St. Xavier's College – Autonomous Mumbai

Syllabus For ODD Semester Courses in MATHEMATICS

(2021 - 2022)

Contents:

T.Y.B.Sc. - Mathematics Course Code: S.MAT.5.01

Title of Paper: CALCULUS - V

Learning Objectives:
After completion of the course, a student should:
(i) Learn about Multiple, Line and Surface integrals.
(ii) Understand the differences between above mentioned integrals.
(iii) Apply the concepts on different physical problems. For e.g., finding centre of gravity, moment of inertia and flux.

Number of lectures: 45

Unit I: Multiple Integrals - I (12 Lectures)

Definition of double (respectively: triple) integral of a function bounded on a rectangle (respectively: 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.

Unit II: Multiple Integrals - II (11 Lectures)

Integrability of bounded functions having finite number of points of discontinuity, Domain additivity of the integral.
Integrability and the integral over arbitrary bounded domains.
Change of variables formula (Statement only), Polar, cylindrical and spherical coordinates and integration using these coordinates.
Differentiation under the integral sign.
Applications to finding the center of gravity and moments of inertia.

Unit III: Line Integrals (11 Lectures)

Review of Scalar and Vector Fields on $\mathbb{R}$, Vector Differential Operators.
Gradient Paths (Parametrized Curves) in $\mathbb{R}$, Smooth and piecewise smooth paths. Closed paths, Equivalence and orientation preserving equivalence of the 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.
Flux across a plane curve.
Green's Theorem (proof in the case of rectangular domains).
Applications to evaluation of line integrals.

Unit IV: Surface Integrals (11 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.
Independence of value of surface integral under change of parametric representation of the surface.
Curl and divergence of a vector field, Elementary identities involving gradient, curl and divergence.
Stokes' Theorem (proof assuming the general form of Green's Theorem), Examples.
Gauss' Divergence Theorem (proof only in the case of cubical domains), Examples.

References:
1. Tom V. Apostol, Calculus, Vol. 2, Second Ed., John Wiley, New York, 1969
2. James Stewart, Calculus: Early transcendental Functions
3. J. E. Marsden and A.J. Tromba, Vector Calculus, Fourth Ed., W.H. Freeman and Co.,
New York, 1996
4. Lawrence Corwin and Robert Szczarba, Multivariable Calculus

Additional References:
1. T Apostol, Mathematical Analysis, Second Ed., Narosa, New Delhi. 1947.
2. R. Courant and F. John, Introduction to Calculus and Analysis, Vol.2, Springer Verlag, New York, 1989.
3. Wendall Fleming, Functions of Several Variables, Second Ed., Springer-Verlag, New York, 1977.
4. M. H. Protter and C. B. Morrey, Jr., Intermediate Calculus, Second Ed., SpringerVerlag, New York, 1995.
5. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, Ninth Ed. (ISE Reprint), Addison- Wesley, Reading Mass, 1998.
6. David Widder Advanced Calculus, Second Ed., Dover Pub., New York. 1989.
7. Sudhir R. Ghorpade and Balmohan Limaye, A course in Multivariable Calculus and Analysis, Springer International Edition.
8. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
9. Michael Spivak, Calculus on Manifolds.
10. Jerrold E. Marsden, Anthony J. Tromba, Alan Weinstein, Basic Multivariable Calculus.

Suggested Practicals (3 practicals per batch per week):
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. Green's theorem, conservative field and applications.
5. Evaluation of surface integrals.
6. Stokes' and Gauss' Divergence Theorem.

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T.Y.B.Sc. – Mathematics Course Code: S.MAT.5.02

Title: ALGEBRA V

Learning Objectives (i) To learn Diagonalization of matrices.

(ii) To learn Quotient spaces and Orthogonal transformations.

Number of lectures: 45

Unit I. Quotient Spaces and Cayley Hamilton Theorem (11L)

Review of vector spaces over $\mathbb{R}$, sub spaces and linear transformation.Quotient Spaces: For a real vector space and a subspace , the cosets and the quotient space , First Isomorphism theorem of real vector spaces(fundamental theorem of homomorphism of vector spaces), Dimension and basis of the quotient space ,when is finite dimensional. Characteristic polynomial of Real matrix. Cayley Hamilton theorem and its applicatios.

Reference for Unit I:

(i) S. Kumaresan, Linear Algebra: A Geometric Approach.
(ii) Inder K Rana, Introduction to Linear Algebra, Ane Books Pvt. Ltd. Inder K Rana, Introduction to Linear Algebra, Ane Books Pvt. Ltd.
(ii) Ramachandra Rao and P. Bhimasankaram, Tata McGraw Hill Publishing Company.

