CBCS: 2020-2021 T. Y. B. Sc.Mathematics

SavitribaiPhule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Mathematics

(Faculty of Science and Technology)

T.Y.B.Sc. (Mathematics)

Choice Based Credit System Syllabus

(With effect from June 2021)

To be implemented from Academic Year 2021-2022

Title of the Course: B. Sc. (Mathematics)

Preamble:

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 the teachers of Mathematics from different colleges affiliated to University of Pune has prepared the syllabus of T.Y.B.Sc. 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.Sc. (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**	
DSE-1A	**MT 351: Metric Spaces**	**DSE-4A**	**MT 361: Complex Analysis**
DSE-1 B	**MT 352: Real Analysis-I**	**DSE-4 B**	**MT 362: Real Analysis-II**
DSE-2 A	**MT 353: Group Theory**	**DSE-5 A**	**MT 363: Ring Theory**
DSE-2 B	**MT 354: Ordinary Differential Equations**	**DSE-5 B**	**MT 364: Partial Differential Equations**
Select any one out of three		**Select any one out of three**	
DSE-3A	**MT 355(A):Operations Research** **MT 355(B): Differential Geometry** **MT 355(C):C- Programming**	**DSE-6A**	**MT 365(A): Optimization Techniques** **MT 365(B):Calculus of Variation and Classical Mechanics** **MT 365(C): Financial Mathematics**
Select any one out of three		**Select any one out of three**	
DSE-3B	**MT 356(A): Machine Learning-I** **MT 356(B): Number Theory** **MT 356(C): Laplace Transform and Fourier Series**	**DSE-6B**	**MT 366(A): Machine Learning-II** **MT 36 (B): Computational Geometry** **MT 366(C): LebesgueIntegration**
Practical Lab		**Practical Lab**	
DSE-1	**MT 357: Practical Course Lab-1 (on Metric Space and Real Analysis-I)**	**DSE-4**	**MT 367: Practical Course Lab-1 (on Complex Analysis and Real Analysis-II)**
DSE-2	**MT 358: Practical Course Lab-II (on Group Theory and Ordinary Differential equations)**	**DSE-5**	**MT 368: Practical Course Lab-II (on Ring Theory and Partial Differential Equations)**
DSE-3	**MT 359: Practical Course Lab-III (on DSE-3A and DSE-3B)**	**DSE-6**	**MT 369: Practical Course Lab-III (on DSE-6A and DSE-6B)**
SEC-I	**MT -3510: Programming in Python-I**	**SEC-III**	**MT 3610: Programming in Python-II**
SEC-II	**MT-3511: LaTeX for Scientific Writing**	**SEC-IV**	**MT 3611: Mathematics into LaTeX**

Note.

i) Papers MT-351 to MT-354 are compulsory, a student can opt one paper from MT-355(A) to MT-355 (C) and opt one paper from MT-356(A) to MT-356 (C) in fifth semester.

ii) Papers MT-361 to MT-364 are compulsory, a student can opt one paper from MT-365(A) to MT-365 (C) and opt one paper from MT-366(A) to MT-366 (C) insixth semester.

iii) For MT-351 to MT-359 and MT-361 to MT-369 each course is of 50 marks (35 marks external examination and 15 marks internal examination).

iv) For SEC: MT-3510, MT-3511, MT-3610 and MT-3611 each course is of 50 marks (15 marks internal evaluation: assignments/ tutorial/seminar/test and 35 marks external theory and practical examination).

Examination:

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

B) Standard of passing: 20 Marks out of 50 marks for each paper. (But for passing a student should obtain minimum 14 marks out of 35 in the externalUniversity examination and should obtain minimum 06 marks out of 15 in the internal examination). For Skill enhancement courses a student should obtain minimum 06 marks out of 15 in internal examination and theory/practical external examination 14 marksout of 35 in the external University examination.

C)Pattern of question papers: For MT-351 to MT-354 and MT-361 to MT-364.

Q.1. Attempt any 05 out of 07 questions each of 01 marks. [05 Marks]

Q.2. Attempt any 02 out of 04 questions each of 05 marks. [10 Marks].

Q.3. Attempt any 02 out of 04 questions each of 05 marks. [10 Marks].

Q.4. Attempt any 02 out of 04 questions each of 10 marks. [10 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 UGC existing rules).**

Equivalence of Previous syllabus along with new syllabus:

New Course	**Old Course**	**New Course**	**Old Course**
Semester-V	**Semester-III**	**Semester-VI**	**Semester-IV**
MT-351: Metric Spaces	MT 331 : Metric Spaces	MT 361: Complex Analysis	MT 341: Complex Analysis
MT-352: Real Analysis-I	MT 332: Real Analysis-I	MT 362 : Real Analysis-II	MT 342: Real Analysis-II

MT 353:Group Theory	MT 334 : Group Theory	MT 363 : Ring Theory	MT 344: Ring Theory
MT 354 : Ordinary Differential Equations	MT 335 : Ordinary Differential Equations	MT 364 : Partial Differential Equations	MT 345: Partial Differential Equations
MT 355 (A): Operations Research	MT 337 A. Operations Research	MT 365 (A): Optimization Techniques	MT 347 A : Optimization Techniques
MT 355 (B): Differential Geometry	MT 337 D: Lattice Theory	MT 365 (B): Calculus of Variation and Classical Mechanics	MT 347 B : Differential Geometry
MT 355 (C): C-Programming	MT 337 B. Dynamical System	MT 365(C): Financial Mathematics	MT 347 E: Lebesgue Integration
MT 356 (A): Machine Learning-I	MT 347D. Graph theory	MT 366 (A): Machine Learning-II	MT 347 C: C-Programming-II
MT 356 (B): Number Theory	MT 337 F. Number Theory	MT 366 (B): Computational Geometry	MT 347F : Computational Geometry
MT 356 (C): Laplace Transform and Fourier Series	MT 337 C. C- Programming I	MT 366(C): Lebesgue Integration	MT 337 E. Financial Mathematics
MT 357: Practical CourseLab-I: Metric Spaces and Real Analysis-I	MT 333 : Problem Course on MT 331 and MT 332	MT 367: Practical CourseLab-I: Complex Analysis and Real Analysis-II	MT 343 : Problem Course on MT 341 and MT 342
MT 358: Practical CourseLab-II: Group Theory and Ordinary Differential Equations	MT 336 : Problem Course on MT 334 and MT 334	MT 368: Practical CourseLab-II: Ring Theory and Partial Differential Equations	MT 346 : Problem Course on MT 344 and MT 345
MT 359: Practical Course Lab-III: DSE-3A and DSE-3B	MT 338: Practical based on papers selected from 337 A to 337 F	MT 369:Practical CourseLab-III: DSE-6A and DSE-6B	MT 348: Practical based on papers selected from 347 A to 347 F
MT 3510: Programming in Python-I		MT 3610: Programming in Python -II	
MT 3511: LaTeX for Scientific Writing		MT 3611: Mathematics IntoLatex	

Details of Syllabus:

Semester-V

DSE-1A: MT 351: Metric Spaces (2 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 and 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 modern 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 **[09 Lectures]**

1.1 Definition and examples
1.2 Open Balls and Open Sets

Unit 2: Convergence **[09 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 **[08 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:CompactnessandConnectedness **[10 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: Sec. 1.1; 1.1.14(only Statement) (Except- 1.1.9 to 1.1.12, 1.1.15 to 1.1.27, 1.1.33 to 1.1.37), Sec. 1.2; 1.2.40(only Statement), 1.2.42 (only Statement) (Except - 1.2.9 to 1.2.17, 1.2.41, 1.2.49 to 1.2.55, 1.2.57 to 1.2.60, 1.2.65, 1.2.66, 1.2.70 to 1.2.73, 1.2.76, 1.2.77, 1.2.87, 1.2.88, 1.2.107).

Unit 2: Chapter -2: Sec. 2.1 (Except 2.1.7, 2.1.8, 2.1.11 to 2.1.13, 2.1.15 to 2.1.19), Sec. 2.2; 2.2.7 (on metric space), 2.2.19(on metric space) (Except- 2.2.11, 2.2.21, 2.2.31), Sec. 2.3; 2.3.12(only statement) (Except - 2.3.4, 2.3.19, 2.3.20), Sec. 2.4 (Except 2.4.8 to 2.4.13, 2.4.16), Sec. 2.5 (Except 2.5.3, 2.5.4, 2.5.15), Sec. 2.7.

Unit 3: Chapter – 3: Sec. 3.1 (Except 3.1.9, 3.1.10, 3.1.12, 3.1.14, 3.1.21to 3.1.24), Sec. 3.2; 3.2.35 (only statement), 3.2.53 (only statement), (Except- 3.2.3, 3.2.4, 3.2.6, 3.2.8, 3.2.12 to 3.2.15, 3.2.19, 3.2.29, 3.2.37 to 3.2.43, 3.2.51, 3.2.52), Sec. 3.3 (Except 3.3.5, 3.3.6, 3.3.10), Sec. 3.4 (Except 3.4.4, 3.4.5, 3.4.12 to 3.4.14, 3.4.16), Sec. 3.5, Sec. 3.6.

