PARVATIBAI CHOWGULE COLLEGE OF ARTS AND SCIENCE (AUTONOMOUS),
MARGAO - GOA
SYLLABUS FOR PROGRAMME BACHELOR OF ARTS/SCIENCE IN MATHEMATICS
T.Y.B.A/B.Sc. (SEMESTER-V)

Course Title: Functions of several variables
Course Code: MAT-V C7
Marks: 100
Credits: 4
Course Pre Requisites: Mathematical Analysis, Co-ordinate geometry.
Aim: - To introduce multivariate calculus, i.e. Continuity, Differentiation and Integration of functions of several variables, applications of differentiation and integration.
Learning outcome: - Students will be able to

C01. Progress from single variable functions to several variable functions.
C02. Learn about partial derivatives and its applications.
C03. Understand the concept of differentiability for several variables
C04. Solve problems using line, double integrals.

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

Introduction: - Neighbourhood of a point in $\mathbf{R}^2$ (in $\mathbf{R}^n$), Open sets in $\mathbf{R}^2$, Sequence in $\mathbf{R}^2$, limit point of a sequence, Limit of a function, Continuity of a function. Functions from $\mathbf{R}^2$ to **R,** Examples, and graphs in three dimensions.

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

Directional derivatives, Partial Derivatives, their geometrical meaning, MVT, higher order partial derivatives, Equality of mixed partial derivatives, Taylor's theorem, Applications of partial derivatives, Maxima-Minima, Saddle Point, Lagrange multiplier method,

Unit 3:- **(15 lectures)**

Differentiability of functions of two variables, sufficient condition for Differentiability, Total derivative, chain rule, Jacobian. Implicit and Inverse function theorems.

Unit 4:- **(15 lectures)**

Integration. Line integral, fundamental theorem of Calculus, Double integral on rectangles & bounded regions, change of order, change of variables, calculating volumes and surface areas of simple geometrical objects.

References:

- S.R. Ghorpade & B.V. Limaye, A Course in Multivariable Calculus and Analysis, Springer
- S.C. Malik & S. Arora, Mathematical Analysis, Fourth Edition, New Age International
- G.B. Thomas Jr. and R.L. Finney, Calculus and Analytic Geometry, Pearson
- W.H. Fleming, Functions of Several Variables, Springer
- T. Apostol, Calculus Volume II, Wiley India

Course Title: Metric Spaces
Course Code: MAT-V E-9
Marks: 100
Credits: 4
Course Objectives: To introduce different kind of 'Distance' and analysis that follows.
Learning outcome: Students will be able to

C01. Understand several standard concepts of metric spaces
C02. Explain properties of metric spaces like openness, closedness, completeness, Bolzano-Weierstrass property, compactness, and connectedness.
C03. Learn about functions defined on metric spaces

Prerequisites: Basic Real Analysis.

Unit1] Idea of 'Distance', definition, examples of Metric Spaces. Basic terminologies – neighbourhood of a point, open ball, open set, closed set, interior point, exterior point, limit point, isolated point, cluster point, closure of a set, interior of a set, frontier (boundary) of a set, Dense set, nowhere dense set, bounded set, diameter of a set, distance between the sets, distance of a point from a set and Results involving these concepts. **(15 lectures)**

Unit2] Equivalence of metrics, geometry with different metrics, Subspace of a metric space, results on subspaces of metric space, sequences in a metric space, convergence of sequences, Cauchy sequence, concepts of complete metric space, completion of a metric space. **(15 lectures)**

Unit3] Connected subsets of a metric space, Separation of a set, connected components of metric space, Results regarding connectedness of a metric space. **(10 lectures)**

Unit4] Compact metric space, open cover, finite cover, sequential compactness, one point compactification, **(10 lectures)**

Unit5] Functions on metric space. Continuous functions (maps), equivalent definitions, invariance of compactness, completeness, connectedness of continuous images. Open maps-closed maps and their basic properties. **(10 lectures)**

References:-

1. E.T. Copson, Metric Spaces, Cambridge University Press
2. G.F. Simmons, Introduction to Topology and Modern Analysis, Mc Graw Hill
3. S. Shirali and H.L. Vasudeva, Metric Spaces, Springer
4. S. Kumaresan, Topology of Metric Spaces, Narosa

