Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B. A. Degree Program in Mathematics

(Faculty of Science & Technology)

T. Y. B. A. (Mathematics)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2021-2022

Introduction:

University of Pune has decided to change the syllabi of various faculties from June, 2019. Taking into consideration the rapid changes in science and technology and new approaches in different areas of mathematics and related subjects Board of Studies in Mathematics with concern of teachers of Mathematics from different colleges affiliated to University of Pune has prepared the syllabus of T. Y. B. A. Mathematics. To develop the syllabus the U.G.C. Model curriculum is followed.

Programme Specific Outcome (PSO)

i) Give the students a sufficient knowledge of fundamental principles, methods and a clear perception of innumerous power of mathematical ideas and tools and know how to use them by modeling, solving and interpreting.

ii) To equip the students sufficiently in both analytical and computational skills in Mathematical Sciences.

iii) To develop a competitive attitude for building a strong academic - industrial collaboration, with focus on continuous learning skills.

iv) Enhancing students overall development and to equip them with mathematical modeling abilities, problem solving skills, creative talent and power of communication necessary for various kinds of employment.

v) Enabling students to develop a positive attitude towards mathematics as an interesting and valuable subject of study.

vi) Enabling students to Gauge the hypothesis, theories, techniques and proofs provisionally.

Programme Outcome:(PO)

A graduate of this program are expected to:

i) Gain sound knowledge on fundamental principles and concepts of Mathematics and computing with their applications related to Industrial, Engineering, Biological and Ecological problems.

ii) Exhibit in depth the analytical and critical thinking to identify, formulate and solve real world problems of science and engineering.

iii) Get a relational understanding of mathematical concepts and concerned structures, and should be able to follow the patterns involved, mathematical reasoning.

iv) A student should get adequate exposure to global and local concerns that explore them many aspects of Mathematical Sciences.

v) Apply their skills and knowledge, that is, translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.

vi) Be capable of undertaking suitable experiments/research methods while solving the real-life problem and would arrive at valid conclusions based on appropriate interpretations of data and experimental results.

vii) Develop written and oral communications skills in order to effectively communicate design, analysis and research results.

viii) Demonstrate appropriate inter-personal skills to function effectively as an individual, as a member or as a leader of a team and in a multi-disciplinary setting.

ix) Acquire competent positions in industry and academia as well.

Eligibility:

S. Y. B. A. (with Mathematics) or T. Y. B. Sc. Computer Science as per University rules.

Medium of Instruction: English

Structure of the course:

Semester –V		**Semester-VI**	
CC 1 E	**MG-5: Group Theory**	**CC 1 F**	**MG-6: Ring Theory**
CC 2 E	**AMG-5: Real Analysis-I**	**CC 2 F**	**AMG-6: Real Analysis-II**
SEC 1 C	**FMG-5 : C-Programming**	**SEC 1 D**	**FMG-6: Financial Mathematics**
SEC 2 C	**LaTeX for Scientific Writing**	**SEC 2 D**	**Mathematics into LaTeX**
DSE 1 C	**MS-5: Metric Spaces**	**DSE 1 D**	**MS-7: Complex Analysis**
DSE 2 C	**MS-6: Ordinary Differential Equations**	**DSE 2 D**	**MS-8: Partial Differential Equations**

Examination:

A) **Pattern of examination:** Semester wise.

B) **Standard of passing:**

1. **3 credit courses:** 40 Marks out of 100 marks for each paper. (But for passing a student should obtain minimum 28 marks out of 70 in the external University examination and should obtain minimum 12 marks out of 30 in the internal examination).

2. **2 credit courses:** For Skill enhancement courses **SEC 2C** and **SEC 2D**, a student should obtain minimum 10 marks out of 25 in internal examination and should obtain minimum 10 marks out of 25 in theory external examination(conducted at college level).

C) The number of credits for each course will be as per the rules and regulations for all B. A courses. The number of lectures will vary accordingly.

If a course is of 3 credits then number of lectures for the course is 48 lectures.

If a course is of 2 credits then number of lectures for the course is 36 lectures.

C) Pattern of question papers:

Q.1. Attempt any 05 out of 07 questions each of 02 marks. [10 Marks]

Q.2. Attempt any 04 out of 06 questions each of 05 marks. [20 Marks].

Q.3. Attempt any 04 out of 06 questions each of 05 marks. [20 Marks].

Q.4. Attempt any 02 out of 04 questions each of 10 marks. [20 Marks].