Unit 4: Chapter -4: Sec. 4.1; 4.1.15(only statement) (Except - 4.1.27 to 4.1.31, 4.1.35, 4.1.36), Sec. 4.2 (Except- 4.2.2, 4.2.6, 4.2.9, 4.2.12 to 4.2.14), Sec. 4.3; 4.3.1(only statement) (Except 4.3.16. 4.3.25, 4.3.26, 4.3.27).
Chapter -5: Sec. 5.1; 5.1.6(on metric space), 5.1.7(only statement) (Except - 5.1.12, 5.1.15 to 5.1.17, 5.1.23, 5.1.24, 5.1.27, 5.1.33, 5.1.34, 5.1.36,5.1.48).

Reference Books:

1. Metric Spaces, Q.H. Ansari: Narosa Publishing House, New Delhi, Chapters 1 – 5.
2. Metric Spaces, SatishShirali, H. Vasudeva, Springer.
3. First Course in Metric Spaces, B. K. Tyagi, Cambridge University Press
4. M. O. Searcoid: Metric spaces, Springer, 2007.
5. Metric Spaces, E.T.Copson, University Press, Cambridge, 2nd edition, Mumbai, 1978.

DSE-1B: MT: 352 Real Analysis-I (2 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 **[10 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 **[07 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 **[07 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 **[12 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.**
   Unit 1: Chapt. 1- Sec.: 1.1, 1.2,1. 3, 1.4, 1.5, 1.6, 1.7, 1.8
2. **Methods of Real Analysis, Second Edition, Richard R. Goldberg, John Wiley & Sons, Inc.**
   Unit 2: Chapt.-2: Sec.: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6,
   Unit3: Chapt.-2 Sec.: 2.7, 2.8, 2.9, 2.10,
   Unit 4: Capt.- 3: Sec.: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.10

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.

DSE-2A: MT-353: Group Theory(2 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 **[06 lectures]**
1.1 Binary Operation
1.2 Isomorphic Binary Structures
1.3 Groups

Unit 2. Subgroups **[06 lectures]**
2.1 Subgroups
2.2 Cyclic Groups

Unit 3. Permutations[12 lectures]
3.1 Groups of Permutations
3.2 Orbits
3.3 Cycles
3.4 Alternating Groups
3.5Cosets and the Theorem of Lagrange
3.6 Direct Products

Unit 4.Homomorphisms and Factor Group **[12 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.
4. Joseph. A. Gallian, Contemporary Abstract Algebra,(4th Edition), Narosa Publishing House.

DSE-2B: MT-354- Ordinary Differential Equations (2 credits)

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of differential equations, system of differential equationsand 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 [08 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 [06 lectures]

3.1 Review the properties of power series
3.2 Series solution near an ordinary point
3.3Regular 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.

DSE-3A: MT 355(A): Operations Research (2 credits)

Course Objectives: This course develops the ideas underlying the Simplex method for Linear programming problem, as an important branch of operations research. The course covers Linear programming with applications to Transportation and Assignment problem. Such problems arise in manufacturing resource planning and financial sectors.

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

i) Analyze and solve linear programming models of real-life situations.
ii) The graphical solution of LPP with only two variables, and illustrate the concept of convex set and extreme points. The theory of the simplex method is developed.
iii) The relationships between the primal and dual problems and their solutions with applications to transportation, assignment and two-person zero-sum game problem.

Course Contents:

Unit 1. Modeling with Linear Programming **[08 Lectures]**

1.1Two variable LP Model
1.2 Solution of LP Model by Graphical Method
1.3 Selected LP Model Applications
1.4 Graphical Sensitivityanalysis.

Unit 2. TheSimplex Method and Duality **[12 Lectures]**

2.1 LP Model in equation form
2.2 Transition from graphical to algebraic solutions
2.3 The Simplex method.
2.4 Definition of the dual problem
2.5 Primal dual relationship
2.6 Economic interpretation of Duality.

Unit 3. Transportation Model **[10 Lectures]**

3.1 Definition of the Transportation model
3.2 The Transportation algorithm.

Unit 4. The Assignment Model **[06 Lectures]**

4.1 The Hungarian method
4.2 Simplex explanation of the Hungarian method.

Text Book:

1. **Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.**

Unit 1: Chapter-2: 2.1,2.2,2.3(2.3.4, 2.3.5, 2.3.6).

Unit 2:**Chapter-3**: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 (3.6.1), Chapter-4: 4.2, 4.3

Unit 3:Chapter -5: 5.1,5.3 (5.3.1, 5.3.2, 5.3.3), **Unit 4:Chapter-5**: 5.4(5.4.1, 5.4.2).

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction toOperation Research (Eighth Edition) Tata McGrawHill.
2. J K Sharma, Operations Research (Theory and Applications,second edition, 2006), Macmillan IndiaLtd.
3. Hira and Gupta, Operation Research.

DSE-3A: MT-355(B): Differential Geometry (2 credits)

Course Objectives: This course enables the students to understand differential geometry of curves, their fundamental properties like torsion, curvature etc. along with their different forms. Also, to make understand different forms of curves and surfaces, along with their diverse properties through the use of differential calculus.

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

i) Gain an understanding to solve problems with the use of differential geometry to diverse situations in mathematical contexts.
ii) Develop different properties associated with curves and surfaces.
iii) Demonstrate a depth of understanding in advanced mathematical topics in relation to geometry of curves and surfaces Learn to analyze mappings between spaces.
iv) Apply the theory of differential geometry to specific research problems in mathematics or other fields.

Course Contents:

Unit 1: Curves in the plane and in space [04 Lecture]

1.1 What is a curve?
1.2 Arc-length
1.3 Reparameterization
1.4 Level Curves vs. Parameterized Curves

Unit 2 : How much does a curve? [06 Lecture]

2.1 Curvature
2.2 Plane Curves
2.3 Space Curves

Unit 3 : Global Properties of curves [06 Lecture]

3.1 Simple Closed Curves
3.2 The Isoperimetric Inequality
3.3 The Four Vertex Theorem

Unit 4 : Surfaces in three dimensions [06 Lecture]

4.1 What is a Surface?
4.2 Smooth Surfaces
4.3 Tangents, Normal and Orientability

4.4 Examples of surfaces
4.5 Quadratic Surfaces
4.6 Triply orthogonal Systems
4.7 Applications of the Inverse Function Theorem

Unit 5 : The first fundamental form [07 Lecture]

5.1 Lengths of Curves on Surfaces
5.2 Isometries of Surfaces
5.3 Conformal Mappings of Surfaces
5.4 Surface Area
5.5 Equiareal Maps and Theorem of Archimedes

Unit 6 : Curvature of surfaces [07 Lecture]

6.1 The Second Fundamental Theorem
6.2 The Curvature of Curves on a Surface
6.3 The Normal and Principal Curvatures
6.4 Geometric Interpretation of Principal Curvatures.

Text book:

1. **Andrew Pressley: Elementary Differential Geometry, Springer International Edition, Indian Reprint 2004.**
   Unit 1: Chapter 1: Section 1.1 to 1.4, Unit 2: Chapter 2: Section 2.1 to 2.3,
   Unit 3: Chapter 3: Section 3.1 to 3.3, Unit 4: Chapter 4: Section 4.1 to 4.7,
   Unit 5: Chapter 5: Section 5.1 to 5.5, Unit 6: Chapter 6: Section 6.1 to 4.4.

Reference Books:

1. John A. Thorpe, Differential Geometry, Springer International Edition, Indian Reprint 2004.
2. M. DoCarmo, Diffrential geometry of Curves and surfaces, Prentice Hall, 1976.

DSE-3A: MT 355(C): C-Programming (2 credits)

Course Objectives: The **course** is designed to provide complete knowledge of **C-language**. Students will be able to develop logics which will help them to create **programs**, applications in **C**. Also, by **learning** the basic **programming** constructs they can easily switch over to any other **language** in future.

Course Learning Outcomes: After the completion of this course, the students will be able to develop applications.

Course Contents:

Unit 1. Fundamentals of C – programming: [06 Lectures]

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

Unit 2. Data Input and Output: [06 Lectures]

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

Unit 3. Preparing, running a complete C Program and Control Statements: [10 Lectures]

3.1Preliminaries.The while statement.The do-while statement.

