Learning Objectives:

1. Inrtroduction to Metric Spaces.

Number of lectures: 45

UNIT 1

Metric spaces **(12 lectures)**

(a) (i) Metrics spaces: Definition, Examples, including R with usual distance, discrete metric space.

(ii) Normed linear spaces: Definition, the distance (metric) induced by the norm, translation invariance of the metric induced by the norm. Examples including

(1) $\mathbb{R}^n$ with sum norm $|| \ ||_1$, the Euclidean norm $|| \ ||_2$, and the sup norm $|| \ ||_\infty$.

(2) $C[a,b]$, the space of continuous real valued functions on $[a,b]$ with norms $|| \ ||_1$, $|| \ ||_2$, $|| \ ||_\infty$, where $||f||_1 = \int_a^b |f(t)|dt$, $||f||_2 = \left(\int_a^b |f(t)|^2 dt\right)^{\frac{1}{2}}$, $||f||_\infty = \sup\{|f(t)|, t \in [a,b]\}$.

(3) $\ell_1, \ell_2, \ell_\infty$, the spaces of real sequences with norms $|| \ ||_1, || \ ||_2, || \ |_\infty$, where $||x||_1 = \sum_{n=1}^\infty |x_n|$, $||x||_2 = (\sum_{n=1}^\infty |x_n|^2)^{\frac{1}{2}}$, $||x||_\infty = \sup\{|x_n|, n \in \mathbb{N}\}$, for $x = (x_n)$.

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(iii) Subspaces, product of two metric spaces.

(b) (i) Open ball and open set in a metric space (normed linear space) and subspace Hausdorff property. Interior of a set.

(ii) Structure of an open set in R, namely any open set is a union of a countable family of pairwise disjoint intervals.

(iii) Equivalent metrics, equivalent norms.

(c) (i) Closed set in a metric space (as complement of an open set), limit point of a set (A point which has a non-empty intersection with each deleted neighbourhood of the point), isolated point. A closed set contains all its limit points. (ii) Closed balls, closure of a set, boundary of a set in a metric space.

UNIT 2 (11 lectures)

(a)(i) Distance of a point from a set, distance between two sets, diameter of a set in a metric space.

(ii) Dense subsets in a metric space. Separability, Rn is separable.

(b) (i) Sequences in a metric space.

(ii) The characterization of limit points and closure points in terms of sequences.

(iii)Cauchy sequences and complete metric spaces. Rn with Euclidean metric is a complete metric space. (c) Cantor's Intersection Theorem.

UNIT 3

Continuity: (11lectures)

(a) Definition of continuity at a point of a function from one metric space to another.

(i) Characterization of continuity at a point in terms of sequences, open sets.

(ii) Continuity of a function on a metric space. Characterization in terms of inverse image of open sets and closed sets.

UNIT 4 *(11 lectures)*

(iii) Urysohn's lemma.

(iv) Uniform continuity in a metric space, definition and examples (emphasis on R), open maps, closed maps.

List Of Recommended Reference Books

1. S. Kumaresan, Topology of Metric spaces.
2. W. Rudin, Principles of Mathematical Analysis.
3. R.G. Goldberg Methods of Real Analysis, Oxford and IBH Publishing House, NewDelhi.

4. P.K. Jain, K. Ahmed. Metric spaces. Narosa, New Delhi, 1996.
5. G.F. Simmons. Introduction to Topology and Modern Analysis. McGraw Hill, New York, 1963.

Practical:

I) Metric spaces and normed linear spaces. Examples.
II) Open balls, open sets in metric spaces, subspaces and normed linear spaces.
III) Limit points: (Limit points and closure points, closed balls, closed sets, closure of a set, boundary of a set, distance between two sets).
IV) Sequences
V) Continuity.
VI) Uniform continuity in a metric space.
VII) Miscellaneous Theoretical Questions based on Unit 1 and 2
VIII) Miscellaneous Theoretical Questions based on Unit 3 and 4

T.Y. B.Sc. Maths Course: S.Mat.5.04 Title: Numerical Methods

Learning Objectives:

1. Newton – Raphson method Chebyshev method etc & their rate of convergence

2. Different types of interpolation methods

Number of lectures: 45

UNIT 1

Transcendental and Polynomial equations **(12 lectures)**

(a) Iteration methods based on first and second degree equation
  (i) The Newton – Raphson method
  (ii) Secant method
  (iii) Muller method
  (iv) Chebyshev method
  (v) Multi-point iteration metbod
(b) Rate of convergence and error analysis
  (i) Secant method
  (ii) The Newton – Raphson method
  (iii) Methods of multiple roots

UNIT 2 **(11 lectures)**

(a) Polynomial equations
  (i) Birge-Vieta method
  (ii) Bairstow method

(iii)Graeffe's Method

UNIT 3

Interpolation and approximation **(11 lectures)**

(a) Higher order interpolation
(b) Finite difference operators and fundamental theorem of difference calculus
(c) Interpolating polynomial using finite differences, factorial notation (d) Hermite interpolation

UNIT 4 (11 lectures)

(a)Piecewise and spline interpolation
(b)Bivariate interpolation – Lagrange bivariate interpolation, Newton`s bivariate interpolation for equispaced points
(c)Least square approximation

List Of Recommended Reference Books

1. M.K.Jain , S.R.K. Iyengar and R.K.Jain. Numerical methods for Scientific and Engineering Computation, New age International publishers,Fourth Edition, 2003
2. S.D.Comte and Carl de Boor, Elementary Numerical analysis- An algorithmic approach, 3rd edition., McGraw Hill, International Book Company,1980.
3. F.B.Hildebrand, Introduction to Numerical Analysis, McGraw Hill, New York, 1956.

Practical:

I) Iteration methods based on first degree equation-Newton Raphson method , Secant method.
II) Iteration methods based on second degree equation-Muller method , Chebyshev method, Multi-point iteration metbod
III) Polynomial equations
IV) Higher order Interpolation/finite difference operators
V) Interpolating polynomial using finite differences / Hermite interpolation VI) Piecewise and spline interpolation / Bivariate interpolation

VII) Miscellaneous Theoretical questions based on Unit 1and 2
VIII)Miscellaneous Theoretical questions based on Unit 3 and 4

T.Y. B.Sc. Maths **Course: S.Mat.5.AC.01**

Title: COMPUTER PROGRAMMING AND SYSTEM ANALYSIS (JAVA PROGRAMMING & SSAD)

Learning Objectives:

1. To learn about OOP through java programming
2. Intro. to DBMS & RDBMS, SQL Commands & Functions, and C-languag

UNIT 1

Java Programming (20 lectures)

Introduction to JAVA Programming

What is java, history of java, different types of java programmes, java virtual machine, JDK tool.

