

**B. Tech - II Year I Semester**

S.No.	Category	Title	L	T	P	Credits
1	BS&H	Discrete Mathematics & Graph Theory	3	0	0	3
2	BS&H	Universal human values – understanding harmony and Ethical human conduct	2	1	0	3
3	Engineering Science	Introduction to Data Science	3	0	0	3
4	Professional Core	Advanced Data Structures & Algorithms Analysis	3	0	0	3
5	Professional Core	Object-Oriented Programming Through JAVA	3	0	0	3
6	Professional Core	Data Science Lab	0	0	3	1.5
7	Professional Core	Object-Oriented Programming Through JAVA Lab	0	0	3	1.5
8	Skill Enhancement course	Python programming	0	1	2	2
9	Audit Course	Environmental Science	2	0	0	-
<b>Total</b>			<b>15</b>	<b>2</b>	<b>10</b>	<b>20</b>

**B. Tech- II Year II Semester**

S.No.	Category	Title	L	T	P	Credit s
1	Management Course- I	Optimization Techniques	2	0	0	2
2	Engineering Science/ Basic Science	Statistical methods for Data science	3	0	0	3
3	Professional Core	Data Engineering	3	0	0	3
4	Professional Core	DBMS	3	0	0	3
5	Professional Core	Digital Logic and Computer Organization	3	0	0	3
7	Professional Core	Data Engineering Lab	0	0	3	1.5
8	Professional Core	DBMS Lab	0	0	3	1.5

9	Skill Enhancement course	Exploratory Data Analysis with Python	0	1	2	2
10	BS&H	Design Thinking &Innovation	1	0	2	2
<b>Total</b>			<b>15</b>	<b>1</b>	<b>10</b>	<b>21</b>

Mandatory Community Service Project Internship of 08 weeks duration during summer Vacation

L	T	P	C
3	0	0	3

## II Year I Semester

### **DISCRETE MATHEMATICS AND GRAPH THEORY**

#### **Course Objectives:**

- To introduce the students to the topics and techniques of discrete methods and combinatorial reasoning.
- To introduce a wide variety of applications. The algorithmic approach to the solution of problems is fundamental in discrete mathematics, and this approach reinforces the close ties between this discipline and the area of computer science.

**Course Outcomes:** At the end of the course students will be able to

1. Build skills in solving mathematical problems (L3)
2. Comprehend mathematical principles and logic (L4)
3. Demonstrate knowledge of mathematical modeling and proficiency in using mathematical software (L6)
4. Manipulate and analyze data numerically and/or graphically using appropriate Software (L3)
5. How to communicate effectively mathematical ideas/results verbally or in writing (L1)

#### **UNIT-I: Mathematical Logic:**

Propositional Calculus: Statements and Notations, Connectives, Well Formed Formulas, Truth Tables, Tautologies, Equivalence of Formulas, Duality Law, Tautological Implications, Normal Forms, Theory of Inference for Statement Calculus, Consistency of Premises, Indirect Method of Proof, Predicate Calculus: Predicates, Predicative Logic, Statement Functions, Variables and Quantifiers, Free and Bound Variables, Inference Theory for Predicate Calculus.

#### **UNIT-II: Set Theory:**

Sets: Operations on Sets, Principle of Inclusion-Exclusion, Relations: Properties, Operations, Partition and Covering, Transitive Closure, Equivalence, Compatibility and Partial Ordering, Hasse Diagrams, Functions: Bijective, Composition, Inverse, Permutation, and Recursive Functions, Lattice and its Properties.

#### **UNIT-III: Combinatorics and Recurrence Relations:**

Basis of Counting, Permutations, Permutations with Repetitions, Circular and Restricted Permutations, Combinations, Restricted Combinations, Binomial and Multinomial Coefficients and Theorems.

**Recurrence Relations:**

Generating Functions, Function of Sequences, Partial Fractions, Calculating Coefficient of Generating Functions, Recurrence Relations, Formulation as Recurrence Relations, Solving Recurrence Relations by Substitution and Generating Functions, Method of Characteristic Roots, Solving Inhomogeneous Recurrence Relations

**UNIT-IV: Graph Theory:**

Basic Concepts, Graph Theory and its Applications, Subgraphs, Graph Representations: Adjacency and Incidence Matrices, Isomorphic Graphs, Paths and Circuits, Eulerian and Hamiltonian Graphs,

**Unit-V: Multi Graphs**

Multigraphs, Bipartite and Planar Graphs, Euler's Theorem, Graph Colouring and Covering, Chromatic Number, Spanning Trees, Prim's and Kruskal's Algorithms, BFS and DFS Spanning Trees.