D) External Students: **Not allowed**.

E) Verification / Revaluation: **Allowed for Theory papers only.**

F) Qualifications for Teacher: **M.Sc. Mathematics (with NET /SET as per existing rules)**

Equivalence of Previous syllabus along with new syllabus:

Old course	New Course
MG-3: Group Theory + Ring Theory	**MG-5 Group Theory(CC 1E) and MG-6 Ring Theory(CC 1F)**
AMG-3 : Real Analysis-I + Real Analysis-II	**AMG-5 Real Analysis-I (CC 2E) and AMG-6 Real Analysis-II(CC 2F)**
FMG-3 Financial Mathematics + Graph Theory	**FMG-5: C-Programming (SEC 1C) and FMG-6: Financial Mathematics (SEC 1D)**
MS-3: Metric Spaces + Complex Analysis	**MS-5:Metric Spaces (DSE 1C) and MS-7: Complex Analysis (DSE 1 D)**
MS-4: Ordinary Differential equations +Partial differential equations	**MS-6:Ordinary Differential equations(DSE 2C) and MS-8: Partial Differential Equations (DSE 2D)**

Details of Syllabus:

Semester-V

CC 1 E: MG-5 Group Theory (3 credits)

Course Objectives: The course objective is to introduce students to the fundamental theory of groups and their homomorphisms. Symmetric groups and symmetries in groups, Lagrange's theorem are also studied in depth.

Course Learning Outcomes: The course will enable the students to:

i) recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc;
ii) analyze consequences of Lagrange's theorem
iii) learn about structure preserving maps between groups and their consequences.
iv) explain the significance of the notion of cosets, normal subgroups, and factor groups.

Course Contents:

Unit 1. Groups **[08 lectures]**

1.1 Binary Operation
1.2 Isomorphic Binary Structures
1.3 Groups

Unit 2. Subgroups **[08 lectures]**

2.1 Subgroups
2.2 Cyclic Groups

Unit 3. Permutations **[16 lectures]**

3.1 Groups of Permutations
3.2 Orbits
3.3 Cycles
3.4 Alternating Groups
3.5 Cosets and the Theorem of Lagrange
3.6 Direct Products

Unit 4.Homomorphisms and Factor Groups **[16 lectures]**

4.1 Homomorphisms
4.2 Factor Groups
4.3 Factor Group Computations and Simple Groups

Text book:

1. **John B. Fraleigh, A First Course in Abstract Algebra, Seventh Edition, Pearson. Sections:** 2,3,4,5,6,8,9,10, 11(only Direct Product), 13,14,15.

Reference Books:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, Second Ed., Foundation Books, New Delhi, 1995.
2. I. N. Herstien, Topics in Algebra, John Wiely and Sons.
3. N.S. Gopalakrishnan, University Algebra, Second Edition, New Age International, New Delhi, 1986.

Joseph. A. Gallian, Contemporary Abstract Algebra,(4th Edition), Narosa Publishing House.

CC 2 E: AMG-5 Real Analysis-I (3 credits)

Course Objectives: The course will provide students with a thorough understanding of real lines and distinguishing concepts in order to prove convergence and divergence of real number sequences and series. These principles have a wide variety of real-world applications.

Course Learning Outcomes: This course will enable the students to:

i) learn the basic facts in logic and set theory
ii) learn to define sequence in terms of functions from N to a subset of R and to understand several properties of the real line.
iii) recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

iv) use the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Course Contents:

Unit 1: Logic and Set Theory **[12 Lectures]**

1.1 Introduction
1.2 "And" and "Or"
1.3 "Not" and "If-Then"
1.4 Contrapositive, Converse, and Iff
1.5 Quantifiers
1.6 Set Theory and Venn Diagrams
1.7 Relations and Functions
1.8 Countable and Uncountable Sets

Unit 2: Sequences of Real Numbers **[10 Lectures]**

2.1 Definition of sequence and subsequence
2.2. Limit of a sequence
2.3 Convergent sequences
2.4 Divergent sequences
2.5 Bounded sequences
2.6 Monotone sequences

Unit 3: Operations on convergent sequences and Limit Superior, Limit Inferior **[10 Lectures]**

3.1 Operations on convergent sequences
3.2 Operations on divergent sequences
3.3 Limit superior and limit inferior
3.4 Cauchy sequences