3.2 The for statement, Nested loops. The if-else statement.The switch statement.

3.3. The break statement. The continue statement. The comma operator.The goto statement.

Unit 4. Functions and Arrays: [14 Lectures]

4.1 Introduction to a function. Defining a function. Accessing a function.

4.2 Passing arguments to a function. Function prototypes, Recursion, Defining an array.

4.3 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.**
   Unit-1: Chapters: 1, 2, 3, Unit-2: Chapter: 4, Unit-3: Chapters: 5, 6.
   Unit-4: Chapters: 7, 9.

Reference Books:

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

DSE-3B: MT-356(A): Machine Learning-I (2 credits)

Course Objectives:

Students will try to learn:

1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To become familiar with **introduction to NumPy Array and Matrices**.
3. To become familiar with discover and visualize data to gain insights.
4. To become familiar with Fine-tuning the model - Grid Search, Randomized Search.
5. To develop the ability to write database applications in Python.

Course Learning Outcomes:

Upon successful completion of this course the student will be able to:

1. Gain knowledge about basic concepts of Machine Learning.
2. Identify machine learning techniques suitable for a given problem.
3. Solve the problems using various machine learning techniques.

Course Contents:

Unit 1: Introduction to Machine Learning [08 Lectures]

1.1 What & why behind machine learning

1.2 Types of Machine Learning - Supervised vs Unsupervised

1.3 Model Based Training

1.4 Main challenges of Machine Learning

1.5. Testing and Validating

Unit 2: Introduction to Python [08 Lectures]

2.1 The Way Of The Program

2.2 Variables, Expressions and Statements

2.3 Functions
2.4 Conditionals and Recursion
2.5 Strings
2.6 Lists

Unit 3: Understanding ML related Python Packages [10 Lectures]

3.1 Numpy Basics: Arrays and Vectorized Computation
1. The NumPyndarray: A Multidimensional Array Object
2. Universal Functions: Fast Element-wise Array Functions
3. Data Processing Using Arrays
4. Linear Algebra

3.2 Getting Started with Pandas
1. Introduction to pandas Data Structures
2. Essential Functionality
3. Summarizing and Computing Descriptive Statistics
4. Handling Missing Data
5. Hierarchical Indexing

3.3 Plotting and Visualization
1. A Brief matplotlib API Primer
2. Plotting Functions in Pandas
3. Plotting Maps: Visualizing Haiti Earthquake Crisis Data

Unit 4: End to End Machine Learning Project [10 Lectures]

4.1 Get the data
4.2 Discover &Visualize the data to gain insights
4.3 Preparing the data for machine learning - Cleaning, Handling categorical values, Feature scaling
4.5 Select and Train a model - Training and Evaluating on the Training Set
4.4 Fine-tuning the model - Grid Search, Randomized Search

Text Books:-

1. **Hands-on Machine Learning with Scikit-Learn, Keras and Tensorflow–AurelienHeron, Sections: 1, 2**
2. **Python for Data Analysis by Wes McKinney (O' Reilly publication)Chapter -4:4.1, 4.2, 4.3, 4.5, Chapter -5: 5.1, 5.2, 5.3, 5.4, 5.5, Chapter-8:8.1, 8.2, 8.3**
3. **Allen Downey,Think Python,How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015, Sections - 1, 2, 3, 5, 8, 10**

Reference Book:-

1. Introduction to Machine Learning With Python - Andreas C. Muller & Sarah Guide
2. Head first Python by Paul Barry (O Reilly publication)
3. Jason Brownlee - Basics of Linear Algebra for Machine Learning, 2018
4. M. P. Deisenroth, A. A. Faisal, C. S. Ong - Mathematics for Machine Learning, Cambridge University Press, 2019
5. DipanjanSarkar, Raghav Bali, Tushar Sharma - Practical Machine Learning with Python, 2018.
6. **Extra Reference Resources -**
   geeksforgeeks.org/machine-learning
   https://towardsdatascience.com/search?q=machine%20learningwww.kaggle.com

DSE-3B: MT-356(B): Number Theory (2 credits)

Course Objectives: There are difficult open problems in number theory that are understandable at the undergraduate level; this course is designed to develop a micro aptitude for understanding the aesthetic aspect of mathematical instructions and to prepare young minds to ponder such problems. Another goal is to familiarise students with basic number theoretic techniques that can be used in data protection.

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

i) some of the open problems related to prime numbers.
ii) about number theoretic functions and modular arithmetic.
iii) the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.

Course Contents:

Unit 1. Divisibility **[06 Lectures]**

1.1 Introduction
1.2 Divisibility
1.3 Prime

Unit 2.Congruences **[08 Lectures]**

2.1 Congruences
2.2 Solution of Congruences
2.3 The Chinese Remainder Theorem

Unit 3. Greatest integer function **[08 Lectures]**

3.1 Greatest integer function
3.2 Arithmetic functions
3.3 The Mobius Inversion formula

Unit 4.Quadratic Reciprocity **[08 Lectures]**

4.1 Quadratic residues
4.2 Quadratic reciprocity
4.3 The Jacobi Symbol

Unit 5. Diophantine Equations **[06 Lectures]**

5.1 Diophantine equations $ax + by = c$
5.2 Pythagorean triplets.

Text Book:

1. **I. Niven, H. Zuckerman and H.L. Montgomery, An Introduction to Theory of Numbers, 5th Edition, John Wiley and Sons.**
   Unit 1 : Chapter 1 Section 1.1- 1.3, Unit 2 : Chapter 2 Section 2.1- 2.3,
   Unit 3 : Chapter 3 Section 3.1- 3.3, Unit 4 : Chapter 4 Section 4.1 -4.3,
   Unit 5 : Chapter 5 Section 5.1 and 5.3

Reference Book:

1. David M. Burton, Elementary Number Theory (Second Ed.), Universal Book Stall, New Delhi, 1991.

DSE-3B: MT-356 (C): Laplace Transform and Fourier Series (2 credits)

Course Objectives: The main objective of this course is to determine properties of Laplace Transform and Fourier series which may be solved by application of special functions.

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

i) Students will be able to know the use of Laplace transform in system modeling, digital signal processing, process control.
ii) Solve an initial value problem for an nth order ordinary differential equation using the Laplace transform.
iii) Find the Fourier series representation of a function of one variable

Course Contents:

Unit 1: The Laplace Transform [10Lectures]

1.1 Definition, Laplace Transform of some elementary functions.
1.2 Sufficient condition for existence of Laplace Transform
1.3 Some important properties of Laplace Transform.
1.4 Methods of finding Laplace Transform: Direct Method, Series Method
1.5 Evaluation of Integration
1.6 Some Special Functions

Unit2: The Inverse Laplace Transform [10Lectures]

2.1 Definition, Some inverse Laplace Transform.
2.2 Some important properties of Inverse Laplace Transform.
2.3 Methods of finding inverse Laplace Transforms: Partial Fraction Method and Series Method.
2.4 The Heaviside's Expansion formula.
2.5 Beta function, Evaluation of Integration.

Unit3: Applications to Differential Equations [10Lectures]

3.1 Ordinary Differential Equations with constant coefficients.
3.2 Ordinary Differential Equations with variable coefficients.
3.3 Simultaneous Ordinary Differential Equations.

Unit 4: Fourier series [06Lectures]

4.1 Even and Odd functions, Its properties.
4.2 Fourier series and its Examples.

Text Book:

1. **Schaum's Outline Series-Theory and Problems of Laplace Transform by Murray R. Spiegel.**
   Unit1:Chapter-1, Unit2:Chapter-2, Unit3:Chapter-3 (Excluding Applications to Mechanics, Electrical circuits, Beam and PDE).
2. **Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co.Pvt.Ltd.(1970).**
   Unit4: Chapter-12(only12.1)

ReferenceBooks:

1. Phil Dyke, An Introduction to Laplace Transforms and Fourier Series, Second Edition, Indian Reprint 2014.
2. Joel L. Schiff, The Laplace Transforms- Theory and Applications, Springer Verlag New York 1999.
3. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applications, Third Edition, CRC Press.