Object oriented programming

Object oriented approach, Object oriented programming, objects and classes, behavior and attributes, fundamental principles of OOPs (encapsulation, inheritance – polymorphism. data abstraction).

Java Basics (Data Concepts)

Variables and data types, declaration variables, literals. numeric literals, Boolean literal, character literals, string literals, keywords, type conversion and casting ,shift operators.

Java Operators

Assignment operator, arithmetic operators ,relational operators, logical operators, bitwise operators , incrementing and decrementing operators , conditional operator, precedence and order of evaluation, statement and expressions

Exception handling

Command line arguments, Parsing , try – catch blocks , types of exception & how to handle them.

Loops and Controls

Control statement for decisions making: selection statements (if statement, if- else statement, if- else - if statement, switch statement), goto statement ,looping (while loop and do while loop and for loop), nested loops, breaking out of loops(break and continue statements), return statement.

Introduction to Classes and Methods

Defining classes, creating- instance and class variables, creating objects of a class, accessing instance variables of a class, Creating methods, naming methods, accessing methods of class, constructor methods, overloading methods.

UNIT 2

Structured System Analysis and Design: (05 lectures)

What is a system, characteristics system, types of information system –
Transaction Processing System (TPS), Management Information System (MIS), Decision Support System (DSS).

System Development Strategies

System Development Life Cycle (SDLC) method. Structured analysis development method. Element of structured analysis – Data Flow Diagrams (DFD), data dictionary.

Tools for determining System Requirements

What is requirement determination. fact finding techniques tools for documenting procedures and decisions – decision tree, decision table.

List Of Recommended Reference Books

1. Analysis and Design of Information System – James A. Senn (McGraw – Hill International Editions)------ (Chapters –1 & 3)

2. The complete reference - Java 2 :- Herbert schildt (TMH). (Chapters 1 to 7,10)

Practical:

Java programs that illustrate

I) the different types of operators
II) the concept of casting and shift operators.
III) the concept of selection statements.
IV) the concept of looping , nested loops, jumping statements
V) the concept of command line arguments ,parsing and try – catch blocks(exception handling)
VI) the concept of java class.
VII) the concept of java class that includes constructor with and without parameters.
VIII) the concept of java class that includes overloading methods

UNIT 3

SQL Commands and Functions **(16 lectures)**

Handling data

Selecting data using SELECT statement. FROM clause, WHERE clause, HAVING clause, ORDER BY, GROUP BY, DISTINCT and ALL predicates. Adding data with INSERT statement. Changing data with UPDATE statement. Removing data with DELETE statement.

Joining Tables
Inner joins, outer joins, cross joins, union.
Functions
Aggregate functions-AVG, SUM, MIN, MAX and COUNT. Date functions - DATEADD(), DATEDIFF(), GETDATE(), DATENAME(), YEAR, MONTH, WEEK, DAY. String functions - LOWER(), UPPER(), TRIM(), RTRIM(), PATINDEX(), REPLICATE(), REVERSE(), RIGHT(), SPACE().
Creating and Altering tables
CREATE statement, ALTER statement, DROP statement.
Views
Simple views, complex views, creating and editing views.
Constraints
Types of constraints, KEY constraints, CHECK constraints, DEFAULT constraints, disabling constraints.
Indexes
Understanding indexes, creating and dropping indexes, maintaining indexes.

UNIT 4

Basics in C- Language : **(09 lectures)** Program Structure
Header and body, use of comments, construction of the program.
Data Concepts
Variables, constants, and data types, declaring variables.
Simple Input/Output Operations
Character strings: printf(), scanf(), single characters: getchar(), putchar() Operators
Assignment operators, compound assignment operators, arithmetic operators, relational operators, logical operators, increment and decrement operators, conditional operator, precedence and order of evaluation, statements and expressions.
Type conversions
Automatic and explicit type conversions.

List Of Recommended Reference Books

1. Professional SQL Server 2000 Programming - Rob Vieira, Wrox Press Ltd, Shroff Publishers & Distributors Pvt Ltd, NewDelhi.(Chapters 4-10).
2. SQL Server 2000 Black Book - Patrick Dalton & Paul Whitehead, Dreamtech Press.

Practical:

- **I)** Single table queries using operators with select columns and restricting rows of output.
- **II)** Supply queries using SELECT command.
- **III)** Supply queries using SELECT with FROM, WHERE and HAVING clauses.
- **IV)** Supply queries using SELECT with ORDER BY, GROUP BY, DISTINCT, ALL and queries along with different clauses.
- **V)** Queries using aggregate functions, string functions, date functions. **VI)** Creating, updating, altering and deleting tables and views.

VII) Creating tables with defaults, integrity constraints, referential integrity constraints and check constraints both at the column and table levels.

St. Xavier's College – Autonomous Mumbai

Syllabus
For Even Semester Courses in MATHEMATICS
(2017-2018)

Contents:

Theory Syllabus for Courses:

F.Y.B.Sc. – Mathematics **Course Code: S.MAT.2.01**

Title: CALCULUS – II

Learning Objectives: To learn about (i) Convergence of infinite series. (ii) Intermediate Value Theorem and Mean Value Theorems. (iii) Applications of real valued differentiable functions of one variable.

Number of lectures : 45

Unit I: Series **(15 Lectures)**

Series of real numbers, simple examples of series, Sequence of partial sums, Convergence of series, convergent and divergent series, Necessary condition: series Σa_n is convergent implies $a_n \to 0$, converse not true, Algebra of convergent series, Cauchy criterion, $\Sigma\frac{1}{n^p}$ converges for p>1, divergence of $\Sigma\frac{1}{n}$, Comparison test, limit form of comparison test, Condensation test, Alternating series, Leibnitz theorem (alternating series test) and convergence of $\Sigma\frac{(-1)^n}{n}$, Absolute convergence, conditional convergence, absolute convergence implies convergence but not conversely, Ratio test, Root test (without proofs) and examples. Tests for absolute convergence.

Unit II: Continuous functions and Differentiation **(15 Lectures)**

Properties of Continuous functions: If $f : [a,b] \to R$ is continuous at x_0 and $f(x_0) > 0$ then there exists a neighbourhood N of x_0 such that $f(x) > 0$ for all x in N. If $f : [a,b] \to R$ is continuous function then the image $f([a,b])$ isa closed interval, 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.