**TEXT BOOKS:**

1. Discrete Mathematical Structures with Applications to Computer Science, J. P. Tremblay and P. Manohar, Tata McGraw Hill.
2. Elements of Discrete Mathematics-A Computer Oriented Approach, C. L. Liu and D. P. Mohapatra, 3rd Edition, Tata McGraw Hill.
3. Theory and Problems of Discrete Mathematics, Schaum's Outline Series, Seymour Lipschutz and Marc Lars Lipson, 3rd Edition, McGraw Hill.

**REFERENCE BOOKS:**

1. Discrete Mathematics for Computer Scientists and Mathematicians, J. L. Mott, A. Kandel and T. P. Baker, 2nd Edition, Prentice Hall of India.
2. Discrete Mathematical Structures, Bernand Kolman, Robert C. Busby and Sharon Cutler Ross, PHI.
3. Discrete Mathematics, S. K. Chakraborty and B.K. Sarkar, Oxford, 2011.
4. Discrete Mathematics and its Applications with Combinatorics and Graph Theory, K. H. Rosen, 7th Edition, Tata McGraw Hill.

**II Year I Semester**

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2	1	0	3

**UNIVERSAL HUMAN VALUES – UNDERSTANDING HARMONY AND ETHICAL HUMAN CONDUCT**

**Course Objectives:**

- To help the students appreciate the essential complementary between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
- To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
- To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behaviour and mutually enriching interaction with Nature.

**Course Outcomes:**

- Define the terms like Natural Acceptance, Happiness and Prosperity (L1, L2)
- Identify one's self, and one's surroundings (family, society nature) (L1, L2)
- Apply what they have learnt to their own self in different day-to-day settings in real life (L3)
- Relate human values with human relationship and human society. (L4)
- Justify the need for universal human values and harmonious existence (L5)
- Develop as socially and ecologically responsible engineers (L3, L6)

**Course Topics**

The course has 28 lectures and 14 tutorials in 5 modules. The lectures and tutorials are of 1- hour duration. Tutorial sessions are to be used to explore and practice what has been proposed during the lecture sessions.

The Teacher's Manual provides the outline for lectures as well as practice sessions. The teacher is expected to present the issues to be discussed as propositions and encourage the students to have a dialogue.

**UNIT I**      Introduction to Value Education (6 lectures and 3 tutorials for practice session)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)

Lecture 2: Understanding Value Education

Tutorial 1: Practice Session PS1 Sharing about Oneself

Lecture 3: self-exploration as the Process for Value Education

Lecture4: Continuous Happiness and Prosperity – the Basic Human Aspirations

Tutorial 2: Practice Session PS2 Exploring Human Consciousness Lecture 5:

Happiness and Prosperity – Current Scenario

Lecture 6: Method to Fulfill the Basic Human Aspirations Tutorial 3:

Practice Session PS3 Exploring Natural Acceptance

**UNIT II** Harmony in the Human Being (6 lectures and 3 tutorials for practice session) Lecture 7: Understanding Human being as the Co-existence of the self and the body.

Lecture 8: Distinguishing between the Needs of the self and the body

Tutorial 4: Practice Session PS4 Exploring the difference of Needs of self and body.

Lecture 9: The body as an Instrument of the self Lecture

10: Understanding Harmony in the self

Tutorial 5: Practice Session PS5 Exploring Sources of Imagination in the self Lecture 11: Harmony of the self with the body

Lecture 12: Programme to ensure self-regulation and Health

Tutorial 6: Practice Session PS6 Exploring Harmony of self with the body

**UNIT III** Harmony in the Family and Society (6 lectures and 3 tutorials for practice session)

Lecture 13: Harmony in the Family – the Basic Unit of Human Interaction Lecture

14: 'Trust' – the Foundational Value in Relationship

Tutorial 7: Practice Session PS7 Exploring the Feeling of Trust Lecture

15: 'Respect' – as the Right Evaluation

Tutorial 8: Practice Session PS8 Exploring the Feeling of Respect Lecture 16:

Other Feelings, Justice in Human-to-Human Relationship Lecture 17:

Understanding Harmony in the Society

Lecture 18: Vision for the Universal Human Order

Tutorial 9: Practice Session PS9 Exploring Systems to fulfil Human Goal

**UNIT IV** Harmony in the Nature/Existence (4 lectures and 2 tutorials for practice session)

Lecture 19: Understanding Harmony in the Nature

Lecture 20: Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature

Tutorial 10: Practice Session PS10 Exploring the Four Orders of Nature

Lecture 21: Realizing Existence as Co-existence at All Levels

Lecture 22: The Holistic Perception of Harmony in Existence

Tutorial 11: Practice Session PS11 Exploring Co-existence in Existence.

**UNIT V** Implications of the Holistic Understanding – a Look at Professional Ethics (6 lectures and 3 tutorials for practice session)

Lecture 23: Natural Acceptance of Human Values Lecture 24:

Definitiveness of (Ethical) Human Conduct

Tutorial 12: Practice Session PS12 Exploring Ethical Human Conduct

Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order

Lecture 26: Competence in Professional Ethics

Tutorial 13: Practice Session PS13 Exploring Humanistic Models in Education

Lecture 27: Holistic Technologies, Production Systems and Management Models-Typical Case Studies

Lecture 28: Strategies for Transition towards Value-based Life and Profession

Tutorial 14: Practice Session PS14 Exploring Steps of Transition towards Universal Human Order

Practice Sessions for UNIT I – Introduction to Value

Education PS1 Sharing about Oneself

PS2 Exploring Human

Consciousness PS3 Exploring

Natural Acceptance

Practice Sessions for UNIT II – Harmony in the Human

Being PS4 Exploring the difference of Needs of self and body

PS5 Exploring Sources of Imagination in the

self PS6 Exploring Harmony of self with the body

Practice Sessions for UNIT III – Harmony in the Family and

Society PS7 Exploring the Feeling of Trust

PS8 Exploring the Feeling of Respect

PS9 Exploring Systems to fulfil Human Goal

Practice Sessions for UNIT IV – Harmony in the Nature

(Existence) PS10 Exploring the Four Orders of Nature

PS11 Exploring Co-existence in Existence

Practice Sessions for UNIT V – Implications of the Holistic Understanding – a Look at Professional Ethics

PS12 Exploring Ethical Human Conduct

PS13 Exploring Humanistic Models in Education

PS14 Exploring Steps of Transition towards Universal Human Order

### READINGS:

#### Textbook and Teachers Manual

##### a. The Textbook

R R Gaur, R Asthana, G P Bagaria, *A Foundation Course in Human Values and Professional Ethics*, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1

##### b. The Teacher's Manual

R R Gaur, R Asthana, G P Bagaria, *Teachers' Manual for A Foundation Course in Human Values and Professional Ethics*, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-2

#### Reference Books

1. *JeevanVidya: EkParichaya*, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
2. *Human Values*, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. *The Story of Stuff* (Book).
4. *The Story of My Experiments with Truth* - by Mohandas Karamchand Gandhi
5. *Small is Beautiful* - E. F Schumacher.
6. *Slow is Beautiful* - Cecile Andrews
7. *Economy of Permanence* - J C Kumarappa
8. *Bharat Mein Angreji Raj* – PanditSunderlal
9. *Rediscovering India* - by Dharampal
10. *Hind Swaraj or Indian Home Rule* - by Mohandas K. Gandhi
11. *India Wins Freedom* - Maulana Abdul Kalam Azad
12. *Vivekananda* - Romain Rolland (English)
13. *Gandhi* - Romain Rolland (English)

#### Mode of Conduct:

Lecture hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify

them. Tutorial hours are to be used for practice sessions. While analyzing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements. In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self-observation, self-reflection and self-exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up "ordinary" situations rather than "extra-ordinary" situations. Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions

commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values. It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses. This course is to be taught by faculty from every teaching department, not exclusively by any one department. Teacher preparation with a minimum exposure to at least one 8-day Faculty Development Program on Universal Human Values is deemed essential.