Unit 4: Series of Real Numbers **[16 Lectures]**

4.1 Convergence and divergence
4.2 Series with nonnegative terms
4.3 Alternating series
4.4 Conditional convergence and absolute convergence
4.5 Rearrangements of series
4.6 Tests for absolute convergence
4.7 Series whose terms form a non-increasing sequence
4.8 The class l^2

Text Books: -

1. **Real Analysis and Foundations, Second Edition, Steven G. Krantz, Chapman and Hall/CRC, Sections: 1.1, 1.2,1. 3, 1.4, 1.5, 1.6, 1.7, 1.8(Logic and Set Theory)**
2. **Methods of Real Analysis, Second Edition, Richard R. Goldberg, John Wiley & Sons, Inc. Sections: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10 (Sequences of Real Numbers) Sections: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.10(Series of Real Numbers)**

Reference Books: -

1. Real Analysis, N.L. Carothers, Cambridge University Press
2. Introduction to Real Analysis, Third edition, Robert, G. Bartle, Donald Sherbert , John Wiley and Sons.
3. A Basic Course in Real Analysis, Ajit Kumar and S.Kumaresan ,CRC Press, Second Indian, , CRC Press (Chapman and Hall)
4. A course of Mathematical Analysis, Revised edition, Shantinarayan and Mittal - S. Chand and Co. (2002).
5. Mathematical Analysis, third Edition, S.C. Malik and Savita Arora - New Age International Publications.

SEC 1 C: FMG-5 C Programming (3 credits)

Unit 1. Fundamentals of C – programming: [09 Lectures]

1.1 Introduction to C, The character set.
1.2 Identifier and keywords. Data types, Constants.
1.3 Variables and arrays, Declarations.
1.4 Expressions, Statements, Symbolic constants, Operators and Expressions.

Unit 2. Data Input and Output: [09 Lectures]

2.1 Preliminaries.
2.2 Single character input- the getchar() function
2.3 Single character output-the putchar() function
2.4 Entering input data- the scanf() function.
2.5 Writing output data- the printf function. Get and put functions.

Unit 3.Preparing, running a complete C Program and Control Statements: [14 Lectures]

3.1 Preliminaries
3.2 The while statement
3.3 The do-while statement
3.4 The for statement, Nested loops
3.5 The if-else statement, the switch statement, the break statement, the continue statement, the comma operator, the go to statement.

Unit 4. Functions and Arrays: **[16 Lectures]**

4.1 Introduction to a function, defining a function, Accessing a function, Passing arguments to a function.

4.2 Function prototypes, Recursion,

4.3 Defining an array, processing an array, Passing arrays to functions, Multidimensional Arrays, Arrays and strings.

Text Book:

1. **Programming with C, by Byron S. Gottfried Schaum's Outline series.** Chapters:1,2,3,4,5,6,7,9.

Reference Books:

1. **T**he C Programming Language. By Brian W. Kernighan, DennisM. Ritchie, 2nd Edition.
2. Spirit of C: An Introduction to Modern Programming. By Henry Mullish and Herbert L. Cooper, Jaico Publishers,

SEC 2 C: LaTeX for Scientific Writing (2 credits)

Course Objectives: The purpose of this course is

i) To provide an understanding of the basic mechanisms of LaTeX, using plain text as a vehicle

ii) To acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting.

Course Learning Outcomes: After studying this course the student will be able to:

i) Write a simple LaTeX input document based on the article class.

ii) Turn the input document into pdf with the pdflatex program.

iii) Format Words, Lines, and Paragraphs.

iv) Understand how to present data using tables.

Course Contents:

1. Introduction **[06 Lectures]**

1.1 Definition and application of LaTeX

1.2 Preparation and Compilation of LaTeX input file

1.3 LaTeX Syntax

1.4 Keyboard Characters in LaTeX

2. Formatting Words, Lines, and Paragraphs **[09 Lectures]**

2.1 Text and Math Mode Fonts.

2.2 Emphasized and Colored Fonts

2.3 Sectional Units

2.4 Labeling and Referring Numbered Items

2.5 Texts Alignment and Quoted text

2.6 New Lines and Paragraphs

2.7 Creating and Filling Blank Space

2.8 Producing Dashes Within Texts

3. Listing and Tabbing Texts **[09 Lectures]**

3.1 Listing Texts

3.2 Tabbing Texts Through the tabbing Environment

4. Table Preparation **[12 Lectures]**

4.1 Table Through the tabular Environment

4.2 Table Through the tabularx Environment

4.3 Vertical Positioning of Tables

4.4 Sideways (Rotated) Texts in Tables

4.5 Adjusting Column Width in Tables

4.6 Additional Provisions for Customizing Columns of Tables

4.7 Merging Rows and Columns of Tables.

Text Book:

LaTeX in 24 Hours, A Practical Guide for Scientific Writing, Dilip Datta, Springer International Publishing AG, 2017.