Differentiation of real valued function of one variable: Definition of differentiation at a point and on an open set, examples of differentiable and non-differentiable functions, differentiable functions are continuous but not conversely, Algebra of differentiable functions, chain rule, Higher order derivatives, Leibnitz rule, Derivative of inverse functions, Implicit differentiation
(only examples).

Unit III: Application of differentiation **(15 Lectures)**

Definition of local maximum and local minimum, necessary condition, stationary points, second derivative test, examples, Graphing of functions using first and second derivatives, concave, convex functions, points of inflection, Rolle's theorem, Lagrange's and Cauchy's mean value theorems, applications and examples, Monotone increasing and decreasing function, examples, L`hospital`s rule without proof, examples of indeterminate forms, Taylor's theorem with Lagrange's form of remainder with proof, Taylor polynomial and applications.

Recommended Books

1. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964.
2. James Stewart, Calculus, Third Edition, Brooks/cole Publishing Company,1994.
3. T. M. Apostol, Calculus Vol I, Wiley & Sons (Asia) Pte. Ltd.

4. Robert G. Bartle and Donald R. Sherbet : Introduction to Real Analysis, Springer Verlag.
5. Howard Anton, Calculus - A new Horizon, Sixth Edition, John Wiley and Sons Inc,1999.

Additional Reference Books

1. Courant and John, A Introduction to Calculus and Analysis, Springer.
2. Ajit and Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
3. Sudhir R. Ghorpade and Balmohan V. Limaye, A Course in Calculus and Real Analysis, Springer International Ltd, 2000.
4. Binmore, Mathematical Analysis, Cambridge University Press, 1982.
5. G. B. Thomas, Calculus, 12th Edition, 2009.

Assignments (Tutorials)

1. Calculating limit of series, Convergence tests.
2. Properties of continuous functions.
3. Differentiability, Higher order derivatives, Leibnitz theorem.
4. Mean value theorems and its applications.
5. Extreme values, increasing and decreasing functions.
6. Applications of Taylor's theorem and Taylors polynomials.

Title: Algebra II

Learning Objectives: To learn about (i) System of linear equations and matrices.
(ii) Vector Spaces
(iii) Basis and linear transformations.

Number of lectures : 45

Prerequisites:

Review of vectors in R^2 and R^3 as points, Addition and scalar multiplication of vectors in terms of co-ordinates, Dot product, Scalar triple product, Length (norm) of a vector.

Unit I: System of Linear equations and Matrices (15 Lectures)

Parametric equation of lines and planes, System of homogeneous and non-homogeneous linear equations, the solution of system of m homogeneous linear equations in n unknowns by elimination and their geometrical interpretation for [m, n]=[1, 2], [1,3], [2,2], [2,3], [3,3]. Definition of n tuples of real numbers, sum of n tuples and scalar multiple of n tuple. Matrices with real entries, addition, scalar multiplication and multiplication of matrices, Transpose of a matrix, Type of matrices: zero matrix, identity matrix, scalar, diagonal, upper triangular, lower triangular, symmetric, skew-symmetric matrices, Invertible matrices, identities such as $[AB]^t = [B]^t [A]^t$, $[AB]^{-1}=[B]^{-1}[A]^{-1}$. System of linear equations in matrix form, elementary row operations, row echelon matrix, Gaussian elimination method, to deduce that the system of m homogeneous linear equations in n unknowns has a non-trivial solution if $m < n$.

Unit II: Vector spaces (15 Lectures)

Definition of real vector space, examples such as R^n with real entries, R[X]-space of m X n matrices over R, space of real valued functions on a non empty set. Subspace: Definition, examples of subspaces of R^2 and R^3 such as lines, plane passing through origin, set of 2 X 2 , 3 X 3 upper triangular, lower triangular, diagonal, symmetric and skew-symmetric matrices as subspaces of $M_2[R]$,$M_3[R]$, $P_n[X]$ of R[X] , solutions of m homogeneous linear equations in n unknowns as a subspace of R^n. Space of continuous real valued functions on a non-empty set X is a subspace of F[X,R]. Properties of subspaces such as necessary and sufficient condition 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 a subset of the other, Linear combinations of vectors in a vector space, Linear span L[S] of a non-empty subset S of a vector space, S is the generating set of L[S], linear span of a non-empty subset of a vector space is a subspace of the vector space. Linearly independent / Linearly dependent sets in a vector space, properties such as a set of vectors in a vector space is linearly dependent if and only if one of the vectors v_i is a linear combination of the other vectors v_j's.

Unit III: Basis and Linear Transformation **(15 Lectures)** Basis of a vector space, Dimension of a vector space, maximal linearly independent subset 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 set of n+1 vectors in a vector space with n elements in its basis is linearly dependent, any two basis of a vector space have the same number of elements, any n linearly independent vectors in an n dimensional vector space is a basis of a vector space. If U and W are subspaces of a vector space then U+W is a subspace of the vector space, dim [U+W]=dim U + dimW – dim [U ∩ W]. Extending the basis of a subspace to a basis of a vector space. Linear transformation, kernel, matrix associated with a linear transformation, properties such as kernel of a linear transformation is a subspace of the domain space, for a linear transformation T image [T] is a subspace of the co-domain space. If V, W are vector spaces with $\{v_1, \ldots, v_n\}$ basis of V and $\{w_1, \ldots, w_n\}$ are any vectors in W then there exists a unique linear transformation T such that $T(v_i) = w_i$. Rank- nullity theorem (only statement) and examples.

Recommended Books

1. Serge Lang, Introduction to Linear Algebra, Second Edition, Springer.
2. S. Kumaresan, Linear Algebra, A Geometric Approach, Prentice Hall of India, Pvt. Ltd, 2000.

Additional Reference Books

1. M. Artin: Algebra, Prentice Hall of India Private Limited, 1991.
2. K. Hoffman and R. Kunze: Linear Algebra, Tata McGraw-Hill, New Delhi, 1971.
3. Gilbert Strang: Linear Algebra and its applications, International Student Edition.
3. L. Smith: Linear Algebra, Springer Verlag.
4. A. Ramachandra Rao and P. Bhima Sankaran: Linear Algebra, Tata McGraw-Hill, New Delhi.
5. T. Banchoff and J. Warmers: Linear Algebra through Geometry, Springer Verlag, New York, 1984.
6. Sheldon Axler: Linear Algebra done right, Springer Verlag, New York.
7. Klaus Janich: Linear Algebra.
8. Otto Bretcher: Linear Algebra with Applications, Pearson Education.
9. Gareth Williams: Linear Algebra with Applications.