#### **Online Resources:**

1. <https://fdp-si.aicte-india.org/UHV-II%20Class%20Notes%20&%20Handouts/UHV%20Handout%201-Introduction%20to%20Value%20Education.pdf>
2. <https://fdp-si.aicte-india.org/UHV-II%20Class%20Notes%20&%20Handouts/UHV%20Handout%202-Harmony%20in%20the%20Human%20Being.pdf>
3. <https://fdp-si.aicte-india.org/UHV-II%20Class%20Notes%20&%20Handouts/UHV%20Handout%203->

Harmony%20in%20the%20Family.pdf

4. <https://fdp-si.aicte-india.org/UHV%201%20Teaching%20Material/D3-S2%20Respect%20July%202023.pdf>
5. <https://fdp-si.aicte-india.org/UHV-II%20Class%20Notes%20&%20Handouts/UHV%20Handout%205-Harmony%20in%20the%20Nature%20and%20Existence.pdf>
6. <https://fdp-si.aicte-india.org/download/FDPTeachingMaterial/3-days%20FDP-SI%20UHV%20Teaching%20Material/Day%203%20Handouts/UHV%203D%20D-3-S2A%20Und%20Nature-Existence.pdf>
7. <https://fdp-si.aicte-india.org/UHV%20II%20Teaching%20Material/UHV%20II%20Lecture%202023-25%20Ethics%20v1.pdf>
8. <https://www.studocu.com/in/document/kiet-group-of-institutions/universal-human-values/chapter-5-holistic-understanding-of-harmony-on-professional-ethics/62490385>
9. [https://onlinecourses.swayam2.ac.in/aic22\\_ge23/preview](https://onlinecourses.swayam2.ac.in/aic22_ge23/preview)

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3	0	0	3

## II Year I Semester

### INTRODUCTION TO DATA SCIENCE

#### **Course Objectives:**

- To provide a comprehensive knowledge of data science using Python.
- To learn the essential concepts of data analytics and data visualization.

#### **Course Outcomes:**

- Upon successful completion of the course, the student will be able to:
- Apply principles of NumPy and Pandas to the analysis of data.
- Make use of various file formats in loading and storage of data.
- Identify and apply the need and importance of pre-processing techniques.
- Show the results and present them in a pictorial format.

**UNIT I: Data science:** Definition, Exploratory Data Analysis, The Data science process, A data scientist role in this process.

**NumPy Basics:** The NumPy ndarray: A Multidimensional Array Object, Creating ndarrays, Data Types for ndarrays, Operations between Arrays and Scalars, Basic Indexing and Slicing, Boolean Indexing, Fancy Indexing, Expressing Conditional Logic as Array Operations, Methods for Boolean Arrays, Sorting , Unique.

**Unit II: Getting Started with pandas:** Introduction to pandas, Library Architecture, Features, Applications, Data Structures, Series, DataFrame, Index Objects, Essential Functionality Reindexing, Dropping entries from an axis, Indexing, selection, and filtering), Sorting and ranking, Summarizing and Computing Descriptive Statistics, Unique Values, Value Counts, Handling Missing Data, filtering out missing data.

**UNIT III:** Reading and Writing Data in Text Format, Reading Text Files in Pieces, Writing Data Out to Text Format, Manually Working with Delimited Formats, JSON Data and HTML: Web Scraping, Binary Data Formats, Using HDF5 Format, Reading Microsoft Excel Files, Interacting with Databases, Storing and Loading Data in MongoDB.

**UNIT IV: Data Wrangling:** Combining and Merging Data Sets, Database style DataFrame Merges, Merging on Index, Concatenating Along an Axis, Combining Data with Overlap , Reshaping and Pivoting, Reshaping with Hierarchical Indexing, Data Transformation, Removing Duplicates, Replacing Values.

**UNIT V: Plotting and Visualization:** A Brief matplotlib API Primer, Figures and Subplots, Colors, Markers, and Line Styles, Ticks, Labels, and Legends, Annotations and Drawing on a Subplot, Saving Plots to File,Plotting Functions in pandas, Line Plots, Bar Plots, Histograms and Density Plots, Scatter Plots.

**Textbook:**

- 1) Wes McKinney, "Python for Data Analysis", O'REILLY, ISBN:978-1-449-31979-3, 1st edition, October 2012.
- 2) Rachel Schutt & O'neil, "Doing Data Science", O'REILLY, ISBN:978-1-449-35865-5, 1<sup>st</sup> edition, October 2013.