Course Title: Graph theory
Course Code: MAT-V E-11
Marks: 100
Credits: 4
Course Pre Requisites: Basic set theory, Principle of counting, Principles of Mathematical Induction
Course objective: To introduce the concept of discrete graphs, trees and some of their applications in real world problems.
Course outcomes: The student will be able to

C01. Appreciate the definition and basics of graphs along with types and their examples.
C02. Understand the definition of a tree and use various algorithms to find the shortest path
C03. Know the applications of graph theory to network flows.
C04. Understand the notion of planarity and colouring of a graph.

Unit 1 Graphs (8 Lectures)

The Konigsberg 7 bridges problem and Euler's solution to it.
Definition of graph examples and types of graphs: complete, directed, bipartite, multi graph, etc, degree of a vertex, Adjacency matrix, incidence matrix, operations on graphs: subgraphs, union, intersection and Cartesian product, isomorphisms in graphs, special graphs: self-complimentary graphs, Petersen graphs, Herschel's Graph

Unit 2 Walks paths and cycles (12 Lectures)

Definition of walks, paths and cycle, distance and weighted distance, radius and diameter of a graph, eccentricity of a vertex. Euler walks, Hamiltonian cycles application: travelling salesman problem

Unit 3 Connectivity, cut-points, blocks, connectivity (8 Lectures)

Unit 4 Trees (12 Lectures)

Definition of tree, results on trees, spanning tree, application: minimum spanning trees and Kruskal's algorithm. Breadth First Search Algorithm and its use in the Chinese postman problem. Dijkstra's Algorithm for shortest path.

Unit 5 Coloring (10 Lectures)

Vertex coloring, chromatic number of a graph and simple relation, chromatic polynomial and its properties, edge colorings.

Unit 6 Planarity (10 Lectures)

Representations and crossing number of graphs, Euler's formula, maps and planar graphs. Proof of five color theorem for planar graphs

References:

1. W.D. Wallis, A Beginners Guide to Graph Theory, Birkhauser
2. Robin J. Wilson Introduction to Graph Theory, Longman Group Ltd.
3. J.A. Bondy, U.S.R Murthy, Graph Theory, Springer
4. D.B. West, Introduction to Graph Theory, second edition, Prentice Hall of India.
5. F Harary, Graph Theory, Narosa
6. V.K. Balakrisnan, Graph Theory (Schaum series), Mc Graw Hill India

Course Title: Cryptography
Course Code: MAT-IV E-8
Marks: 100
Credits: 4
Course prerequsites: Algebra-1 and Number Theory-1
Course objectives: - To introduce some applications of algebra and number theory to students.
Learning Outcome: - Students will be able to

C01. Understand the difference between classical and modern cryptography.
C02. Learn the fundamentals of cryptography, including Data and Advanced Encryption Standards and RSA.
C03. Encrypt and decrypt messages using block ciphers
C04. Know about the aspects of number theory which are relevant to cryptography.

Unit 1: Review of some topics of Number theory and algebra :- **(12Lectures)**
Divisibility and primes, Prime factorization, Euclidian algorithm, Fermat's little theorem, Congruence and ring of integers.
Groups of compositions, order of permutation, Fields, finite fields, ring of polynomials, factorization of polynomials, to be reviewed.
Unit 2: Classical Cryptosystems. **(8Lectures)**
Affine cryptosystem, Hill cryptosystem, Block Ciphers, Stream Ciphers, Linear feedback shift registers.
Unit 3: Public Key cryptosystem. **(16Lectures)**
One way functions, Trapdoor functions, RSA Public Key cryptosystem, Key exchange protocols, hash functions.
Unit 4: Private Key cryptosystem. **(8Lectures)**
Modern techniques and algorithms like DSE and AES.
Unit 5: Elliptic curve cryptosystem. **(16Lectures)**
Introduction to elliptic curves and its application to factorization and cryptography.