Assignments (Tutorials)

1. Solving homogeneous system of m equations in n unknowns by elimination for m , n = 1, 2, 1, 3 , 2, 2 , 2, 3 , 3, 3. Row echelon form.
2. Solving system AX= B by Gauss elimination, Solutions of system of linear equations.
3. Verifying whether V is a vector space for a given set V.
4. Linear span of a non-empty subset of a vector space, determining whether a given subset of a vector space is a subspace. Showing the set of convergent real sequences is a subspace of the space of real sequences etc.
5. Finding basis of a vector space such as $P_3[X]$, $M_2[R]$ etc. Verifying whether a set is a basis of a vector space. Extending basis to a basis of a finite dimensional vector space.
6. Verifying whether $T : V \rightarrow W$ is a linear transformation, finding kernel of a linear transformations and matrix associated with a linear transformation, verifying the Rank Nullity theorem.

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CIA I – 20 marks, 45 mins. (Objectives/Short questions, not more than 5 marks each)

CIA II – 20 marks, 45 mins. (Objectives/Short questions, not more than 5 marks each)

End Semester exam – 60 marks, 2 hours.

There will be three questions, one per unit. The Choice is internal- i.e. within a unit and could be between 50% to 100%

.Y.B.Sc. – Mathematics Course Code: S.MAT.4.01

Title: CALCULUS IV

Learning Objectives: (i) To learn about sequences in R^n and limit, continuity, differentiability, partial/ directional derivatives, gradients of scalar fields.
(ii) To study about limits, continuity, differentiability of scalar fields.
(iii) To learn about Second derivative test for extrema of functions of two variables and the method of Lagrange`s multipliers.

Number of lectures : 45

Unit I: Functions of several variables (15 Lectures)

1. Euclidean space, R^n– norm, inner product, distance between two points, open ball in R^n, definition of an open set / neighborhood, sequences in R^n, convergence of sequences–these concepts should be specifically discussed for n = 2 and n = 3.
2. Functions from $R^n \rightarrow R$ (Scalar fields) and from $R^n \rightarrow R^n$ (Vector fields). Iterated limits, limits and continuity of functions, basic results on limits and continuity of sum, difference, scalar multiples of vector fields, continuity and components of vector fields.
3. Directional derivatives and partial derivatives of scalar fields.
4. Mean value theorem for derivatives of scalar fields.

Reference for Unit I:
(1) T. Apostol, Calculus, Vol. 2, John Wiley.
(2) J. Stewart, Calculus, Brooke/Cole Publishing Co.

Unit II: Differentiation (15 Lectures)

1. Differentiability of a scalar field at a point (in terms of linear transformation) and in an open set, Total derivative, Uniqueness of total derivative of a differentiable function at a point. (Simple examples of finding total derivative of functions such as $f(x, y) = x^2 + y^2$, $f(x, y, z) = x + y + z$ may be taken). Differentiability at a point implies continuity, and existence of directional derivative at the point. The existence of continuous partial derivatives in neighborhood of point implies differentiability at the point.
2. Gradient of a scalar field, geometric properties of gradient, level sets and tangent planes.
3. Chain rule for scalar fields.
4. Higher order partial derivatives, mixed partial derivatives. Sufficient condition for equality of mixed partial derivative.

Reference for Unit II:
(1) Calculus, Vol. 2, T. Apostol, John Wiley.
(2) Calculus. J. Stewart. Brooke/Cole Publishing Co.

Unit III: Applications (15 Lectures)

1. Second order Taylor's formula for scalar fields.
2. Differentiability of vector fields, definition of differentiability of a vector field at a point, Hessian /Jacobian matrix, differentiability of a vector field at a point implies continuity, the chain rule for derivative of vector fields (statement only).
3. Mean value inequality.
4. Maxima, minima and saddle points.
5. Second derivative test for extrema of functions of two variables.
6. Method of Lagrange`s multipliers.

Reference for Unit III:
sections 9.9, 9.10, 9.11, 9.12, 9.13, 9.14 from T. Apostol, Calculus Vol. 2, John Wiley.

Suggested Tutorials:

1. Sequences in R^2 and R^3, limits and continuity of scalar fields and vector fields using "definition" and otherwise iterated limits.
2. Computing directional derivatives, partial derivatives and mean value theorem of scalar fields.
3. Total derivative, gradient, level sets and tangent planes.
4. Chain rule, higher order derivatives and mixed partial derivatives of scalar fields.
5. Taylor's formula, differentiation of a vector field at a point, finding Hessian/ Jacobian matrix, Mean value inequality.
6. Finding maxima, minima and saddle points, second derivative test for extrema of functions of two/three variables and method of Lagrange`s multipliers.

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S.Y.B.Sc. – Mathematics   Course Code: S.MAT.4.02

Title: ALGEBRA–IV

Learning Objectives: (i) To learn properties of groups and subgroups
(ii) To study cyclic groups and cyclic subgroups
(iii) To understand Lagrange's theorem and Group homomorphisms and isomorphisms.

Number of lectures : 45

Unit I: Groups and subgroups (15 Lectures)

(a) 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\{0}), R*(=R\{0}), C*(=C\{0}), 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 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 $M_{\times}$ (R) under addition of matrices; $GL_n(R)$ – the set of invertible real matrices under multiplication of matrices.
(ix) Examples such as S^1 as a subgroup of C , μ – the subgroup of n^{th} roots of unity.

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 a, b 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) $(a^{-1})^{-1} = a$
(iv) $(ab)^{-1} = b^{-1} a^{-1}$
(v) if $a^2 = e$ for every a in G then (G, .) is an abelian group
(vi) if $(aba^{-1})^n = ab^n a^{-1}$ for every a, b in G and for every integer n
(vii) if $(ab)^2 = a^2 b^2$ for every a, b in G then (G, .) is an abelian group
(viii) $(Z^*, .)$ is a group if and if n is prime

3) Properties of order of an element such as (n and m are integers)
(i) Let o(a) = n. Then $a^m = e$ if and only if n| m
(ii) If o(a) = nm then $o(a^n) = m$.
(iii) If o(a) = n then $o(a^m) = \frac{\quad}{(\ ,\ )}$ where (n, m) is GCD of n and m
(iv) $o(aba^{-1}) = o(b)$, o(ab) = o(ba)
(v) If o(a) = n, o(b) = m, ab = ba, (n, m) = 1 then o(ab) = nm.