Unit 1: Chapter 1; 1.1 to 1.6, Unit 2: Chapter 2; 2.1 to 2.4, Chapter 3; 3.1 to 3.7

Unit 3: Chapter 6; 6.1, 6.2, Unit 4: Chapter 7; 7.1 to 7.7

Reference Books:

1. LaTeX, A Document Preparation System, User's Guide and Reference Manual, Leslie Lamport, Addison-Wesley Publishing Company, Inc., 1994.
2. LaTeX Beginner's Guide, Stefan Kottwitz, Packt Publishing Ltd, 2011.
3. LaTeX and Friends, M.R.C. van Dongen, Springer-Verlag Berlin Heidelberg ,2012.

DSE 1 C: MS-5 Metric Spaces (3 credits)

Course Objectives: The course aims at providing the basic knowledge pertaining to metric spaces such as neighborhood, interior, closure, open and closed balls, continuity, completeness, compactness, connectedness etc.

Course Learning Outcomes: The course will enable the students to:

i) Understand the introductory concepts of metric spaces;

ii) Correlate these concepts to their counter parts in real analysis by studying examples;

iii) Learn to analyze mappings between spaces.

iv) Attain background for advanced courses in real analysis, functional analysis, and topology.

v) Appreciate the abstractness of the concepts such as open balls, closed balls, compactness, connectedness etc. beyond their geometrical imaginations.

Course Contents:

Unit 1. Basic Notions **[10 Lectures]**
1.1 Definition and examples
1.2 Open Balls and Open Sets

Unit 2. Convergence **[12 Lectures]**
2.1 Convergent Sequences
2.2 Limit and Cluster points
2.3 Cauchy Sequences and Completeness
2.4 Bounded Sets
2.5 Dense Sets
2.6 Boundary of a set

Unit 3. Continuity **[12 Lectures]**
3.1 Continuous Functions
3.2 Equivalent Definitions of Continuity
3.3 Topological Property
3.4 Uniform Continuity
3.5 Limit of **a** Function
3.6 Open and closed maps

Unit 4. Compactness and Connectedness **[14 Lectures]**
4.1 Compact Spaces and their Properties
4.2 Connected Spaces

Text Book:

1. Topology of Metric Spaces, S. Kumaresan, Narosa Publishing House (2nd edition), 2011.
Unit 1: Chapter 1; 1.1 to 1.2 (Except theorems 1.1.14,1.1.15,1.1.21,1.1.35,1.1.36,1.1.37)
Unit 2: Chapter 2; 2.1 to 2.5 (Except theorems- 2.2.28, 2.3.12, Lemma 2.5.6), 2.7
Unit 3: Chapter 3; 3.1 to 3.6 (Except theorems-3.2.33, 3.2.46, 3.2.49, 3.4.10)
Unit 4: Chapter 4; 4.1 to 4.39 Except theorems- Lemma 4.1.28,4.2.13,4.3.14,4.3.24),
Chapter 5; 5.1

Reference Books:

1. Metric Spaces, Q.H. Ansari: Narosa Publishing House, New Delhi, Chapters 1 – 5.
2. Metric Spaces, Satish Shirali, H. Vasudeva, Springer.
3. First Course in Metric Spaces, B. K. Tyagi, Cambridge University Press
4. M. O. Searcoid: Metric spaces, Springer, 2007.

DSE 2 C: MS6 - Ordinary Differential Equations (3 credits)

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of differential equations, system of differential equations and their applications.

Course Learning Outcomes: The course will enable the students to:

i) understand the genesis of ordinary differential equations.
ii) learn various techniques of getting exact solutions of solvable first order differential equations and linear differential equations of higher order.
iii) grasp the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.