References:

1. N. Koblitz, a course in Number theory and Cryptography, Springer.
2. J Katze & Y Lindell, Introduction to modern cryptography, Springer.
3. C Paar & J Pelze, Understanding Cryptography: A textbook for students and practitioners, Springer.
4. W Trappe, Introduction to Cryptography with coding theory, Pearson.

Course Title: Logic and Boolean algebra.
Course Code: MAT- (Sem IV)
Marks: 100
Credits: 4
Course objective: To formalize logic and set theory and introduce students to Boolean algebra**.**
Course outcome: At the completion of the course students will be able to

1. Use symbolic logic and illustrate it. 2. Appreciate set theoretical relations and examples. 3. Apply Boolean algebra in some real-life situations.

Prerequisites: Basic Algebra
Content
Unit 1: Logic – 15 lectures
1.1 Revision: Statements in logic, symbolic representation, connectives, truth-tables.

1.2 The logic of compound statements: Logical form and logical equivalence, conditional statements, duality law, normal forms, rules of inference, valid and invalid arguments.
1.3 Quantified statements: Predicates and quantified statements, universal quantifiers, existential quantifiers, statements with multiple quantifiers, arguments with quantified statements.
1.4 Study of logic gates: AND, OR, NOT, XOR, XNOR, NAND and NOR gates.

Unit 2: Sets – **15 lectures**

2.1 Revision: Basic concepts of set theory, finite and infinite sets, set operations, laws of set theory.
2.2 Binary relations, types of relations, equivalence relations, Partial ordering relations, posets, Hasse diagrams, upper bound, lower bound, lub, glb.

Unit 3: Lattices & Boolean algebra – **30 lectures**

3.1 Lattice as a poset, duality principle for lattices, properties of lattice.
3.2 Sub-lattice, complemented lattice, distributive lattice,
3.3 Lattice homomorphisms & isomorphisms, order preserving homomorphisms.
3.4 Boolean algebra, its properties, sub-algebra, direct products, homomorphisms, joint-irreducible elements.
3.5 Boolean expressions, equivalent boolean expressions, minterm, maxterm, values of boolean expressions, Stone's representation theorem for finite boolean algebra,
3.6 Canonical forms: sum-of-products, product-of-sums canonical forms.
3.7 Boolean functions and their representations- cube notation, Karnaugh maps, applications.

References:

1. Discrete mathematical structures with applications to computer science
- by J.P. Tremblay, R. Manohar (Principle text)
2. Elements of Discrete mathematics – by C. Liu
3. Discrete mathematics – (Schaum's outlines) by Seymour Lipschutz, Marc Laras Lipson & Varsha H. Patil.

1. Course Title : Operations Research II

2. Course Code : MAT-V. E -13

3. Marks : 100

4. Credits : 4

5. Duration : 60 hours

6. Prerequisite Courses : Operations Research I

7. Course Objectives : This course aims to teach more methods of OR.

8. Course Outcomes : Students will be able to

C01. Solve game theory using different methods
C02. Evaluate EOQ in different inventory models.
C03. Evaluate various measures of performance in queueing models
C04. Find better approximations of results using simulations

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Syllabus :

Unit 1. Game Theory: (15 Hours)
Optimal Solution of Two-Person Zero-Sum Games, Solution of Mixed Strategy Games, Graphical solution of *2 x n* and *2 x m* Games, arithmetic method for *n x n* games, general solution of *m x n* games, Converting Game theory into LPP.
Unit 2. Inventory Control: (15 Hours)
Types, Reasons, Objective and the Factors affecting inventory control, Concept of EOQ, deterministic Inventory problem with/without shortage, Price Breaks, Multi-item deterministic problem. Uncertain demands, one period problem with / without set-up cost.
Unit 3. Queueing Theory: (15 Hours)
Elements of Queueing system, Probability Distribution in queuing system, Classification of queuing system, queuing models, Transient and Steady states, Poisson/ non-Poison queuing systems, Cost model in queuing.
Unit 4.Simulation: (15 Hours)
Need of simulation, prosses of simulation, simulation models, Event type of simulation, generation of random numbers, Monte-Carlo simulation, Simulation of – Inventory/ Queuing/ Maintenance problems. Simulation in investments, budgeting and job sequencing.