(b) Subgroups

1) Definition, necessary and sufficient condition for a non-empty set to be a Subgroup
2) The center Z(G) of a group G is a subgroup.
3) Intersection of two (or a family of) subgroups is a subgroup.
4) Union of two subgroups is not a subgroup in general. Union of two sub groups is a subgroup if and only if one is contained in the other.
5) Let H and K are subgroups of a group G. Then HK is a subgroup of G if and only if HK = KH.

Reference for Unit I:
(1) I.N. Herstein, Topics in Algebra.
(2) P.B. Bhattacharya, S.K. Jain, S. Nagpaul. Abstract Algebra.

Unit II: Cyclic groups and cyclic subgroups (15 Lectures)
(a) Cyclic subgroup of a group, cyclic groups, (examples including Z, Zn, μ).
(b) Properties such as

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) Let G = <a> and o(a) = n. Then G = $< a^m >$ if and only if (m, n) = 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

Reference for Unit II:
(1) I.N. Herstein, Topics in Algebra.
(2) P.B. Bhattacharya, S.K. Jain, S. Nagpaul. Abstract Algebra.

Unit III: Lagrange's Theorem and Group homomorphism (15 Lectures) a) Definition of a Coset and properties such as

1) If H is a subgroup of group G and x∈G then prove that
   (i) xH = Hx if and only if x∈G (ii) Hx = H if and only if x∈G
2) If H is a subgroup of group G and x, y∈G then prove that
   (i) xH = yH if and only if $x^{-1}y$ ∈H (ii) Hx = Hy if and only if xy^{-1} ∈H
3) Lagrange's theorem and consequences such as Fermat's Little theorem, Eulers's theorem.

If a group G has no nontrivial subgroups then order of G is a prime and G is Cyclic.

b) Group homomorphisms and isomorphisms, automorphisms
1) Definition
2) Kernel and image of a group homomorphism.
3) Examples including inner automorphism.

Properties such as
(i) If f : G → G` is a group homomorphism then Ker f < G.
(ii) Let f : G → G` be a group homomorphism. Then Ker f ={e} if and only if f is 1-1.

(iii) Let $f : G \rightarrow G`$ be a group isomorphism. Then G is abelian/cyclic if and only if G` is abelian/cyclic

Reference for Unit III:
(1) I.N. Herstein, Topics in Algebra.
(2) P.B. Bhattacharya, S.K. Jain, S. Nagpaul. Abstract Algebra.

Recommended Books:
1. I.N. Herstein. Topics in Algebra, Wiley Eastern Limited, Second edition.
2. N.S. Gopalakrishnan, University Algebra, Wiley Eastern Limited.
3. M. Artin, Algebra, Prentice Hall of India, New Delhi.
4. P.B. Bhattacharya, S.K. Jain, and S.R. Nagpaul, Abstract Algebra, Second edition, Foundation Books, New Delhi, 1995.
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. Luther, I.B.S. Passi. Algebra, Vol. I and II.

Suggested Tutorials:
1. Examples and properties of groups.
2. Group of symmetry of equilateral triangle, rectangle, square.
3. Subgroups.
4. Cyclic groups, cyclic subgroups, finding generators of every subgroup of a cyclic group.
5. Left and right cosets of a subgroup, Lagrange's Theorem.
6. Group homomorphisms, isomorphisms.

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S.Y.B.Sc. – Mathematics Course Code: S.MAT.4.03

Title: DIFFERENTIAL EQUATIONS

Learning Objectives: (i) To learn First order First degree Ordinary Differential equations
(ii) To study Second order Ordinary Linear Differential equations
(iii)To learn how to solve Partial Differential equations Number of lectures : 45

Unit I: First order First degree Ordinary Differential equations (15 Lectures)

1. 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 solutions of a second order initial value problem (statement only). Define Lipschitz function; solve examples 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 of partial derivative. Exact Equations: General Solution of Exact equations of first order and first degree. 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

   $\frac{1}{Mx+Ny}$ (i) is an I.F. if $Mx + Ny \neq 0$ and $Mdx + Ndy$ is homogeneous.

   (ii) is an I.F. if $Mx - Ny \neq 0$ and $Mdx - Ndy$ is of the type $f(x, y)y\,dx + f(x, y)x\,dy$.

   (iii) $e^{\int}$ ( ) is an I.F. if $N \neq 0$ and $-(- \quad -$ $-$ is a function of x alone, say $f(x)$.

   (iv) $e^{\int}$ ( ) is an I.F. if $M \neq 0$ and $-(- \quad -)$ $-$ is a function of y alone, say $g(y)$.
4. Linear and reducible to linear equations, finding solutions of first order differential equations of the type for applications to orthogonal trajectories, population growth, and finding the current at a given time.

Unit II: Second order Ordinary Linear Differential equations (15 Lectures)

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 equation. The use of known solutions to find the general solution of homogeneous equations. The general solution of a non-homogeneous second order equation. Complementary functions and particular integrals.
2. The homogeneous equation which constant coefficient. auxiliary equation. The general solution corresponding to real and distinct roots, real and equal roots and complex roots of the auxiliary equation.
3. Non-homogeneous equations: The method of undetermined coefficients. The method of variation of parameters.

Unit III: Partial Differential equations (15 Lectures)

1. Classification of Second Order Partial Differential Equations
2. One-Dimensional Wave Equation
   (i) Vibration of an Infinite String
   (ii) Vibration of a Semi-infinite String
   (iii) Vibration of a Finite String
3. Laplace Equation
   (i) Green's Equation

4. Heat Conduction problem (i)
   Infinite Rod Case
   (ii) Finite Rod Case

Recommended Books for Unit – III:

1. An Elementary Course in Partial Differential Equations – T. Amarnath, Narosa Publishing House
2. Differential Equations with Applications and Historical Notes – G. F. Simmons – McGraw Hill.

References:

1. Differential equations with applications and historical notes- G. F. Simmons-McGraw Hill.
2. An introduction to ordinary differential equations - E. A. Coddington.
3. Differential Equations-Shepley L. Ross-Wiley.
4. Mathematical Modeling with Case Studies, A Differential Equation Approach Using Maple- Belinda Barnes and Glenn R. Fulford-Taylor and Francis.
5. Differential Equations and Boundary Value Problems: Computing and Modeling-C. H. Edwards and D. E. Penny-Pearson Education.
6. Linear Partial Differential Equation for Scientists and Engineers-Tyn Myint-U and Lokenath Debnath-Springer.
7. Partial Differential Equations: An Introduction with Mathematica and MAPLE- Ioannis P Stavroulakis and Stepan A Tersian.
8. Ordinary and Partial Differential Equations-M.D.Raisinghania-S.Chand.