Course Contents:

Unit 1. Linear Differential Equations with constant coefficients [12 lectures]

1.1 Constant coefficient homogeneous equations
1.2 Characteristic equations
- 1.2.1 distinct real roots
- 1.2.2 repeated roots
- 1.2.3 complex roots

1.3 Particular solution
1.4 Initial value problem
1.5 The operator $\frac{1}{f(D)}$ and its evaluation for the functions x^m, e^{ax} , $e^{ax}v$, xv and the operator $\frac{1}{D^2+a^2}$ acting on $\sin ax$ and $\cos ax$ with proofs.

Unit 2. Non -Homogeneous Linear Equations [14 lectures]

2.1 Principle of superposition
2.2 Method of undetermined coefficients
2.3 Method of reduction of order
2.4 Method of variation of parameters.

Unit 3. Series Solutions of Linear Second Order Equations [12 lectures]

3.1 Review the properties of power series
3.2 Series solution near an ordinary point
3.3 Regular singular points
3.4 Euler equations

Unit 4. System of Equations [10 lectures]

4.1 Introduction to system of differential equations
4.2 linear systems: basic theory of homogeneous linear systems , constant coefficient
4.3 Homogeneous systems.

Text Books:

1. **William F Trench , Elementary Differential Equations with Boundary Value Problems ,** E book (Free download)
   Unit 1 : Chapter 5: Sections 2 to 3 . Unit 2 : Chapter 5: Sections 4 to 7 .

Unit 3: Chapter 7: sections 1 to 4. Unit 4 : Chapter 10 : sections 1 to 6.

2. **Frank Ayres JR, Theory and Problems on Differential Equations, Schaum's outline Series, SI (metric) edition.** Unit 1 Chapter 16 Short methods

Reference Books:

1. M. D. Raisinghania , Ordinary and Partial Differential Equations , S. Chand and Company LTD 2009.
2. Elementary Differential Equations seventh edition by Earl D. Rainville and Philip E Bedient.
3. George F. Simmons and Stevan G. Krantz , Differential Equations, Tata McGraw-Hill.
4. W. R. Derrick and S. I. Grossman, A First Course in Differential Equations with Applications . CBS Publishers and Distributors , Delhi 110032, Third Edition.
5. Daniel Murray, Introductory Course in Differential Equations, Orient Longman.

Semester-VI

CC 1 F: MG-6 363 Ring Theory (3 Credits)

Course Objectives: The objective of this course is to introduce the fundamental theory of rings and their corresponding homomorphisms. The basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers.

Course Learning Outcomes: The course will enable the students to learn about:

i) The fundamental concept of Rings, Fields, subrings, integral domains and the corresponding morphisms.
ii) Learn in detail about polynomial rings, fundamental properties of finite field extensions, and classification of finite fields.
iii) Appreciate the significance of unique factorization in rings and integral domains.

Unit 1: Rings and Fields **[10 lectures]**

1.1 Ring, Subring, Fields.
1.2 Divisors of zero, Integral Domain, The Characteristics of a Ring.
1.3 The Field of Quotients of an Integral Domain.

Unit 2: Rings of Polynomials & Factorization **[10 lectures]**

2.1 Polynomials in an determinate,
2.2 The Evaluation Homomorphism Zeros.
2.3 Factorization of a Polynomial over a Field: The Division Algorithm in F[x]
2.4 Irreducible Polynomials, Uniqueness of Factorization in F[x].

Unit 3: Ideals and Factor Rings **[12 lectures]**

3.1 Homomorphism, Properties of Homomorphism
3.2 Ideals, Factor Ring, Fundamental Homomorphism Theorem.
3.3 Maximal Ideal, Prime Ideal, Ideal Structure in F[x].

Unit 4: Factorization **[16 Lectures]**

4.1 Unique Factorization Domain, Principal Ideal Domain, Gauss Lemma, D[x] is a UFD.
4.2 Euclidean Norm, Euclidean Domain, Euclidean Algorithm (Without Proof).

4.3 Gaussian Integers, Multiplicative Norm.

Text Book:

1. John B. Fraleigh, A First Course In Abstract Algebra, 7th Edition, Pearson.

Unit 1: Section 18, 19, 21. Unit 2: Section 22 and 23.
Unit 3: Section 26 and 27. Unit 4: Section 45, 46 and 47 (except theorem 47.10).

Reference Books:

1. Josheph A. Gallian, Contemporary Abstract Algebra, 7th Edition, Narosa Publishing House.
2. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Edition, Jonh Wiley and Sons, Inc.
3. I.N. Herstein, Abstract Algebra, 3rd Edition, Prentice Hall of India.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, 2nd Edition, Cambridge University Press.