DSE-1: MT 357: Practical Course Lab-I (Metric Spaces and Real Analysis-I)(2 credits)

Section-I: Metric Spaces Practical

Practical 1: Definition and examples of Metric Spaces (Unit-1; 1.1)

Practical 2: Open and Closed sets in metric spaces (Unit-1; 1.2)

Practical 3: Convergences (Unit 2)

Practical 4: Continuity (Unit 3)

Practical 5: Compactness (Unit 4)

Practical 6: Connectedness (Unit 4)

Section-II: Real Analysis-I Practical

Practical 1: Logic, Set Theory, Functions and Cardinality (Unit-1)

Practical 2: Convergent and Divergent Sequences of Real Numbers (Unit-2)

Practical 3: Monotone Sequences and Algebra of Convergent Sequences (Unit-2)

Practical 4: Limit Superior, Inferior and Cauchy Sequences (Unit-3)

Practical 5: Series of Real Numbers, Alternating Series and Conditional/Absolute Convergence (Unit-4)

Practical 6: Convergent and Divergent Series of Real Numbers (Unit-4)

DSE-2: MT 358: Practical Course Lab-II (Group Theory and Ordinary Differential Equations)(2 credits)

Section-I: Group Theory Practical

Practical 1: Isomorphic Binary Structures and Groups (Unit-1)

Practical 2: Subgroups and Cyclic Groups (Unit-2)

Practical 3: Groups of Permutations, Orbits and Cycles (Unit-3)

Practical 4: Alternating Groups, Cosets and the Theorem of Lagrange (Unit-3)

Practical 5: Direct Productsand Homomorphisms (Unit-4)

Practical 6: Factor Groups, Factor Group Computations and Simple Groups (Unit-4)

Section-II: Ordinary Differential Equations Practical

Practical 1: Linear differential equations with constant coefficients (Unit 1.1 to 1.4)

Practical 2: Inverse differential operators (Short methods) (Unit 1.5)

Practical 3: Non homogeneous linear equations Part I (Unit 2.1 to 2.2)

Practical 4: Non homogeneous linear equations Part II (Unit 2.3 to 2.4)

Practical 5: Series solution of linear second order equations (Unit 3)

Practical 6: System of equations (Unit 4).

DSE-3: MT 359: Practical Course Lab-III (Based on DSE-3A and DSE-3B)(2 credits)

Section-I: Operations Research/ Differential Geometry/C-Programming

Section-I (A): Operations Research Practical

Practical 1: Modeling withLinearProgramming (Unit-1)

Practical 2: TheSimplex Method-I (Unit-2)

Practical 3: TheSimplex Method-II (Unit-2)

Practical 4: Duality (Unit-2)

Practical 5: TransportationModel (Unit-3)

Practical 6: TheAssignmentModel (Unit-4)

OR

Section-I (B): Differential GeometryPractical

Practical 1: Curves in the plane and in space (Unit 1)

Practical 2: How much does a curve? (Unit 2)

Practical 3: Global Properties of curves (Unit 3)

Practical 4: Surfaces in three dimensions (Unit 4)

Practical 5: The first fundamental form (Unit 5)

Practical 6: Curvature of surfaces (Unit 6)

OR

Section-I(C): C- Programming Practical

Practical-1: Operators and expressions-I (Unit 1)

Practical-2: Operators and expressions-II (Unit 2)

Practical-3: Control statements-I (Unit 3)

Practical-4: Control statements-II (Unit 3)

Practical-5: Arrays (Unit 4)

Practical-6: Functions (Unit 4)

Section-II: Machine Learning-I/ Number Theory/Laplace Transform and Fourier Series

Section-II(A): Machine Learning-I Practical

Practical 1: Introduction to Python, Python Data Types-I (Unit 2)

Practical 2: Python Data Types- II (Unit 2)

Practical 3: Control statements in Python-I (Unit 2)

Practical 4: Control statements in Python-II (Unit 2)

Practical 5: Python collection type - List (Unit 2)

Practical 6: Data handling with Panda - 1 (Unit 3)

Practical 7: Data handling with Panda - 2 (Unit 3)

Practical 8: Data visualization with Matplotlib (Unit 3)

Practical 9: Introduction to scikit-learn (Unit 3)

Practical 10: End to end model implementation - 1 (Unit 4)

Practical 11: End to end model implementation - 2 (Unit 4)

Practical 12: End to end model implementation - 3 (Unit 4)

OR

Section-II(B): Number TheoryPractical

Practical 1: Divisibility and GCD – I (Unit 1)

Practical 2: Divisibility and GCD – II (Unit 1)

Practical 3: Congruences (Unit 2)

Practical 4: Quadratic Reciprocity (Unit 3)

Practical 5: Number Theoretic Functions (Unit 4)

Practical 6: Linear Diophantine Equations, Pythagorean Triplets (Unit 5)

OR

Section-II(C): LaplaceTransformsandFourierSeries Practical

Practical1:The Laplace Transform(Unit1:1.1,1.2,1.3,1.4)

Practical2:Special Functions(Unit1:1.5,1.6)

Practical3:The Inverse Laplace Transform-I(Unit2:2.1,2.2,2.3,2.4)

Practical4:The Inverse Laplace Transform-II(Unit2:2.4, 2.5)

Practical5:Applications to Differential Equations(Unit3)

Practical6:Fourier Series(Unit4)

SEC-I: MT -3510: Programming in Python–I (2 credits)

Course Objectives:

1. To understand why **Python** is a useful scripting language for developers.
2. To learn how to use lists, tuples, and dictionaries in **Python** programs.

3. To learn and understand python looping, control statements and string manipulations.
4. To acquire programming skills in core Python.

Course Learning Outcomes: At the end of the course:

1. The student will be able to explain basic principles of Python programming language.
2. The student will implement object oriented concepts.

Course Contents:

Unit 1: Introduction to Python [06 Lectures]

1.1 Installation of Python
1.2 Values and types: int, float and str,
1.3 The Print Function: Print basics
1.4 Variables: assignment statements, printing variable values, types of variables.
1.5 Mathematical Operators, operands and precedence:+, -, /, *, **, % PEMDAS (Rules of precedence)
1.6 String operations: + : Concatenation, * : Repetition
1.7 Boolean operator:
1.7.1 Comparison operators: ==, !=, >, =, <=
1.7.2 Logical operators: and, or, not
1.8 Mathematical functions from math, cmath modules, random module
1.9 Keyboard input: input() statement
1.10 Calculus: Differentiation, Integration, Limit and Series

Unit 2: String, list, tuple [06 Lectures]

2.1 Strings:
2.1.1 Length (Len function)
2.1.2 String traversal: Using while statement, Using for statement
2.1.3 String slice
2.1.4 Comparison operators (>, <, ==)
2.2 Lists:
2.2.1 List operations
2.2.2 Use of range function
2.2.3 Accessing list elements
2.2.4 List membership and for loop
2.2.5 List operations
2.2.6 Updating list: addition, removal or updating of elements of a list
2.3 Tuples:
2.3.1 Defining a tuple,
2.3.2 Index operator,
2.3.3 Slice operator,
2.3.4 Tuple assignment,
2.3.5 Tuple as a return value

Unit 3: Iterations and Conditional statements [10 Lectures]

3.1 Conditional and alternative statements, Chained and Nested Conditionals: if, if-else, if-elif-else, nested if, nested if-else
3.2 Looping statements such as while, for etc, Tables using while.
3.3 Functions:

3.3.1 Calling functions: type, id
3.3.2 Type conversion: int, float, str
3.3.3 Composition of functions, Returning values from functions
3.3.4 User defined functions, Parameters and arguments

Unit 4: Linear Algebra [04 Lectures]

4.1 Matrix construct, eye(n), zeros(n,m) matrices
4.2 Addition, Subtraction, Multiplication of matrices, powers and invers of a matrix.
4.3 Accessing Rows and Columns, Deleting and Inserting Rows and Columns
4.4 Determinant, reduced row echelon form, nullspace, columnspace, Rank
4.5 Solving systems of linear equations (Gauss Elimination Method, Gauss Jordan Method, LU- decomposition Method)
4.6 Eigenvalues, Eigenvectors, and Diagonalization

Unit 5: Numerical methods in Python [06 Lectures]

5.1 Roots of Equations
5.2 Newton-Raphson Method
5.3 False Position (RegulaFalsi) Mehtod
5.4 Numerical Integration:
5.4.1 Trapezoidal Rule,
5.4.2 Simpson's $1/3^{rd}$ Rule,
5.4.3 Simpson's $3/8^{th}$ Rule

Unit 6: 2D and 3D Graphs [04 Lectures]

6.1 Installation of numpy, matplotlib packages
6.2 Graphs plotting of functions
6.3 Different formats of graphs, PyDotPlus (Scalable Vector Graphics), PyGraphviz.
Decorate Graphs with Plot Styles and Types: Markers and line styles, Control colors, Specifying styles in multiline plots, Control linestyles, Control marker styles.
Polar charts: Navigation Toolbar with polar plots, Control radial and angular grids.
6.4 Three-dimensional Points and Lines
6.5 Three-dimensional Contour Plots, Wireframes and Surface Plots.