Suggested Practicals:

1. Application of existence and uniqueness theorem, solving exact and non exact equations.
2. Linear and reducible to linear equations, applications to orthogonal trajectories, population growth, and finding the current at a given time.
3. Finding general solution of homogeneous and non-homogeneous equations, use of known solutions to find the general solution of homogeneous equations.
4. Solving equations using method of undetermined coefficients and method of variation of parameters.
5. Determining whether a given second order linear partial differential equation is elliptic, parabolic or hyperbolic.
6. Using method of separation of variables for different equations including heat equation and Laplace equation.

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Course: S.Mat.6.01

Calculus VI

Learning objectives: To understand Differentiability of vector fields, Parametric representation of a surface and Stokes' theorem.

Number of lectures: 45

Unit 1. Differential Calculus

(a) Limits and continuity of vector fields.
Basic results on limits and continuity of sum, difference, scalar multiples of vector fields.
Continuity and components of vector fields.
(b) Differentiability of scalar functions.
(i) Derivative of a scalar field with respect to a non-zero vector.
(ii) Direction derivatives and partial derivatives of scalar fields.
(iii) Mean value theorem for derivatives of scalar fields. (iv) Differentiability of a scalar field at a point (in terms of linear transformation).
Total derivative ,differentiability at a point implies continuity, and existence of direction derivative at the point. The existence of continuous partial derivatives in a neighbourhood of a point implies differentiability at the point.
(v) Chain rule for scalar fields.
(vi) Higher order partial derivatives, mixed partial derivatives.
Sufficient condition for equality of mixed partial derivative.
Second order Taylor formula for scalar fields.

Unit 2. Differentiability of vector fields and its applications.

(i) Gradient of a scalar field. Geometric properties of gradient, level sets and tangent planes.
(ii) Differentiability of vector fields.
(iii) Definition of differentiability of a vector field at a point.
Differentiability of a vector field at a point implies continuity.
(iv) The chain rule for derivative of vector fields.

Unit 3. Parameterization of a surface.

(a) (i) Parametric representation of a surface.

(ii) The fundamental vector product, definition and it being normal to the surface.
(iii) Area of a parametrized surface.

Unit 4. Surface integral.

(a) (i) Surface integrals of scalar and vector fields (definition).
(ii) Independence of value of surface integral under change of parametric representation of the surface.
(iii) Stokes' theorem, (assuming general form of Green's theorem)
Divergence theorem for a solid in 3-space bounded by an orientable closed surface for continuously differentiable vector fields.

List Of Recommended Reference Books

(1) Calculus. Vol. 2, T. Apostol, John Wiley.
(2) Calculus. J. Stewart. Brooke/Cole Publishing Co.
(3) Robert G. Bartle and Donald R. Sherbert. Introduction to Real Analysis, Second edition, John Wiley & Sons, INC.
(4) Richard G. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
(5) Tom M. Apostol, Calculus Volume II, Second edition, John Wiley & Sons, New York.

Practicals:

1. Limits and continuity of vector fields, Partial derivative, Directional derivatives.
2. Differentiability of scalar fields.
3. Differentiability of vector fields.
4. Parametrisation of surfaces, area of parametrised surfaces.
5. Surface integrals.
6. Stokes' Theorem and Gauss' Divergence Theorem.
7. Miscellaneous Theoretical questions based on Units 1 and 2.
8. Miscellaneous Theoretical questions based on Units 3 and 4.

COURSE S.Mat.6.02

Title: ALGEBRA VI

Learning objectives:

Number of lectures: 45

Unit 1. Quotient Spaces (12)

Review of vector spaces over R:

(a) Quotient spaces:
(i) 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.) (ii) Dimension and basis of the quotient space V=W, when V is finite dimensional.
(b) (i) Orthogonal transformations and isometries of a real finite dimensional inner product space. Translations and reflections with respect to a hyperplane. Orthogonal matrices over R.
(ii) Equivalence of orthogonal transformations and isometries fixing origin on a finite dimensional inner product space. Characterization of isometries as composites of orthogonal transformations and isometries.
(iii) Orthogonal transformation of R^2. Any orthogonal transformation in R^2 is a reflection or a rotation.
(c) Characteristic polynomial of a square real matrix and a linear transformation of a finite dimensional real vector space to itself. Cayley Hamilton Theorem (Proof assuming the result A adj(A) = In for an square matrix over the polynomial ring R[t].)

Unit 2. Diagonalizability. (10)

(i) Diagonalizability of an real matrix and a linear transformation of a finite dimensional real vector space to itself.
Definition: Geometric multiplicity and Algebraic multiplicity of eigenvalues of an real matrix and of a linear transformation. (ii) matrix A is diagonalisable if and only if R^n has a basis of eigen vectors of A if and only if the algebraic and geometric multiplicities of eigenvalues of A coincide.
(e) Triangularization.
(i) Triangularization of a real matrix having n real characteristic roots.
(f) Orthogonal diagonalization
(i) Orthogonal diagonalization of real symmetric matrices.
(ii) Application to real quadratic forms. Positive definite, semidefinite matrices. Classification in terms of principal minors. Classification of conics in R^2 and quadric surfaces in R^3.

Unit 3. Intrduction to Rings. (14)

(a) (i) Definition of a ring. (The definition should include the existence of a unity element.)
(ii) Properties and examples of rings, including Z, Q, R, C, Mn(R), Q[X], R[X], C[X], Z[i], Z[n]. (iii) Commutative ring. (iv) Units in a ring. The multiplicative group of units of a ring.
(v) Characteristic of a ring. (vi) Ring homomorphisms. First Isomorphism theorem of rings. Second Isomorphism theorem of rings.
(vii) Ideals in a ring, sum and product of ideals.

(viii) Quotient rings. (b) Integral domains and fields. Definition and examples. (i) A finite integral domain is a field. (ii) Characteristic of an integral domain, and of a finite field. (c) (i) Construction of quotient field of an integral domain (Emphasis on Z, Q). (ii) A field contains a subfield isomorphic to Zp or Q. (d) Prime ideals and maximal ideals. Definition. Examples in Z. Characterization in terms of quotient rings.