CC 2 F: AMG-6 Real Analysis-II (3 Credits)

Course Objectives: To comprehend bounded function integration on a closed and bounded interval, as well as its extension to situations where either the integration interval is infinite or the integrand has infinite limits at a finite number of points on the integration interval. The sequence and series of real-valued functions.

Course Learning Outcomes: The course will enable the students to learn about:

i) some of the families and properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.
ii) beta and gamma functions and their properties.
iii) recognize the difference between pointwise and uniform convergence of a sequence of functions.
iv) illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability.

Course Contents:

Unit 1: Riemann Integration [14 Lectures]

1.1 Sets of Measure zero
1.2 Definition of the Riemann Integral
1.3 Existence of the Riemann Integral
1.4 Properties of the Riemann Integral
1.5 Fundamental Theorems of Calculus

Unit 2: Improper Integrals [14 Lectures]

2.1 Improper Integrals on Closed and Bounded Intervals
2.2 Tests for Convergence of Positive Integrands
2.3 Improper Integrals on Unbounded Intervals and Tests for their Convergence
2.4 Tests for Convergence of the Integral of Product

Unit 3: Sequences of Functions **[10 Lectures]**

3.1 Pointwise convergence of sequences of functions
3.2 Uniform convergence of sequences of functions
3.3 Consequences of uniform convergence

Unit 4: Series of Functions **[10 Lectures]**

4.1 Convergence and uniform convergence of series of functions
4.2 Integration and differentiation of series of functions

Text Books:

1. **Methods of Real Analysis, Second Edition, Richard R. Goldberg, John Wiley and amp; Sons, Inc.**
   Sections: 7.1,7.2,7.3,7.4,7.8 (Riemann Integration)
   Sections: 9.1, 9.2, 9.3, 9.4, 9.5 (Sequences and Series of Functions)

2. **Introduction to Real Analysis, Eighth Edition, S.K. Mapa, Sarat Book House**
   Sections: 12.1, 12.2, 12.3, 12.4,12.5, 12.6, 12.7, 12.8, 12.9, 12.10 (Improper Integrals)

Reference Books:

1. Real Analysis, N.L. Carothers, Cambridge University Press
2. Introduction to Real Analysis, Third edition, Robert, G. Bartle, Donald Sherbert, John Wiley and Sons.
3. A Basic Course in Real Analysis, Ajit Kumar and S. Kumaresan, CRC Press, Second Indian, CRC Press (Chapman and Hall)
4. A course of Mathematical Analysis, Revised edition, Shanti Narayan and Mittal - S. Chand and Co. (2002).
5. Mathematical Analysis, third Editions'. Malik and Savita Arora - New Age International Publications.

SEC 1 D: FMG-6 Financial Mathematics (3 credits)

Course Objectives: This course enables the students to understand the basic securities, organization of financial markets, the concept of interest rates, present and future value of cash flow.

Course Learning Outcomes: The course will enable the students to:

i) describe and explain the fundamental features of a financial instruments.
ii) demonstrate a clear understanding of financial research planning, methodology and implementation.
iii) demonstrate understanding of basic concepts in linear algebra, relating to linear equations, matrices, and optimization.
iv) demonstrate understanding of concepts relating to functions and annuities.

Course Contents:

Unit 1: Mathematical models in economics, recurrences, and the elements of finance [12 Lectures]

1.1 Introduction, a model of the market, market equilibrium and excise tax.
1.2 The first-order recurrence, limits, special cases, continuous compounding of interest.
1.3 Interest and capital growth, income generation, the interval of compounding.

Unit 2: The Cobweb model, and Introduction to optimization [12 Lectures]

1.1 Stability of market equilibrium, the general linear case and economic interpretation.
1.2 Marginal cost as a derivative, Profit maximization, critical points, optimization in an interval and infinite intervals.

Unit 3: The derivative in economics [10 Lectures]

3.1 Elasticity of demand, profit maximization again.
3.2 Competition versus monopoly, the efficient small firm, startup and break-even points.

Unit 4: Linear equations and the input-output model [14 Lectures]

3.1 Making money with matrices, a two-industry 'economy', arbitrage portfolios and state prices and IS-LM analysis.
3.2 An economy with many industries and the technology matrix.