Practicals:

Practical 1: Introduction to Python, Python Data Types-I (Unit 1)

Practical 2: Python Data Types- II (Unit 2)

Practical 3: Control statements in Python-I (Unit 3- 3.1, 3.2)

Practical 4: Control statements in Python-II (Unit 3- 3.3)

Practical 5: Application: Matrices (Unit 4 – 4.1-4.3)

Practical 6: Application: Determinants, system of Linear Equations (Unit 4- 4.4, 4.5)

Practical 7: Application: System of equations (Unit 4- 4.5)

Practical 8: Application: Eigenvalues, Eigenvectors (Unit 4 – 4.6)

Practical 9: Application: Eigenvalues, Eigenvectors (Unit 4 – 4.6)

Practical 10: Application: Roots of equations (Unit 5 – 5.1)

Practical 11: Application: Numerical integration (Unit 5 – 5.2, 5.3,5.4)

Practical 12: Graph Plotting (Unit 6)

Text Books:-

1. **Allen Downey,Think Python, How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015,**
   Unit1-1: Chapter-1:1.1-1.5, Capter-2: 2.1-2.6, Chapter-3: 3.1-3.6, Chapter-5: 5.1-5.3
   Unit1-2: Chapter-8: 8.1-1.5, Capter-10: 10.12, Chapter-12: 12.1.- 12.6
   Unit-3: Chapter 5:5.4 -5.7, Chapter 7: 7.1-7-7.5
2. **Robert Johansson, Introduction to Scientific Computing in Python, 2016**
   Unit-1: 6.5-6.8
   Unit- 4: Chapter-4: 4.6 (4.6.1 - 4.6.6), Chapter-6: 6.9-6.10, Unit-5: Chapter-4: 4.8, Unit-6: Chapter-5
3. **Hans-PetterHalvorsen,Python for Scientific engineering, 2020 Unit-5: Chapter-31**

Reference Books:-

1. Lambert K. A., Fundamentals of Python - First Programs, Cengage Learning India, 2015.
2. Guzdial, M. J., Introduction to Computing and Programming in Python, Pearson India.
3. Perkovic, L., Introduction to Computing Using Python, 2/e, John Wiley, 2015.Zelle, J., Python Programming: An Introduction to Computer Science, Franklin,Beedle and Assiciatesn Inc.
4. SandroTosi, Matplotlib for Python Developers, Packt Publishing Ltd. (2009) BIRMINGHAM – MUMBAI. (Use for 2D and 3D plots and also use Lambert K. A book).
5. Python: Notes for Professionals, Goalkicker.com, Free Programming books.

SEC-II: MT-3511: LaTeX for Scientific Writing (2 credits)

Course Objectives: The purpose of this course is

i) To provide an understanding of the basicmechanisms 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:

Unit 1. Introduction to LaTeX [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

Unit 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

Unit 3.Listing and Tabbing Texts [09 Lectures]

3.1 Listing Texts
3.2 Tabbing Texts Through the tabbing Environment

Unit 4.Table Preparation [12 Lectures]

4.1Table 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.

Practicals:

Practical 1: Introduction to LaTeX (Unit-1; 1.1, 1.2)

Practical 2: Syntax and Keyboard Characters in LaTeX (Unit-1; 1.3, 1.4)

Practical 3: Fonts in LaTeX (Unit -2; 2.1, 2.2)

Practical 4: Sections, Labelling and Text Alignment in LaTeX (Unit-2; 2.3, 2.4, 2.5)

Practical 5: New Lines, Paragraphs, Blank Space and Dashes in LaTeX (Unit-2; 2.6-2.8)

Practical 6: Listing Texts -I (Unit-3; 3.1[Chapter 6, 6.1.1, 6.1.2])

Practical 7: Listing Texts -II (Unit-3; 3.1[Chapter 6, 6.1.3, 6.1.4, 6.1.5])

Practical 8: Tabbing Texts (Unit-3; 3.2)

Practical 9: Table Through the tabular Environment (Unit-4; 4.1)

Practical 10: Table Through the tabularx Environment (Unit-4; 4.2)

Practical 11: Positioning and Texts in Tables (Unit-4; 4.3, 4.4)

Practical 12: Customizing Tables in LaTeX (Unit-4; 4.5, 4.6, 4.7)

Text Book:

1. **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.

Semester-VI

DSE-4A: MT - 361: Complex Analysis (2 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 [09 Lectures]

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

Unit 2: Elementary Functions [07 Lectures]

2.1 The Exponential functions
2.2 The Logarithmic function, Branches and derivatives oflogarithms, Some identities involvinglogarithms
2.3 Complex exponents, Trigonometricfunctions.

Unit 3. Integrals [11 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-GoursatTheorem (without proof), Simply and multiply Connected domains.Cauchy integral formula, Derivatives of analytic functions. Liouville's Theorem andFundamental Theorem of Algebra (Without Proof).

Unit 4. Series [04 Lectures]

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

Unit 5. Residues and Poles [05 Lectures]

5.1 Isolated singular points, Residues
5.2 Cauchy residue theorem (Without Proof), residue atinfinity, types of isolated singular points,residues at poles
5.3 Zeros of analytic functions, zerosand poles.

Text Book:

1. **J.W. Brown and R.V. Churchill, Complex Variables and Applications, International StudentEdition, 2009. (Eighth Edition).**
   Unit -1: Chapter 1: Sec.11, 12, 15 to 26. Unit-2: Chapter 3: Sec.29 to 34.
   Unit -3: Chapter 4: Sec. 37 to 44, 46 and48 to53.
   Unit -4: Chapter 5:Sec. 55 to 60 and 62. Unit – 5: Chapter 6: Sec.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-4B: MT: 362 Real Analysis-II(2 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 **[12 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 **[10 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 **[07 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 **[07 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.**
   Unit -1:Sec.: 7.1,7.2,7.3,7.4,7.8, Unit -3: Sec.: 9.1, 9.2, 9.3, Unit-4: Sec.9.4, 9.5
2. **Introduction to Real Analysis, Eighth Edition, S.K. Mapa, Sarat Book House**
   Unit-2: Sections: 12.1, 12.2, 12.3, 12.4,12.5, 12.6, 12.7, 12.8, 12.9, 12.10

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, SecondIndian, 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 AgeInternational Publications

DSE-5A: MT: 363 Ring Theory (2 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.

Course Contents:

Unit 1: Rings and Fields [08 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 [08 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 [08 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 [12 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.

DSE-5B: MT 364: Partial Differential Equations (2 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 methodsand 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 [10 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 [08 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 [10 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 [08 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.**

Unit-1: Chapter-1 : 1,2,3,5 , Unit-2: Chapter-2 :1,2,4,5, Unit-3:Chapter-3: 1,4,5

2. **J.N. Sharma, Kehar Singh, Partial Differential equations for Engineers and Scientists, second Edition, Narasa Publications.**

Unit-4: Chapter No.3: 3.3, Chapter No.4: 4.3 ,Chapter No.5: 5.5

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.

DSE-6A: MT365 (A): Optimization Techniques(2 Credits)

Course Objectives: This course enables the students to get an idea about the

i) Network and basic components, Determination of critical path: Critical Path Method (CPM),Project Evaluation and Review Techniques(PERT).Time-cost optimization Algorithm.

ii) Problem of Sequencing, Processing n Jobs through Two Machines, Processing n Jobs through 3 Machines and Processing n Jobs through k Machines.

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

i) understand fundamentals of Network Analysis using CPM and PERT.

ii) solve a sequencing Problem for various jobs and machines.

Course Contents:

Unit 1: Network Models [10 Lectures]

1.1 CPM and PERT, Network representation, Critical Path Computations

1.2 Construction of the time schedule, PERT networks.

Unit 2: Game Theory [08 Lectures]

2.1 Game theory, Some basic terminologies

2.2 Optimal solution of two person zero sum game

2.3 Solution of mixed strategy games (Graphical solution of gamesonly).

Unit 3: Replacement and Maintenance Models [08 Lectures]

3.1 Introduction, Types of failure

3.2 Replacement of items whose efficiencydeteriorates with time.

Unit 4: Sequencing Problems [05 Lectures]

4.1 Introduction, Notation, terminology and assumptions

4.2 processing n jobs throughtwo machines, processing n jobs through three machines.

Unit 5: Classical Optimization Theory [05 Lectures]

5.1 Unconstrained problems, Necessary and sufficient conditions

5.2 Newton Raphsonmethod, Constrained problems, Equality constraints (Lagrangian Method Only).

Text Books:

1. **Hamdy A. Taha, Operation Research (Eighth Edition, 2009), PrenticeHall of India Pvt. Ltd, New Delhi.**
   Unit-11: Ch.6: 6.5 (6.5.1 to 6.5.3 & 6.5.5), Unit-2: Ch.13: 13.4(13.4.1,13.4.2,13.4.3), Unit-4:Ch.18: 18.1(18.1.1, 18.1.2), 18.2 (18.2.1).
2. **J K Sharma, Operations Research (Theory and Applications, secondedition, 2006), Macmilan India Ltd.**
   Unit-5: Ch.17: 17.1,17.2, 17.3, Ch.20: 20.1, 20.2, 20.3, 20.4.