References :

1. Kanti Swarup, Gupta P.K, Man Mohan, Operations research, S Chand
2. Loomba, Linear Programming
3. Taha H, Operation Research, Pearson
4. Vajda, Game Theory

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SYLLABUS FOR PROGRAMME BACHELOR OF ARTS/SCIENCE IN MATHEMATICS

T.Y.B.A/B.Sc. (SEMESTER-VI)

Course Title: Vector Analysis
Course Code: MAT-VI C-8
Marks: 100
Credits: 4
Course Objectives: To introduce students to Vector representations of geometrical objects, analysis done on them and their applications in Physics.
Learning outcome: Students will be able to

C01. Define Vector valued functions and various concepts like gradient, divergence and curl of these functions
C02. Analyse vector functions to find limits, derivatives, tangent lines, integrals, arc length, curvature, torsion
C03. Evaluate line integrals, surface area, surface integrals and volume integrals
C04. Apply Green, Gauss and Stokes' theorems to solve problems

Prerequisites: functions of several variables.
Unit 1: Revision of vectors :- Basic concept such as dot product, cross product, scalar triple product, vector triple product, geometrical understanding of all algebraic operations, orthogonal vectors, vector equations of geometrical objects, **(10 lectures)**
Unit 2: Vector valued functions (vector fields), scalar valued functions (scalar fields), concepts of 'curves', 'plane', 'surface' in $\mathbf{R^3}$ Idea of continuous, smooth and regular objects in $\mathbf{R^3}$, Gradient, Divergence and Curl of these functions, Physical interpretations. Irrotational and solenoidal vector fields.
(20 lectures)
Unit 3: Line integral, surface integral and volume integral, (arc length, surface area, and volume of simple objects), Green's theorem, Stokes theorem, Gauss Theorem and Green's formulas.
(20 lectures)
Unit 4: Theory of Curves in $\mathbf{R^3}$, Unit speed curve, Tangent, Normal, Bi-normal, Curvature, Torsion, Ferret-Serrate formulae, evolutes and involutes. (**10 lectures)**
References:

1 .H.F. Davis and A.D. Snider, Introduction to Vector Analysis, Sixth Edition, Allyn & Bacon
2. J.E. Marsden and A. Tromba, Vector Calculus, Sixth Edition, W.H. Freeman Publishers
3. E. Kreysig, Advanced Engineering Mathematics, Tenth Edition, Wiley Inida
4. M. Spiegel, Vector Analysis: Schaum's Outline Series, Mc Graw Hill

Course Title: COMPLEX ANALYSIS
Course Code: MAT-VI E-13
Marks: 100
Credits: 4
Course Objectives: Introduce students to complex numbers, complex functions and complex differentiation and integration.

Learning outcome: The student will be able to

C01. Understand complex numbers and their representations
C02. Understand the significance of differentiability and analyticity of complex functions
C03. Evaluate contour integrals.
C04. Compute Taylor and Laurent series expansions of analytic functions,
C05. Classify the nature of singularity, poles and residues and application of Cauchy Residue theorem.

Prerequisites: Basic Real Analysis, Mathematical Analysis, Functions of several Variables

Unit 1: Complex Numbers

Algebraic properties of complex numbers, modulus, Argand diagram, exponential form and polar coordinates, triangle inequality and metric properties, connectedness of regions. **(10 lectures)**

Unit 2: Analytic Functions

Complex valued functions on complex domain, limits and continuity of complex valued function on a complex domain, differentiability and analytic functions, algebra of analytic functions, Cauchy-Riemann equations, sufficient condition for analyticity, Harmonic Functions. **(10 lectures)**

Unit 3: Elementary Functions

Exponential, logarithmic function and its branches, trigonometric functions, hyperbolic functions, complex exponents and roots. **(10 lectures)**

Unit 4: Contour Integration

Contours and contour integrals, Cauchy Goursat's theorem, Simply connected domains, Cauchy's integral formula, higher derivatives of analytic functions, Liouville's theorem, fundamental theorem of algebra, maximum modulus principle. **(10 lectures)**