Text Book:

1. **Martin Anthony and Norman Biggs, Mathematics for Economics and Finance Methods and Modeling, Cambridge University Press, Reprint 2012.**
   Chapters 1, Chapters 3[3.2, 3.3, 3.4 only], Chapter 4, Chapter 5, Chapter 6 [6.3 only] Chapter 7 [7.3 only], Chapter 8, Chapter 9, Chapter 10, Chapter 15[15.3 only], Chapter 16 [16.1 only], Chapter 17[17.4 only], Chapter 18 [18.5 only], Chapter 19.

Reference Books:

1. Edward T. Dowling, Mathematical Economics, Second Edition, Schaum's Outline Series, McGraw Hill International Edition.
2. Aswath Damodaran, Corporate Finance- Theory and Practice, John Wiley and Sons, Inc.
3. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge University Press.

SEC 2 D: Mathematics into LaTeX (2 Credits)

Course Objectives: The purpose of this course is to acquaint students with typesetting basic Mathematics in LaTeX.

Course Learning Outcomes: After studying this course the student will be able to:

i) typeset mathematical formulas, use nested list, tabular and array environments.
ii) import figures and pictures that are stored in external files.

Course Contents:

1. Figure Insertion **[06 Lectures]**

1.1 Commands and Environment for Inserting Figures
1.2 Inserting a Simple Figure
1.3 Side-by-Side Figures
1.4 Sub-numbering a Group of Figures
1.5 Figures in Tables

2. Equation Writing -I **[12 Lectures]**

2.1 Basic Mathematical Notations and Delimiters.
2.2 Mathematical Operators
2.3 Mathematical Expressions in Text-Mode
2.4 Simple Equations
2.5 Array of Equations
2.6 Left Aligning an Equation
2.7 Sub-numbering a Set of Equations

3. Equation Writing -II **[12 Lectures]**

3.1 Texts and Blank Space in Math-Mode
3.2 Conditional Expression
3.3 Evaluation of Functional Values
3.4 Splitting an Equation into Multiple Lines
3.5 Vector and Matrix
3.6 Overlining and Underlining
3.7 Stacking Terms
3.8 Side-by-Side Equations

4. User-Defined Macros **[06 Lectures]**

4.1 Defining New Commands
4.2 Defining New Environments

Text Book:

1. LaTeX in 24 Hours, A Practical Guide for Scientific Writing, Dilip Datta, Springer International Publishing AG 2017.

   Unit 1: Chapter 9; 9.1 to 9.4, 9.8, Unit 2: Chapter 11; 11.1 to 11.7

   Unit 3: Chapter 12; 12.1 to 12.8 , Unit 4: Chapter 13; 13.1, 13.3 (13.3.1, 13.3.2, 13.3.3)

Reference Books:

1. LaTeX, A Document Preparation System, User's Guide and Reference Manual, Leslie Lamport, Addison-Wesley Publishing Company, Inc., 1994.
2. LaTeX Beginner's Guide, Stefan Kottwitz, Packt Publishing Ltd, 2011.
3. LATEX and Friends, M.R.C. van Dongen, Springer-Verlag Berlin Heidelberg ,2012.

Math into LaTeX, George Gratzer, Springer Science Business Media New York, 1996.

DSE 1 D: MS-7 Complex Analysis (3 Credits)

Course Objectives: This course aims to introduce the basic ideas of analysis for complex functions in complex variables with visualization through relevant Practicals. Particular emphasis has been laid on Cauchy's theorems, series expansions and calculation of residues.

Course Learning Outcomes: The completion of the course will enable the students to:

i) Understand the significance of differentiability of complex functions leading to the understanding of Cauchy-Riemann equations.
ii) Evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.
iii) Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.
iv) Represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

Course Contents:

Unit 1: Analytic functions [12Lectures]

1.1.Functions of a Complex Variables
1.2.Limits, Theorems on limits (Without Proof), Limits involving the point at infinity, Continuity, Derivatives, Differentiation formulas (Without Proof)
1.3.Cauchy- Riemann Equations, Sufficient Conditions for differentiability (Only Statement and Examples)
1.4.Polar coordinates, Analytic functions, Harmonic functions.

Unit 2: Elementary Functions [10 Lectures]

2.1 The Exponential functions
2.2 The Logarithmic function, Branches and derivatives of logarithms, Some identities involving logarithms
2.3 Complex exponents, Trigonometric functions.