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to OperationResearch (Eighth Edition) Tata McGraw Hill.
2. Hira and Gupta, Operation Research

DSE-6A: MT 365(B): Calculus of Variation and Classical Mechanics (2 credits)

Course Objectives: Using mathematical methods, the course seeks to comprehend various definitions of physical quantities and their effects on various bodies. It stresses the acquisition of knowledge in order to apply mathematics to the real world.

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

i) understand problems, methods and techniques of calculus of variations.

ii) understand necessary conditions for the equilibrium of particles acted upon by various forces and learn the principle of virtual work for a system of coplanar forces acting on a rigid body.

iii) deal with the kinematics and kinetics of the rectilinear and planar motions of a particle including the constrained oscillatory motions of particles.

iv) determine the center of gravity of some materialistic systems and discuss the equilibrium of a uniform cable hanging freely under its own weight.

Course Contents:

Unit 1: Variational Problems with Fixed Boundaries [06 Lectures]

1.1 Necessary condition of extremum of functionals

1.2 Euler equation

1.3 Euler-Poisson equation

1.4 Euler-ostrogradsky equation

1.5 Euler equation in parametric form

1.6 Isoperimetric problems

1.7 Principle of reciprocity

Unit 2: Variational Problems with Moving Boundaries [06 Lectures]

2.1 Moving boundaries in explicit form

2.2 Moving boundaries in implicit form

2.3 One sided variation

2.4 Functional in parametric form

Unit 3: Sufficient Conditions of Extremum [03 Lectures]

3.1Higher order variations

3.2 Sufficient condition for extremum

3.3 Jacobi equation and Jacobi equation

Unit 4: Mechanics of a Particle and System of Particles [06 Lectures]

4.1 Conservation principles (laws)

4.2 Conservation of linear momentum

4.3 Conservation of angular momentum

4.4 Conservation of energy, Constrained motion, constraints, degrees of freedom

4.5 Generalized co-ordinates

4.6 Limitations of Newton's laws

Unit 5: Variational Principle and Lagrangian Formulation [15 Lectures]

5.1 Hamilton's variational principle

5.2 Deduction of Lagrange's equations of motion fromHamilton's principle

5.3 Deduction of Lagrange's equations by D'Alembert's Principle

5.4 Lagrangian for charged particle in an electromagnetic field, gyroscopic forces,nonconservative forces.

5.5 Deduction of Hamilton's principle form D'Alembert's Principle

5.6 Deduction of Newton's second law of motion from Hamilton's principle

5.7 Deduction of Lagrange's equations of motion using variational principle for non-conservative systems

5.8 Applications of Lagrange's equations of motion

5.9 Non -holonomic systems

5.10 Conservation theorems

5.11 Worked Examples

Text Books:

1. Classical Mechanics by SL Gupta, V. Kumar and H.V. Sharma PragatiPrakashan.
   Unit-4: Chapter 1: 1.1 to 1.6, Unit-5: Chapter-2: 2.1 to 2.12
2. An elementary course on variational problems in Calculus, Naveen Kumar Narosa Publishing House.
   Unit-1: Chapter 1: 1.1 to 1.9, Unit-2: Chapter-2: 2.1 to 2.4, Unit-3: Chapter-3: 3.1 to 3.3.

Reference Books:

1. Classical Mechanics by Herbert Goldstein, Pearson Publication.
2. Introduction to classical Mechanics: with problems and solutions by David J. Morrin Cambridge University Press.
3. Mathematical Methods of Classical Mechanics by V.I. Arnold. Springer Publication.

DSE-6A: MT 365 (C): Financial Mathematics (2 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 [08 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 [10 Lectures]

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

Unit 3: The derivative in economics [08 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 [10 Lectures]

4.1 Making money with matrices, a two-industry 'economy', arbitrage portfolios and state prices and IS-LM analysis.
4.2 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.**
   Unit-1: Chapters-3: 3.2, 3.3, 3.4 and Chapter-4,
   Unit-2: Chapter-5, Chapter-6: 6.3, Chapter-8
   Unit-3: Chapter-9, Chapter-10,
   Unit-4: Chapter-15:15.3, Chapter-16:16.1, Chapter-17:17.4, Chapter-18:18.5, Chapter- 19.

Reference Books:

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

DSE-6B: MT-366(A): Machine Learning-II (2 Credits)

Course Objectives:

The main goal of this course is to help students learn, understand, and practice machine learning approaches, which include the study of modern computing big data technologies and scaling up machine learning techniques focusing on industry applications.

Course Learning Outcomes:

The students learning outcomes are designed to specify what the students will be able to perform after completion of the course: Ability to select and implement machine learning techniques and computing environment that are suitable for the applications under consideration.

Course Contents:

Unit 1: Classification of MNIST dataset [10 Lectures]

1.1 MNIST
1.2 Training a Binary Classifier
1.3 Performance Measures - Measuring accuracy using Cross Validation, Confusion Matrix, Precision and Recall
1.4 Multiclass Classification
1.5 Multilabel Classification

Unit 2: Linear Regression [10 Lectures]

2.1 Linear Regression
1. The Normal Equation
2.2 Gradient Descent
1. Batch Gradient Descent
2. Stochastic Gradient Descent
3. Mini-batch Gradient Descent
2.3 Polynomail Regression

Unit 3: Logistic Regression [06 Lectures]

3.1 Estimating Probabilities
3.2 Training and Cost Function
3.3 Decision Boundary
3.4 Softmax Regression

Unit 4: Other Supervised Algorithms [10 Lectures]

4.1 K Nearest Neighbors
4.2 Decision Trees
4.3 Ensembles of Decision Trees - Random Forest
4.4 Support Vector Machines

Text Books:-

1. **Hands-on Machine Learning with Scikit-Learn, Keras and Tensorflow – Aurelien Geron. Chapter-3:** Sections: 3.1, 3.2, 3.3, 3.4, 3.6, Chapter-4: 4.1, 4.2, 4.3, 4.6
2. **Introduction to Machine Learning With Python - Andreas C. Muller & Sarah Guido,** Chapter-2: Sections: 2.2.2, 2.2.5, 2.2.6, 2.2.7

Reference Book:-

1. Introduction to Machine Learning With Python - Andreas C. Muller & Sarah Guide.
2. Head first Python by Paul Barry (O Reilly publication).
3. Jason Brownlee - Basics of Linear Algebra for Machine Learning, 2018.
4. M. P. Deisenroth, A. A. Faisal, C. S. Ong - Mathematics for Machine Learning, Cambridge University Press, 2019.

5. DipanjanSarkar, Raghav Bali, Tushar Sharma - Practical Machine Learning with Python, 2018.
6. Andrew Ng Playlist - https://www.youtube.com/playlist?list=PLLssT5z_DsK-h9vYZkQkYNWcItqhlRJLN **(First 4 Lectures (till 4.6))**

geeksforgeeks.org/machine-learning
https://towardsdatascience.com/search?q=machine%20learningwww.kaggle.com

DSE-6B: MT- 366(B): Computational Geometry(2 credits)

Course Objectives: This course enables the students to gain detailed knowledge of the fundamental problems within computation geometry and general techniques for solving problems within computational geometry and practical experience with implementation issues involved in converting computation geometry algorithms into running programs.

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

v) construct algorithms for simple geometrical problems.
vi) characterize invariance properties of Euclidean geometry by groups of transformations.
vii) describe and construct basic geometric shapes and concepts by computational means.

Course Contents:

Unit 1: Two Dimensional Transformations [12 Lectures]

1.1 Introduction.
1.2 Representation of points.
1.3 Transformations and matrices.
1.4 Transformation of – points, straight lines.
1.5 Midpoint Transformation.
1.6 Transformation of – parallel lines, intersecting lines.
1.7 Transformation: rotations, reflections, scaling.
1.8 Combined transformations.
1.9 Transformation of a unit square.
1.10 Solid body transformations.
1.11 Translations and homogeneous coordinates.
1.12 Rotation about an arbitrary point.
1.13 Reflection through an arbitrary line.
1.14 Projection – A Geometric Interpretation of Homogeneous Coordinates.
1.15 Overall Scaling.
1.16 Points at Infinity.

Unit 2: Three Dimensional Transformations [08 Lectures]

2.1 Introduction.
2.2 Three dimensional – Scaling, shearing, rotation, reflection, translation.
2.3 Multiple transformations.
2.4 Rotation about – an axis parallel to coordinate axes, an arbitrary axis in space.
2.5 Reflection through an arbitrary plane.

Unit 3: Projection [08 Lectures]

3.1 Orthographic projections.
3.2 Axonometric projections.

3.3 Oblique projections.
3.4 Perspective Transformations.

Unit 4: Plane and Space Curves [08 Lectures]

4.1 Introduction.
4.2 Curve representation.
4.3 Parametric curves.
4.4 Parametric representation of a circle.
4.5 Bezier Curves – Introduction, definition, properties (without proof), Curve fitting (up to n = 3), equation of the curve in matrix form (up to n = 3).