Unit 5: Series

Convergence of series, Taylor series, Laurent series. **(10 lectures)**

Unit 6: Residue Theory

Singularities of a function, poles and essential singularities, residues at a singular point and its computation, Cauchy residue theorem **(10 lectures)**

References:

1. R.V. Churchill and J.W. Brown, Complex variables and Applications, Eight Edition, Mc Graw Hill
2. L. V. Ahlfors, Complex Analysis, Mc Graw Hill
3. A.R. Shastri, Complex Analysis, Laxmi Publications
4. M. Spiegel and S. Lipschutz, Complex Variable: Schaum's Outline Series, Mc Graw Hill
5. J.B. Conway, Functions of a Complex Variable, Narosa
6. S. Ponnusamy, Complex Analysis, Narosa
7. S. Ponnusamy and H. Silverman , Complex variables with Applications, Birkhauser
8. T.W. Gamelin, Complex Analysis, Springer
9. E.M. Stein and R. Shakarchi, Complex Analysis, Princeton Lectures in Analysis

Course Title: Algebra II
Course Code: MAT- (Sem 6)
Marks: 100

Credits: 4
Course Objectives: - To further the knowledge of algebraic structures.
Learning Out comes: the students will be able to
C01. Recognize and use the Sylow theorems to characterize certain finite groups.
C02. Learn in detail about polynomial rings,
C03. Understand fundamental properties of finite field extensions, and classification of finite fields

Prerequisites: Basic Algebra, Algebra I
Content
1) **Sylow Theorems** (25 Hours)
Orbit- Stabiliser theorem, Conjugacy classes, The Class equations, The Sylow Theorems and their Applications
3)**Polynomial Rings:** (25 Hours)
Definition, The Division Algorithm and its consequences, factorisation of Polynomials, reducibility and irreducibility tests, Eisenstein criteria, Unique factorization in Z[x], Irreducible element, Prime element, UFD, PID, ED.
4) **Finite Fields** (10 Hours)
Definition, examples, Classification of finite Fields, Z_p, Z_{p^n} , Special case study when p=2.
References:
1) Gallian J, Contemporary Abstract Algebra, Cengage Learning
2) Fraleigh J.B., A First Course in Abstract Algebra, Pearson
3) Herstein I.N., Topics In Algebra, Wiley

Course Title: COMPUTATIONAL LINEAR ALGEBRA
Course Code: MAT-IV E-17
Max Marks: 100
Credits: 4
Course Objectives: To learn about the different computational techniques in linear algebra
Learning Outcome: The student will be able to
C01. Use Gaussian Elimination to understand the system of linear equations
C02. Understand the orthogonal vectors
C03. Test a matrix for positive definiteness
C04. Find the singular value decomposition of the matrix
C05. Understand matrix norm and condition number

Unit 1: Review of Gaussian Elimination (8 lectures)
Unit 2: Orthogonality (10 lectures)
Orthogonal vectors and subspaces, projections and least squares, QR Factorizations
Unit 3: Positive Definite Matrices (20 lectures)
Maxima, minima and saddle points, test for positive definiteness, singular value decompositions, Lagrange multipliers and Rayleigh quotients, finite element method
Unit 4: Matrix norm and Condition Number (22 lectures)
References:
1. G. Strang, Linear Algebra and its Applications

Course Title : Computers for Mathematics

Course Code : MAT-III.E-16

Marks : 100

Credits : 4

Duration : 60 hours

Prerequisite Courses : Basic knowledge of computers, a basic course in ODE, Numerical analysis. Familiarity with computer programming will be helpful but not compulsory.