Unit II. Orthogonal transformations (11 L)

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

Reference for Unit II:

(i) K Hoffman and Kunze, Linear Algebra, Prentice Hall of India, New Delhi.
(ii) S. Kumaresan, Linear Algebra: A Geometric Approach.

Unit III. Eigenvalues and eigen vectors (11L)

Eigen values and eigen vectors of a linear transformation T: V→V ,where V is a finite dimensional real vector space and examples, Eigen values and Eigen vectors of × real matrices, The linear independence of eigenvectors corresponding to distinct eigenvalues of a linear transformation and a Matrix. The characteristic polynomial of a × real matrix and a linear transformation of a finite dimensional real vector space to itself, characteristic roots, Similar matrices, Relation with change of basis, Invariance of the characteristic polynomial and (hence of the) eigen values of similar matrices, Every square

matrix is similar to an upper triangular matrix. Minimal Polynomial of a matrix, Examples like minimal polynomial of scalar matrix, diagonal matrix, similar matrix, Invariant subspaces.

Reference for Unit III:

(i) K Hoffman and Kunze, Linear Algebra, Prentice Hall of India, New Delhi.

Unit IV: Diagonalisation (12L)

Geometric multiplicity and Algebraic multiplicity of eigen values of a nxn real matrix. Matrix is diagonalizable if and only if it has basis containing eigen vectors if and only if sum of dimensions of eigen spaces is n if and only if their geometric and algebraic multiplicities coincide. Examples of non diagonalizable matrices. Diagonalisation of a linear transformation.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 in $\mathbb{R}$ and quadric surfaces in $\mathbb{R}$. Positive definite and semi definite matrices, Characterization of positive definite matrices in terms of principal minors.

Reference for Unit IV:

(i) S. Kumaresan, Linear Algebra: A Geometric Approach.
(ii) K Hoffman and Kunze, Linear Algebra, Prentice Hall of India, New Delhi.

Recommended Books:

(i) S. Kumaresan, Linear Algebra: A Geometric Approach.
(ii) K Hoffman and Kunze, Linear Algebra, Prentice Hall of India, New Delhi.
(iii)Inder K Rana, Introduction to Linear Algebra, Ane Books Pvt. Ltd.

Additional Reference Books:

(i) Ramachandra Rao and P. Bhimasankaram, Tata McGraw Hill Publishing Company.

(ii) T. Banchoff and J. Wermer, Linear Algebra through Geometry, Springer.
(iii) L. Smith, Linear Algebra, Springer.
(iv) M. R. Adhikari and Avishek Adhikari, Introduction to linear Algebra, Asian Books Private Ltd.
(v) N. S. Gopalakrishnan, University Algebra, Wiley Eastern Limited.

Suggested Practicals:

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.

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Title: Topology of Metric Spaces I Course Code: S.MAT.5.03

Learning Objective: Introduction to Metric Spaces.

Unit I. Metric Spaces (10 L)

Definition, examples of metric spaces, $\mathbb{R}$ with usual distance, the Euclidean space $\mathbb{R}^2$, sup and sum metric, discrete metric, the metric space of complex numbers.The metric induced by a norm, translation invariance of the metric induced by the norm. Metric subspaces, Product of two metric spaces. Open balls and open set in a metric space, examples of open sets in various metric spaces, Hausdorff property, Interior of a set, Properties of open sets, Structure of an open set in $\mathbb{R}$, Equivalent metrics.

Unit II. Closed Sets, Distance of a point from a Set, Distance between Sets (10 L)
Closed ball in a metric space, Closed sets- definition, examples. Limit point of a set, closure point, isolated point. A closed set contains all its limit points, Closure of a set and boundary, Sequences in a metric space, Distance of a point from a set, distance between two sets, diameter of a set, Bounded sets.

Unit III. Sequences (10 L)

Convergent sequence in a metric space, Cauchy sequence in a metric space, subsequences, examples of convergent and Cauchy sequences in metric spaces,

$\mathbb{R}$ with different metrics and other metric spaces. Characterization of limit points and closure points in terms of sequences. Definition and examples of relative openness,

Unit IV. Compact sets (15 L)

Definition of compact metric space using open cover, examples of compact sets in different metric spaces. Properties of compact sets—compact set is closed and bounded, every infinite bounded subset of a compact metric space has a limit point, Heine- Borel theorem. Equivalent statements for compact sets in $\mathbb{R}^n$; Heine- Borel property, Closed and boundedness property, Bolzano- Weierstrass property, Sequential compactness property.

Recommended Books :
1. P.K. Jain and Khalil Ahmed,Metric Spaces
2. S. Kumaresan, Topology of Metric spaces.
3. E. T. Copson. Metric Spaces. Universal Book Stall, New Delhi, 1996.