Unit 3. Integrals [14 Lectures]

3.1 Derivatives of functions, Definite integrals of functions
3.2 Contours, Contour integral, Examples
3.3 Upper bounds for Moduli of contour integrals, Anti-derivatives (Only Examples)
3.4 Cauchy-Goursat Theorem (without proof), Simply and multiply Connected domains. Cauchy integral formula, Derivatives of analytic functions. Liouville's Theorem and Fundamental Theorem of Algebra (Without Proof).

Unit 4. Series [06 Lectures]

4.1 Convergence of sequences and series (Theorems without proof)
4.2 Taylor's series (without proof), Laurent series (without proof), examples only.

Unit 5. Residues and Poles **[06 Lectures]**

5.1 Isolated singular points, Residues

5.2 Cauchy residue theorem (Without Proof), residue at infinity, types of isolated singular points, residues at poles

5.3 Zeros of analytic functions, zeros and poles.

Text Book:

1. **J.W. Brown and R.V. Churchill, Complex Variables and Applications, International Student Edition, 2009. (Eighth Edition).**
   Chapter 1: §12,§15 to §26. Chapter 3 : §29 to §34. Chapter4 : §37 to §44, §46 and §48 to §53. Chapter:5 §55 to §60 and §62.Chapter 6: §68 to §76.

Reference Books:

1. S. Ponnusamy, Complex Analysis, Second Edition (Narosa).
2. S. Lang, Complex Analysis, (Springer Verlag).
3. A.R. Shastri, An Introduction to Complex Analysis, (MacMillan).
4. L.V.Ahlfors, Complex Analysis, 3rd edition, McGraw Hill, 2000.
5. H.A.Priestley, Introduction to Complex Analysis, 2nd edition (Indian), Oxford, 2006.

DSE 2 D: MS-8: Partial Differential Equations (3 credits)

Course Objectives: The main goals of this course are to teach students how to form, solve, and apply partial differential equations to solve physical problems. Also, to introduce first and second order partial differential equations and their classifications and methods of finding solutions of these partial differential equations.

Course Learning Outcomes: The course will enable the students to:

i) formulate, classify and transform partial differential equations into canonical form.
ii) solve linear partial differential equations using various methods and apply these methods in solving some physical problems.
iii) solve Laplace equations using various analytical methods demonstrate uniqueness of solutions of certain kinds of these equations.

Course Contents:

Unit 1: Introduction to Ordinary and Partial Differential Equations **[12 Lectures]**

1.1 Surfaces and Curves in Three Dimensions

1.2 Simultaneous Differential Equations of the First Order and the First Degree in Three Variables.

1.3 Methods of solution of $dx/P = dy/Q = dz/R$

1.4 Pfaffian Differential Forms and Equations.

1.5 Solution of Pfaffian Differential Equations in Three Variables

Unit 2: Partial Differential Equations [10 Lectures]

2.1 Introduction to Partial Differential Equations

2.2 Origin of first order Partial Differential Equations

2.3 Linear Equations of First order equations

2.4 Integral surfaces passing through given curve

Unit 3: Second Order Partial Differential Equations [14 lectures]

3.1 The Origin of Second Order Partial Differential Equations.

3.2 Linear Partial Differential Equations with constant coefficients.

3.3 Methods of solving Linear Partial Differential Equations

3.3.1. Solution of reducible equations

3.3.2. Solution of irreducible equations with constant coefficients

3.3.3. Rules of finding complementary functions

3.3.4. Rule of finding particular integrals

Unit 4 : Classification of Partial Differential Equations [12 lectures]

4.1 Classification of second order partial differential equations, canonical forms

4.2 Solution of Laplace equations by separation variables methods

4.3 Solution of periodic differential equations by separation variables method

4.4 Solution of wave equation by separation variables method.

Text Books:

1. **Ian Sneddon, Element of Partial Differential Equations, McGraw-Hill Book Company, McGraw-Hill Book Company.**
   Chapter No.1 : 1,2,3,5 (Unit-I), Chapter No.2 :1,2,4,5 (Unit-II)
   Chapter No.3: 1,4,5 (Unit-III)
2. **J.N. Sharma, Kehar Singh, Partial Differential equations for Engineers and Scientists, second Edition, Narasa Publications.**
   Chapter No.3: 3.3 (Unit-IV), Chapter No.4: 4.3 (Unit-IV)
   Chapter No.5: 5.5 (Unit-IV)

Reference Books:

1. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing, House 2nd Edition, 2003 (Reprint, 2006).
2. K. Sankara Rao, Introduction to Partial Differential Equations, Third Edition, PHI.