Course Objectives : To train students to use computers for mathematical typing, computing and plotting. Helping them understand theory using computational methods

Course Outcomes : Students will be able to

C01. Type mathematics using Latex
C02. Understand basic aspects of programming.
C03. Use programming languages to solve mathematical problems
Perform basic data analysis using R

Syllabus :

Unit 1.Introduction to LaTeX (15 Lectures)

Mathematical typing in MS Word 07/13
Short comings of Word, need of some other package of writing.
Document Editing using LaTeX: - Text formatting, Paragraph formatting
Fonts and colours, special char acters, Tables, Page layout, importing graphics, footnotes, referencing, Beamer Presentations

Unit 2.Mathematical typesetting in LaTeX (10 Lectures)

Mathematical environments and packages Symbols, Greek letters and operators, Powers and indices, fractions, Roots, Sums, integrals and derivatives, Brackets, Matrices

Unit 3. Introduction R Programming. (12 Lectures)

Fundamentals of R programming:-Introduction to interface (R studio), evolution, features, All Data types in R, Variable (assignment, its data type), All operators in R, Loops and R functions (user defined and built in functions), Entering data from keyboard, Importing data from various data Sources.

Unit 4. R Statistics , data visualization and management (12 Lectures)

R charts and graphs, Data frame, Data reshaping, Mean, Median , Mode.

Unit 5. Scilab/ Matlab/ Geogebra (11 Lectures)

Introduction to Scilab, familiarizing with the Scilab, Scilab syntax, Variables, functions, Loops, plotting graphs.

References :

1. M.Alley, the Craft of Scientific Presentations, Springer (2003).

2. W.C. Booth, G.G. Colomb, and J.M. Williams, The Craft of Research (Chicago Guides to Writing, Editing, and Publishing) Univ. of Chicago Press, 2008.
3. George Graetzer, Math into LaTex, An introduction to LaTex and AMS-LaTex, Birkhauser, 1996.
4. Donald E. Knuth; Tracy E Larrabee, Paul M. Roberts: Mathematical writing, Mathematical Association of America, 1989.
5. S. Krantz: A Primer of Mathematical Writing: Being a Disquisition on Having Your Ideas Recorded, Typeset, Published, Read & Appreciated, American Mathematical Society, 1996.
6. S. Krantz: How to Teach Mathematics, American Mathematical Society, 1999.
7. Leslie Lamport: LaTex, a document preparing system, Addison-Wesley, 1994.
8. Jr. Strunk, William; E. B. White, The Elements of Style, Fourth Edition, Longman; 4th edition (1999).
9. Robert I. Kabacoff(2011): R in Action – Data Analysis and graphics in R, Manning.
10. Hadley Wickham(2009):ggplot: Elegant graphics for Data Analysis, Springer.

Course Title: PEDAGOGY OF MATHEMATICS
Course Code: MAT-V E-12
Marks: 100
Credits: 4
Course Objectives: To make the students aware of the different methods used for the teaching of mathematics.
Learning outcome: Students will be able to

C01. Understand the nature and value of mathematics
C02. Learn different methods and techniques of teaching mathematics
C03. Find the appropriate method to teach various topics of school mathematics

Unit 1: Meaning and History of Mathematics **(10 lectures)**

Meaning of Mathematics
Branches of Mathematics
Historical Development of Mathematics

Unit 2: Methodology of Teaching Methods **(40 lectures)**

Inductive - Deductive
Analytic- Synthetic
Heuristic/ Discovery
Project Method
Open Ended Approach
Investigative Approach
Problem Solving
Concept Attainment Model
(With applications in different topics in School level Mathematics syllabus)

Unit 3: Techniques of Teaching **(8 lectures)**

Assignments
Drill work

Remedial teaching
Accelerated teaching

Unit 4: Qualities of a good Mathematics Teacher **(2 lectures)**

References:

1. E.T Bell, Men of Mathematics, Touchstone
2. M. Ediger, Essays on teaching mathematics, Discovery Publishing Pvt.Ltd
3. R.G. Goel, Teaching of Mathematics, Lotus Press
4. A. James., Methods of teaching Mathematics, Neelkamal
5. Kline Morris, Mathematical Thought From Ancient to Modern Times, Oxford University Press
6. S. Krantz, How to teach Mathematics, American Mathematical Society
7. G. Polya, How to Solve It, Penguin UK
8. Sidhu Kulbir Singh., Teaching of Mathematics, Sterling Publishers Pvt. Ltd
9. J. Stillwell, Mathematics and its History, Springer
10. P.P Zubair., Teaching of Mathematics, Aph Publishing