Unit 4. Polynomial rings. (9)

Irreducible polynomials over an integral domain. Unique Factorization Theorem for polynomials over a field. (f) (i) Definition of a Euclidean domain (ED), Principal Ideal Domain (PID), Unique Factorization Domain (UFD). Examples of ED: Z, F[X], where F is a field, and Z[i]. (ii) An ED is a PID, a PID is a UFD. (iii) Prime (irreducible) elements in R[X], Q[X], Zp[X]. Prime and maximal ideals in R[X], Q[X]. (iv) Z[X] is a not a UFD (Statement only).

Recommended Books

1. I.N. Herstein. Topics in Algebra, Wiley Eastern Limited, Second edition.
2. N.S. Gopalakrishnan, University Algebra, Wiley Eastern Limited.
3. M. Artin, Algebra, Prentice Hall of India, New Delhi.
4. Tom M. Apostol, Calculus Volume 2, Second edition, John Wiley, New York, 1969.
5. W.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 7) M. Artin. Algebra.
8) N.S. Gopalkrishnan. University Algebra.
9) P.B. Bhattacharya, S.K. Jain, S. Nagpaul. Abstract Algebra.

Suggested Practicals :

1. Rings, Integral domains and fields.
2. Ideals, prime ideals and maximal ideals.
3. Euclidean Domain, Principal Ideal Domain and Unique Factorization Domain.
4. Quotient spaces.
5. Orthogonal transformations,Isometries.
6. Diagonalization and Orthogonal diagonalization.
7. Miscellaneous Theoretical questions based on Unit 1,2.
8. Miscellaneous Theoretical questions based on Unit 3,4.

Course S.Mat.6.03

Title: Analysis

Learning objectives: Introduction to connectedness and compactness and Fourier Series.

Number of lectures: 45

Unit 1. Compactness (12 lectures)

(a) Definition of a compact set in a metric space (as a set for which every open cover has a finite subcover). Examples, properties such as (i) continuous image of a compact set is compact.
(ii) compact subsets are closed.
(iii) a continuous function on a compact set is uniformly continuous.
(b) Characterization of compact sets in Rn: The equivalent statements for a subset of Rn to be compact:
(i) Heine-Borel property.
(ii) Closed and boundedness property.
(iii) Bolzano-Weierstrass property.
(iv) Sequentially compactness property.

Unit 2. connectedness.(10 lectures)

(c) (i) Connected metric spaces. Definition and examples.
(ii) Different characterizations of a connected space
(iii) Connected subsets of a metric space, connected subsets of R.
(iv) A continous image of a connected set is connected.
(d) (i) Path connectedness in Rn, definitions and examples.
(ii) A path connected subset of Rn is connected.
(iii) An example of a connected subset of Rn which is not path connected.

Unit 3. The function spaces (10 lectures)

(i) The function space C(X;R) of real valued continuous functions on a metric space X. The space C[a; b] with sup norm, Weierstrass approximation Theorem.(Statement only)
(ii) Fourier series of functions on C[-π , π], Bessel's inequality.

Unit 4.Sum of Fourier Series.(13 lectures.)

Dirichlet kernel, Fejer kernel, Cesaro summability of Fourier series of functions on C[-π , π], Pareseval's identity, convergence of the Fourier series in L_2 norm.

List Of Recommended Reference Books

1. S. Kumaresan. Topology of Metric spaces.
2. R.G. Goldberg Methods of Real Analysis, Oxford and IBH Publishing House, New Delhi.
3. W. Rudin. Principles of Mathematical Analysis. McGraw Hill, Auckland, 1976.
4. P.K. Jain, K. Ahmed. Metric spaces. Narosa, New Delhi, 1996.
5. G.F. Simmons. Introduction to Topology and Modern Analysis. McGraw Hill, New York,
6. T. Apostol. Mathematical Analysis, Second edition, Narosa, New Delhi, 1974.
7. E.T. Copson. Metric spaces. Universal Book Stall, New Delhi, 1996.
8. Sutherland. Topology.

9. D. Somasundaram, B. Choudhary. A _rst course in Mathematical Analysis. Narosa, New Delhi.
10. R. Bhatia. Fourier series. Texts and readings in Mathematics (TRIM series), HBA,

Suggested Practicals

1. Compactness in Rn (emphasis on R1, R2). Properties.
2. Connectedness.
3. Path connectedness.
4. Continuous image of compact and connected sets
5 Fourier series;
6 Parseval's identity.
7. Miscellaneous Theoretical Questions based on Unit 1and 2.
8. Miscellaneous Theoretical Questions based on Unit 3 and 4.

Course: S.MAT.6.04 **Title:** Complex Variables

Learning Objectives:-To learn about
i) Analytic functions & integration of such functions
ii) Conformal mapping , cross ratio, Bilinear transformation
iii) Laurent Series, Singularities and its types , Residues , Cauchy`s Residue theorem, Rouche`s theorem

Number of lectures: 45

Unit 1. Complex Numbers (10 Lectures)
Review of complex numbers ,the complex plane,Cartesian-polar-exponential form of a complex number ,Inequalities wrt absolute values, De Moivre`s theorem and its applications, Circular and Hyperbolic functions, Inverse circular and Hyperbolic functions, Separation of real and imaginary parts.

Unit 2. Functions of a Complex Variable(10 Lectures)
Limit ,Continuity ,dirivatives ,analytic functions ,Cauchy-Riemann equations (in cartesian and polar form), harmonic functions, orthogonal curves. To find analytic function when its real/imaginary part or corresponding harmonic function is given. Conformal mapping , cross ratio, Bilinear transformation, fixed(invariant) points.

Unit 3. Complex Integration (10 Lectures)
Rectifiable curves ,integration along piecewise smooth paths , contours.
Cauchy`s theorem & its consequences , Cauchy`s integral formula for derivatives of analytic functions.

Unit 4. Laurent series,Types of singularities & Residues(15 Lectures)
Development of analytic functions as power series–Taylor & Laurent Series.

Entire functions ,Singularities and its types ,Residues , Cauchy`s Residue theorem and its applications-evaluation of standard integrals by Residue calculus method , the Argument principle, Rouche`s theorem & its applications- The Fundamental theorem of Algebra.