Text Book:

1. **D. F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics,Tata McGraw Hill, Second Edition.**

Unit 1: Chapter 2: Sec. 2.1 to 2.20, Unit 2: Chapter 3: Sec. 3.1 to 3.10.
Unit 3: Chapter 3: Sec. 3.12 to 3.15, Unit 4: Chapter 4: Sec. 4.1, 4.2, 4.4, 4.5,
Chapter 5: Sec. 5.1, 5.8.

Reference Books:

1. Computer Graphics with OpenGL, Donald Hearn, M. Pauline Baker, WarrenCarithers, Pearson (4th Edition).
2. Schaum Series, Computer Graphics by Zhigang Xiang and Roy A. Plastock.

DSE-6B: MT-366(C): Lebesgue Integration (2 Credits)

Course Objectives: To develop skills and to acquire knowledge on basic concepts of Lebesgue Measure, The Lebesgue Integral, Measurable Functions, Convergence and completeness.

Course Learning Outcomes: The course will enable the students:

i) To understand the concept of measure and properties of Lebesgue measure.
ii)To study the properties of Lebesgue integral and compare it with Riemann integral.

Course Contents:

Unit 1.Measurable Sets: [08 Lectures]

1.4 Length of open sets and closed sets
1.5 Inner and outer measure
1.6 Measurable sets
1.7 Properties of measurable sets.

Unit 2. Measurable Functions: [08 Lectures]

1.4 Definition of measurable functions and other criteria for measurability equivalent
1.5 Sums, Products, and limits of a measurable functions
1.6 Sequences of a measurable function

Unit 3. The Lebesgue integral for bounded function [10 Lectures]

3.1 Measurable partition, lower sum, upper sum,
3.2 Lebesgue integral for bounded measurable function
3.3 Properties of Lebesgue integrals for bounded measurable functions

Unit 4. The Lebesgue integral for unbounded function [10 lectures]

4.1 The Lebesgue integral for non-negative valued function
4.2 The Lebesgue integral for real valued function
4.3 Properties of Lebesgue integrals for unbounded functions
4.4 Some fundamental theorems

Text-Book:

1. **Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd. (1970).**

Unit 1: Chapter 11: Sec 11.1 to 11.3. (Theorem No. 11.1B and 11.1C Statements only).
Unit 2: Chapter 11: Sec 11.4. Unit 3: Chapter 11: Sec 11.5 to 11.4.
Unit 4: Chapter 11: Sec. 11.5 to 11.8 (Theorem 11.8 D statement only)

Reference Books:

1. Tom M. Apostol, Mathematical Analysis, Second Edition, Narosa Publishing House.
2. D. Somasundaram and B. Choudhari, A first course in Mathematical Analysis,Narosa Publishing House.
3. R.G. Bartle and D.R. Scherbert, Introduction to real analysis Fourth Edition, Wiley India Edition.
4. Inder K. Rana, An Introduction to Measure and Integration Second Edition, NarosaPublishing House.
5. G. de Barra, Measure Theory and Integration, New Age International (P) Limited, Publishers.

MT 367: Practical Course Lab-I (Complex Analysis and Real Analysis-II) (2 Credits)

Section-I: Complex Analysis Practical

Practical No. 1: Analytic Functions (Unit 1)

Practical No. 2: Elementary Functions (Unit 2)

Practical No. 3: Integrals - I (Unit 3 upto and including Anti-derivatives)

Practical No. 4: Integrals – II(Unit 3 from Cauchy-Groursat's Theoremonwards)

Practical No. 5: Series (Unit 4)

Practical No. 6: Residues and Poles (Unit 5)

Section-II: Real Analysis-IIPractical

Practical 1: Definition and Existence of Riemann Integral (Unit 1)

Practical 2: Properties of Riemann Integrals and Applications (Unit 1)

Practical 3: Improper Integrals (Unit 2)

Practical 4: Pointwise Convergence of Sequences of Functions (Unit 3)

Practical 5: Uniform Convergence of Sequences of Functions (Unit 3)

Practical 6: Series of Functions: Convergence and Divergence (Unit 4)

MT 368: Practical Course Lab-II (Ring Theory and Partial Differential equations) (2 credits)

Section-I: Ring Theory Practical

Practical 1: Rings and Fields (Unit 1)

Practical 2: Rings of Polynomials (Unit 2)

Practical 3: Homomorphism and Factor Ring (Unit 3: 3.1)

Practical 4: Ideals in a Ring (Unit 3: 3.2)

Practical 5: Unique Factorization Domain (Unit 4: 4.1)

Practical 6: Euclidean Domain and Gaussian Integers (Unit 4: 4.2, 4.3)

Section-II: Partial Differential Equations Practical

Practical 1: Simultaneous Differential Equations of the First Order and the First Degree in Three Variables (Unit 1: 1.1, 1.2, 1.3)

Practical 2: Pfaffian Differential Equations and their Solution (Unit 1: 1.4, 1.5)

Practical 3: Solution of First order Partial Differential Equations (Unit 2: 2.1, 2.2, 2.3)

Practical 4: Linear Equations of First order equations and Integral surfaces passing through given curve (Unit 2: 2.3, 2.4)

Practical 5: Solution of Second order Partial Differential Equations (Unit 3)

Practical 6: Canonical Forms and Solution of Second order Partial Differential Equations by Separation Variables Method (Unit 4)

MT 369: Practical Course Lab-III (Based on DSE-6A and DSE-6B) (2 credits)

Section-I: Optimization Techniques/Calculus of Variation and Classical Mechanics/Financial Mathematics

Section-I(A): Optimization Techniques Practical

Practical 1: Network Models (Unit 1)

Practical 2: Game Theory (Unit 2)

Practical 3: Network Models and Game Theory (Unit 1, Unit 2)

Practical 4: Replacement Theory (Unit 3)

Practical 5: Sequencing (Unit 4)

Practical 6: Classical Optimization Theory (Unit 5)

OR

Section-I(B): Calculus of variation and classical Mechanics Practical

Practical 1: Applications of Euler -Lagrange's equation (Unit 1)

Practical 2: Isoperimetric Problems and Variational Problems with Moving Boundaries (Unit 1 and Unit 2)

Practical 3: Degrees of freedom and Generalized coordinates (Unit 3)

Practical 4: Problems on Conservation laws (Unit 4)

Practical 5: Lagrangian Formulation and worked examples-I (Unit 5)

Practical 6: Lagrangian Formulation and worked examples-II (Unit 5)

OR

Section-I (C): Financial Mathematics Practical

Practical 1: Mathematical Models in Economics (Unit 1)

Practical 2: Rrecurrences and the elements of finances (Unit 1)

Practical 3: The Cobweb model (Unit 2)

Practical 4: Introduction to Optimization (Unit 2)

Practical 5: The derivative in Economics (Unit 3)

Practical 6: Linear Equations and the Input Output Model (Unit 4)

Section-II(A): Machine Learning-II Practical

Practical 1: Revision of python and scikit learn (Unit 1)

Practical 2: MNIST classification with python - 1 (Unit 1)

Practical 3: MNIST classification with python - 1 (Unit 1)

Practical 4: Linear Regression Implementation - 1 (Unit 2)

Practical 5: Linear Regression Implementation - 2 (Unit 2)

Practical 6: LogisticRegressionImplementation 1 (Unit 3)

Practical 7: LogisticRegressionImplementation 2 (Unit 3)

Practical 8: Dealingwith Data (Unit 4)

Practical 9: KNN Implementation (Unit 4)

Practical 10: Decision Tree Implementation 4 (Unit 4)

Practical 11: Random Forest Implementation 4 (Unit 4)

Practical 12: Support Vector Machine Implementation 4 (Unit 4)

OR

Section-II (B): Computational Geometry Practical

Practical 1: Two Dimensional Transformation-I (Unit 1)

Practical 2: Two Dimensional Transformation-II (Unit 1)

Practical 3: Two and three Dimensional Transformation-I (Unit 1, Unit 2)

Practical 4: Three Dimensional Transformation-II (Unit 2)

Practical 5: Projection (Unit 3)

Practical 6: Plane and Space Curve (Unit 4)

OR

Section-II(C): Lebesgue Integration Practical

Practical 1: Length of Open and closed sets (Unit 1:1.1, 1.2)

Practical 2: Measurable Sets (Unit 1: 1.2, 1.3)

Practical 3: Measurable functions (Unit 2)

Practical 4: Lebesgue Integral - I (Unit 3: 3.1, 3.2, 3.3)

Practical 5: Lebesgue Integral - II (Unit 3: 3.3, 3.4)

Practical 6: Fourier Series(Unit 4: 4.1, 4.2)

SEC-III: MT-3610: Programming in Python –II(2 Credits)

Course Objectives:

1. To acquire Object Oriented Skills in Python.
2. To develop the skill of designing Graphical user Interfaces in Python.
3. To learn and understand Python programming basics and paradigm.
4. To learn the concepts of visualization of data and database connectivity.
5. To develop the ability to write database applications in Python.