Additional Reference Books.
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.

Suggested Practicals:

1. Metric spaces.
2. Open sets , Closed sets in Metric spaces.
3. Sequences
4. Cauchy sequence, subsequences
5. Compact sets
6. Bolzano- Weierstrass property, Sequential compactness property

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T.Y. B.Sc. Mathematics Course Code: S.Mat.5.04

Title: Numerical Methods-I

Learning Objectives: To learn about (i) Iteration methods based on first/second degree equation.

(ii) Iteration methods for polynomial equations.
(iii) solving a system of linear algebraic equations.
(iv) Eigen Value Problem

Number of lectures: 45

Unit I. Errors Analysis, Transcendental and Polynomial Equations-I (12 L)

Measures of Errors: Relative, absolute and percentage errors. Types of errors: Inherent error, Round-off error and Truncation error. Examples using Taylor's series Significant digits and numerical stability. Concept of simple and multiple roots. Direct and Iterative methods, error tolerance, use of intermediate value theorem and finding initial approximation of a root. Iteration methods based on first degree equation: Regula-Falsi method, Secant method, Newton-Raphson method, General Iteration Method. Condition of convergence and Rate of convergence of all above methods. Methods for multiple roots.

Unit II. Transcendental and Polynomial Equations-II (11 L)

Iteration methods based on second degree equation: Muller method, Chebyshev method, Multipoint iteration method and their rate of convergence.

Iterative methods for polynomial equations: Descart's rule of signs, Sturm sequence, BirgeVieta method, Bairstow method, Graeffe`s root squaring method.

Unit III. System of Linear Algebraic Equations (11 L)

Matrix representation of linear system of equations.
Direct methods: Gauss elimination method. Pivot element, Partial and complete pivoting, Forward and backward substitution method, Triangularization methods-Doolittle`s and Crout`s method, Cholesky's method, LU decomposition, Partition method, Error analysis of direct methods.
Iteration methods: Jacobi iteration method, Gauss-Siedal iterative method, SOR method. Convergence analysis of iterative methods.

Unit IV. Eigen Value Problem
(11 L)
Eigen values and Eigen Vectors. Bounds on Eigen values, Jacobi's method for symmetric matrices, Given`s method for symmetric matrices, HouseHolder`s method for symmetric matrices, Rutihauser method for arbitrary matrices, Power method and inverse Power method.

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, McGraw Hill 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.

Suggested Practicals :

1) Iteration methods based on first degree equation.
2) Iteration methods based on second degree equation.
3) Iteration methods for polynomial equations.
4) Linear System of equations.
5) Eigen values and Eigen Vectors-Jacobi method, Given`s method, HouseHolder`s method for symmetric matrices.
6) Eigen values and Eigen Vectors- Rutishauser method, Power method for arbitrary matrices.

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Mathematics Applied Component

5TH Semester

B.Sc. Mathematics Course: S.MAT.5.AC

Title: COMPUTER PROGRAMMING

Learning Objectives:

1) To learn about OOP through java programming, applets.
2) Intro. to DBMS & RDBMS, SQL & PL/SQL Commands & Functions.

(3) Database Management Systems, Ramakrishnam, Gehrke, McGraw-Hill
(4) Ivan Bayross, "SQL,PL/SQL -The Programming language of Oracle", B.P.B. Publications, 3rd Revised Edition.

Unit I Introduction to Java Programming 15L

(a) Introduction: History of Java, Java features, different types of Java programs, Differentiate Java with C. Java Virtual Machine.
(b) Java Basics: Variables and data types, declaring variables, literals: numeric, Boolean, character and string literals, keywords, type conversion and casting. Standard default values. Java Operators, Loops and Controls (No Questions are to be asked on this topic).
(c) Classes: Defining a class, creating instance and class members: creating object of a class; accessing instance variables of a class; creating method; naming method of a class; accessing method of a class; overloading method; 'this' keyword, constructor and Finalizer: Basic Constructor; parameterized constructor; calling another constructor; finalize() method; overloading constructor.
(d) Arrays: one and two-dimensional array, declaring array variables, creating array objects, accessing array elements.
(e) Access control: public access, friendly access, protected access, private access.

Unit II Inheritance, Java Applets and Graphics Programming 15L

(a) Inheritance: Various types of inheritance, super and subclasses, keywords- 'extends'; 'super', overriding method, final and abstract class: final variables and methods; final classes, abstract methods and classes. Concept of interface. (b) Applets: Difference of applet and application, creating applets, applet life cycle, passing parameters to applets.
(c) Graphics, Fonts and Color: The graphics class, painting, repainting and updating an applet, sizing graphics. Font class, draw graphical figures - lines and rectangle, circle and ellipse, drawing arcs, drawing polygons. Working with Colors: Color methods, setting the paint mode.