Reference Books:-

1) Theory & problems of Complex Variables by Murray R.Spiegel , Schaum`s Outline series McGraw-Hill Book Company,Singapore.
2) Functions of one complex variable by John B.Conway, Narosa Publishing House ,New Delhi.
3) Complex variables and applications by R.V.Churchill
4) Foundations of Complex Analysis by S.Ponnusamy, Narosa Publishing House ,New Delhi.
5) john mathews, russel howell from Narosa

Practicals

1) Analytic functions, Cauchy-Riemann equations, Harmonic functions.
2) Conformal mappings, Bilinear transformations.
3) Integration along piecewise smooth paths, Cauchy`s theorem, Cauchy`s integral formula.
4) Taylor`s & Laurent Series
5) Singularities and its types ,Residues , Cauchy`s Residue theorem and its applications.
6) Rouche`s theorem & its applications
7) Miscellaneous Theoretical questions based on Unit 1 and 2. 8) Miscellaneous Theoretical questions based on Unit 3 and 4.

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Course:S.Mat.6.AC
Title: Computer programming and system analysis

Learning Objectives:-To learn about OOP through java programming, applets

Number of lectures: 50

<u>Unit 1. Java Programming and applets</u> **(16 Lectures)**

Introduction to Classes and Methods(continued)

Defining classes, creating- instance and class variables, creating objects of a class, accessing instance variables of a class, Creating methods, naming methods, accessing methods of class, constructor methods, overloading methods.

Arrays: Arrays (one and two dimensional) declaring arrays, creating array objects, accessing array elements.

Inheritance, interfaces and Packages: Super and sub classes, keywords- "extends", "super‟, „final‟, finalizer methods and overriden methods, abstract classes, concept of interfaces and packages.

Java Applets Basics: Difference of applets and application, creating applets, life cycle of applet, passing parameters to applets.

Graphics, Fonts and Color

The graphics classes, painting the applet, font class, draw graphical figures (oval, rectangle, square, circle, lines,polygones) and text using different fonts.

Unit 2. Networking (09 Lectures)

Introduction

What is networking, need for networking, networking components- nodes, links (point to point and broadcast), networking topologies – bus, star, mesh, network services (connection oriented and connectionless).

Network Design

What is network design, requirement and tasks of a network, LAN MAN, WAN, VAN.

Network Architectures Layering principle, OSI Reference Model, TCP/ IP Reference Model. Comparison of OSI and TCP/P Reference Models.

Network Switching and Multiplexing

Bridges, interconnecting LANs with bridges spanning tree algorithm. What is multiplexing. Static multiplexing (FDM, TDM, WDM), dynamic multiplexing. What is switching, circuit switching, packet switching.

outing and Addressing Router, router table, routing (direct and indirect), routing characteristics, shortest path routing Dijkstra`s algorithm. TCP/IP internetworking, IP addresses (class, classless), and sub netting and subnet mask, Domain names

Unit 3. C Programming. (16 lectures)

Loops and Controls

Control statements for decision making: branching (if statement, if-else statement, else-if statement, switch statement), looping (while loop, do while loop and for loop), breaking out of loops (break and continue statements).
Storage Classes
Automatic variables, external variables, register variables, static variables - scope and functions.
Functions and Arguments
Global and local variables, function definition, return statement, calling a function (by value, by reference), recursion, recursive functions.
Strings and Arrays
Arrays (one and two dimensional), declaring array variables, initialization of arrays, accessing array elements, string functions (strcpy, strcat, strchr, strcmp, strlen, strstr, atoi, atof).Pointers Fundamentals, pointer declarations, operators on pointers, passing pointers to functions, pointers and one dimensional array, pointers and two dimensional array. Structures.Basics of structures, structures and functions.

Unit 4. Introduction to DBMS and RDBMS (9 Lectures)

Introduction to Database Concepts
Database systems vs file systems, view of data, data models, data abstraction, data independence,
three level architecture, database design, database languages - data definition language(DDL), data manipulation language(DML). E - R Model
Basic concepts, keys, E-R diagram, design of E-R diagram schema (simple example).
Relational structure
Tables (relations), rows (tuples), domains, attributes, candidate keys, primary key, entity integrity constraints, referential integrity constraints, query languages, normal forms 1,2,and 3 (statements only), translation of ER schemas to relational (database) schemas (logical design), physical design.

Recommended Books:-

(1)The complete reference java2: Patrick maughton, Hebert schind (TMH).
(Chapters 1 – 6, 8-9, 12, 21)
(2)Computer Networks – Andrew S. Tanenbaum (PHI) (Chapter 1: 1.1-1.4, chapter 2:2.5.4.2.5.5 Chapter 5:P 5.2.1-5.2.4,5.5.1-5.5.2,5.6.1-5.6.2, Chapter 7:7.1.1. 7.1.3).

(3)Programming in Ansi C - Ram Kumar and Rakesh Agarwal (Tata McGraw Hill)
(Chapters 2 - 8).
(4) Database System Concepts - Silberschatz, Korth, Sudarshan (McGraw-Hill Int. Edition) 4th Edition (Chapter 1: 1.1 - 1.5, Chapter 2: 2.1 - 2.5, 2.8 - 2.9, Chapter 3: 3.1, Chapter 7: 7.1,7.2, 7.7)

Practicals:- Java programs that illustrate

1) the concept of java class
   (i) with instance variable and methods
   (ii) with instance variables and without methods
   (iii) without instance variable and with methods

Create an object of this class that will invoke the instance variables and methods accordingly.

2) the concept of (one dimensional) arrays
3) the concept of (two dimensional) arrays
4) the concept of java class that includes inheritance
5) the concept of java class that includes overridden methods
6) the concept of java class that includes interfaces and packages
7) applets
8)Java programs on numerical methods.

C programs for:

1. Creating and printing frequency distribution.
2. (a) Sum of two matrices of order $m \times n$ and transpose of a matrix of order $m \times n$, where $m, n = 3$.

(b) Multiplication of two matrices of order m, where $m = 3$, finding square and cube of a square matrix using function.

3. Simple applications of recursive functions (like Factorial of a positive integer, Generating

Fibonacci Sequence, Ackerman Function, univariate equation)

4. Sorting of Numbers (using bubble sort, selection sort), and strings.
5. Using arrays to represent a large integer (that cannot be stored in a single integer variable).
6. Counting number of specified characters (one or more) in a given character string.
7. Writing a function to illustrate pointer arithmetic.
8. Using structures to find and print the average marks of five subject along with the name of a student.
9. Program to find g.c.d. using Euclidean algorithm.
10. Numerical methods with C programs.
11. Program to decide whether given number is prime or not.
12. Finding roots of quadratic equation using C program.
13. Programs to find trace, determinant of a matrix.
14. Program to check given matrix is symmetric or not.

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