Course Learning Outcomes:

Upon successful completion of this course the student will be able to:

1. Demonstrate the use of Python in Mathematics such as operations research and computational Geometry etc.
2. Study graphics and design and implement a program to solve a real world problem.
3. The students will implement the concepts of data with python and database connectivity.

Course Contents:

Unit 1: Graphics [06 Lectures]

1.1 Turtle Graphics: Overview of Turtle Graphics , Turtle Operations, Object Instantiation and the turtle graphics Module.
1.2 Drawing Two-Dimensional Shapes
1.3 Taking a Random Walk
1.4 Colors and the RGB System
1.5 Drawing with Random Colors
1.6 Using the str Function with Objects.

Unit 2: Data Visualization with Python [04 Lectures]

2.1 Seaborn
2.2 Matplotlib
2.3 Plotly
2.4 MayaVI

Unit 3: Dictionary and Sorting, Minimum and Maximum: [08 Lectures]

3.1 Introduction to Dictionary , Avoiding Key Error Exceptions, Iterating Over a Dictionary,

3.2 Dictionary with default values, Merging dictionaries, Accessing keys and values,Accessing values of a dictionary, Creating dictionary, Creating an ordered dictionary,Unpacking dictionaries using the ** operator.

3.3 Sorting, Minimum and Maximum:Special case: dictionaries, Using the key argument, Default Argument to max, min,Getting a sorted sequence, Extracting N largest or N smallest items from an iterable,Getting the minimum or maximum of several values, Minimum and Maximum of asequence.

Unit 4: Computational Geometry [10 Lectures]

4.1 Points: The distance between two points, Lists of Points - the PointList class, Integer point lists, Ordered Point sets, Extreme Points of a PointList, Random sets of Points not in general position.

4.2 Points: Displaying Points and other geometrical objects, Lines, rays, and line segments, The geometry of line segments, Displaying lines, rays and line segments.

4.3 Polygon: Representing polygons in Python, Triangles, Signed area of a triangle, Triangles and the relationships of points to lines, is Collinear, is Left, is Left On, is Right, is Right On, Between

4.4 Two dimensional rotation and reflection

4.5 Three dimensional rotation and reflection

4.6 Generation of Bezier curve with given control points

Unit 5: Study of Operational Research in Python [08 Lectures]

5.1 Linear Programming in Python

5.2 Introduction to Simplex Method in Python

Practicals:

Practical 1: Turtle Graphics (Unit 1)

Practical 2: Data Visualization (Unit 2)

Practical 3: Dictionary and Sorting, Minimum and Maximum (Unit 3)

Practical 4: Application to Computational Geometry-I (Unit 4)

Practical 5: Application to Computational Geometry-II (Unit 4)

Practical 6: Application to Computational Geometry-II (Unit 4)

Practical 7: Study of Graphical aspects of Two dimensional transformation matrix using Matplotlib (Unit 4)

Practical 8: Study of Graphical aspects of Three dimensional transformation matrix using Matplotlib (Unit 4)

Practical 9: Study of Graphical aspects of Three dimensional transformation matrix using Matplotlib and Study of effect of concatenation of Two dimensional and Three dimensional transformations(Unit 4)

Practical 10: Generation of Bezier curve using given control points (Unit 4)

Practical 11: Study of Operational Research in Python (Unit 5-5.1)

Practical 12: Study of Operational Research in Python (Unit 5-5.2)

Text Books:

1. **Kenneth A. Lambert, Fundamentals of Python:From First Programs to DataStructure, Martin Osborne, 2010, Course Technology, Cengage Learning.** Unit-1: Chapter-7: Sec-7.1.1 to 7.1.8
2. **Python: Notes for Professionals, Goalkicker.com, Free Programming books.** Unit-2: Chapter-108, Unit-3: Chapter-19 Section:19.1 to 19.10 and Chapter-72:Section:72.1 to 72.8
3. **Jim Arlow, Interactive Computational Geometry in Python.** Unit-4: Chapter-1: Sec.-1 to 7, Chapter-2: Sec.-1 to 2, Chapter-3: Sec.-1, 3 to 11, Chapter-4: Sec.-1 to 3, :Chapter-5: Sec.-3 to 7.
4. **Operations Research: Unit-5:** https://pypi.org/project/PuLP/

Reference Books:

1. Guzdial, M. J., Introduction to Computing and Programming in Python, Pearson India.
2. Perkovic, L., Introduction to Computing Using Python, 2/e, John Wiley, 2015.
3. Zelle, J., Python Programming: An Introduction to Computer Science, Franklin,Beedle and Associates Inc.
4. Jim Arlow, Interactive Computational Geometry in Python.
5. Robert Johansson, Introduction to Scientific Computing in Python.
6. Jason Brownlee, Basics of Linear Algebra for Machine Learning, Discover the Mathematical Language of Data in Python.
7. JaanKiusalaas, Numerical Methods in Engineering with Python, Cambridge University Press, (2005).

SEC-IV: MT-3611: 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:

Unit 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

Unit 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

Unit 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

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

4.1 Defining New Commands
4.2 Defining New Environments

Practicals:

Practical 1: Commands and Environment for Inserting Figures (Unit 1: 1.1, 1.2)

Practical 2: More about Figure Insertion (Unit-1; 1.3, 1.4, 1.5)

Practical 3: Mathematical Notations, Operators and Expression in LaTeX (Unit 2: 2.1- 2.3)

Practical 4: Simple Equations (Unit-2: 2.4)

Practical 5: Array of Equations (Unit-2: 2.5)

Practical 6: Alignment and numbering a Set of Equations (Unit-2: 2.6, 2.7)

Practical 7: Texts, Blank Space and Conditional Expression in Math mode (Unit-3: 3.1, 3.2)

Practical 8: Evaluation of Functional Values and Splitting an Equation (Unit-3: 3.3, 3.4)

Practical 9: Vector and Matrix (Unit-3; 3.5)

Practical 10: More about equation writing in LaTeX (Unit-3: 3.6, 3.7, 3.8)

Practical 11: New Commands in LaTeX (Unit-4: 4.1)

Practical 12: New Environments in LaTeX (Unit-4: 4.2)

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

Modalities For Conducting The Practical and The Practical Examination:

1. There will be one 4 hours and 20 minutes (260 minutes) practical session for each batch of 15 students per week for each practical course.
2. The College will conduct the Practical Examination at least 15 days before the commencement of the Main Theory Examination. The University practical examination will consist of written examination of 30 marks and oral examination of 05 marks.
3. There will be external examiner; the practical exam will be of the duration of 3hours. The teacher will set a question paper at the time of paper setting meeting conducted by SavitribaiPhule Pune University, Pune based on respective papers I and II given in **Practical Lab-I, Practical Lab-II and Practical Lab-III**,and the pattern is as follows

Q1. Any 3 out of 5 each question of 5 marks on paper – I (from Practical Lab-I,

Practical Lab-II and Practical Lab-III).

Q2. Any 3 out of 5 each question of 5 marks on paper – II(fromPractical Lab-I,

Practical Lab-II and Practical Lab-III).

4. **SEC:MT -3510, MT -3511, MT -3610**, **MT -3611 University practical writtenexaminationof 30 marks, oral examination 05 marks and internal examination of 15 marks.**
5. **The courses MT-356(A): Machine Learning-I, MT-366(A): Machine Learning-II, MT -3510: Programming in Python -I, MT -3610: Programming in Python –II, MT-3511: LaTeX for Scientific Writing and MT 3611: Mathematics into LaTeX**will teach in Computer Laboratory with live sessions for better understanding of students.
6. Each student will maintain a journal to be provided by the college.The internal 15 marks will be given on the basis of journal prepared by student and the cumulative performance of student at practical.**Methods of assessment for Internal exams:** Seminars, Viva-voce, Projects, Surveys, Field visits, Tutorials, Assignment, Group Discussion.
7. It is recommended that concept may be illustrated using computer software (Python, Maxima etc.) and graphing calculators wherever possible.
8. Study tours may be arranged at places having important mathematical institutes or historical places.
9. **Special Instruction:**
   a) There should be well equipped mathematics practical laboratory of size 20x20 sq. fts containing at least 20 computers because there are six papers based on Software's (**like Machine Learning-I & II, Programming in Python –I & II, LaTeX Software for Scientific Writing and Mathematics into LaTeX**).
   b) Examiners should set separate question papers, solutions and scheme of marking for each batch and claim the remuneration as per University rule.
   c) Before starting each practical necessary introduction, basic definitions, intuitive inspiring ideas and prerequisites must be discussed**.**

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