Unit III Relational Database Management System 15L

(a) Introduction to Database Concepts: Database, Overview of database management system. Database Languages- Data Definition Language (DDL) and Data Manipulation Languages (DML).
(b) Entity Relation Model: Entity, attributes, keys, relations, Designing ER diagram, integrity constraints over relations, Conversion of ER to relations with and without constraints.
(c) SQL commands and Functions:
(i) Creating and altering tables: CREATE statement with constraints like KEY, CHECK, DEFAULT, ALTER and DROP statement.
(ii) Handling data using SQL: 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.
(iii) Functions: Aggregate functions-AVG, SUM, MIN, MAX and COUNT, Date functions- ADD_MONTHS(), CURRENT_DATE(), LAST_DAY(),

MONTHS_BETWEEN(), NEXT_DAY(). String functions LOWER(), UPPER(), LTRIM(), RTRIM(), TRIM(), INSTR(), RIGHT(), LEFT(), LENGTH(), SUBSTR(). Numeric functions: ABS(), EXP(), LOG(), SQRT(), POWER(), SIGN(), ROUND(number). (iv) Joining tables: Inner, outer and cross joins, union.

Unit IV Introduction to PL/SQL 15L

(a) Fundamentals of PL/SQL: Defining variables and constants, PL/SQL expressions and comparisons: Logical Operators, Boolean Expressions, CASE Expressions Handling, Null Values in Comparisons and Conditional Statements,
(b) PL/SQL Data types: Number Types, Character Types, Boolean Type. Datetime and Interval Types.
(c) Overview of PL/SQL Control Structures: Conditional Control: IF and CASE Statements, IF-THEN Statement, IF-THEN-ELSE Statement, IF-THEN-ELSIF Statement, CASE Statement,
(d) Iterative Control: LOOP and EXIT Statements, WHILE-LOOP, FOR-LOOP, Sequential Control: GOTO and NULL Statements.

Recommended Books:

(1) Programming with Java: A Primer 4th Edition by E. Balagurusamy, Tata McGraw Hill.
(2) Java The Complete Reference, 8th Edition, Herbert Schildt, Tata McGraw Hill.
(3) Database Management Systems, Ramakrishnam, Gehrke, McGraw-Hill.
(4) Ivan Bayross, "SQL,PL/SQL -The Programming language of Oracle", B.P.B. Publications, 3rd Revised Edition.

Additional References:

(a) Elsmasri and Navathe, "Fundamentals of Database Systems", Pearson Education.

(b) Peter Rob and Coronel, "Database Systems, Design, Implementation and Management", Thomson Learning
(c) C.J.Date, Longman, "Introduction to database Systems", Pearson Education.
(d) Jeffrey D. Ullman, Jennifer Widom, "A First Course in Database Systems", Pearson Education. (e) Martin Gruber, "Understanding SQL",B.P.B. Publications.
(f) Michael Abbey, Michael J. Corey, Ian Abramson, Oracle 8i – A Beginner's Guide, Tata McGraw-Hill.Eric Jendrock, Jennifer Ball, D Carson and others, The Java EE 5 Tutorial, Pearson
Education, Third Edition, 2003. (g)
Ivan Bayross, Web Enabled Commercial Applications Development Using Java 2, BPB Publications,Revised Edition, 2006
(h) Joe Wigglesworth and Paula McMillan, Java Programming: Advanced Topics, Thomson Course
Technology (SPD), Third Edition, 2004
(i) The Java Tutorials of Sun Microsystems Inc. http://docs.oracle.com/javase/tutorial.

Suggested Practicals:

1) Write a Java program to create a Java class: (a) without instance variables and methods, (b) with instance variables and without methods, (c) without instance variables and with methods, (d) with instance variables and methods
2) Write a Java program that illustrates the concepts of one, two dimension arrays.

3) Write a Java program that illustrates the concepts of Java class that includes (a) constructor with and without parameters (b) Overloading methods.
4) (a) Write a Java program to demonstrate inheritance by creating suitable classes.
(b)Write a Java applet to demonstrate graphics, Font and Color classes.
5) Creating a single table with/ without constraints and executing queries. Queries containing aggregate, string and date functions fired on a single table.
6) Updating tables, altering table structure and deleting table Creating and altering a single table and executing queries. Joining tables and processing queries.
7) Writing PL/SQL Blocks with basic programming constructs. 8) Writing PL/SQL Blocks with control structures.

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