**Reference Books:**

- 1) Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media, 2015
- 2) Matt Harrison, "Learning the Pandas Library: Python Tools for Data Munging, Analysis, and Visualization , O'Reilly, 2016.

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## II Year I Semester

### ADVANCED DATA STRUCTURES & ALGORITHM ANALYSIS

#### **Course Objectives:**

- To understand and apply asymptotic notations (Big-O, Big-Theta, Big-Omega) for analyzing the time and space complexities of algorithms.
- To implement and manipulate advanced data structures such as AVL trees, B-trees, heaps, and graphs, and apply them effectively to solve computational problems.
- To design and apply diverse algorithmic strategies including divide and conquer, greedy method, dynamic programming, and backtracking, for solving complex computational problems across various domains.
- To proficiently implement algorithms and data structures in programming languages like C++ or Java, ensuring correctness, efficiency, and adherence to specified computational constraints.

#### **Course Outcomes:**

Students will be able to:

- Analyze algorithms using asymptotic notations to evaluate their efficiency and scalability in diverse computational contexts. (L4-Analyze).
- Implement and manipulate advanced data structures effectively to solve computational problems. (L3-Apply).
- Design and apply diverse algorithmic strategies to solve complex problems across various domains. (L6-Create).
- Implement algorithms and data structures proficiently in programming contexts. (L3-Apply).
- Develop comprehensive computational problem-solving skills, integrating theoretical knowledge with practical application across diverse domains. (L6-Create).

#### **UNIT - I:**

**Performance Analysis:** Algorithm, Performance Analysis-Space complexity, Time complexity, Asymptotic Notations- Big oh notation, Omega notation, Theta notation and Little oh notation.

#### **Trees Part-I:**

**AVL Trees:** Basics, Representation, Rotations, Insertion and Deletion operations.

**Red Black Trees:** Basics, Representation, Insertions, Deletions and Search Operations.

**UNIT – II:**

**Trees Part-II:**

**B Trees:** Basics, Representation, Insertions, Deletions and Search Operations.

**B+ Trees:** Representation, Operations, Applications.

**Splay Trees:** Representation, Operations, Applications.

**Binary Heaps:** Representation, Operations, Applications.

**Graphs:** Terminology, Representations, Basic Search and Traversals, Connected Components and Biconnected Components, applications.

**UNIT – III:**

**Divide and Conquer, Greedy Method and Dynamic Programming:**

**Divide and Conquer:** The General Method, Binary Search, Finding the maximum and minimum, Quick Sort, Merge Sort, Strassen's matrix multiplication.

**Greedy method:** General method, applications-Job sequencing with deadlines, knapsack problem, Minimum cost spanning trees, Single source shortest path problem.

**Dynamic Programming:** General Method, All pairs shortest paths, Single Source Shortest Paths- General Weights (Bellman Ford Algorithm), Optimal Binary Search Trees, 0/1 Knapsack, String Editing, Travelling Salesperson problem.

**UNIT – IV:**

**Back tracking, Branch and Bound.**

**Backtracking:** General Method, 8-Queens Problem, Sum of Subsets problem, Graph Coloring, 0/1 Knapsack Problem.

**Branch and Bound:** The General Method, 0/1 Knapsack Problem, Travelling Salesperson problem.

**UNIT – V: NP Hard and NP Complete Problems.**

**NP Hard and NP Complete Problems:** Basic Concepts, Cook's theorem

**NP Hard Graph Problems:** Clique Decision Problem (CDP), Chromatic Number Decision Problem (CNDP), Traveling Salesperson Decision Problem (TSP).

**NP Hard Scheduling Problems:** Scheduling Identical Processors, Job Shop Scheduling.

**Textbooks:**

1. Fundamentals of Data Structures in C++, Horowitz, Ellis; Sahni, Sartaj; Mehta, Dinesh 2nd Edition Universities Press
2. Computer Algorithms/C++ Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran 2nd Edition University Press

**Reference Books:**

1. Data Structures and program design in C, Robert Kruse, Pearson Education Asia
2. An introduction to Data Structures with applications, Trembley & Sorenson, McGraw Hill

3. The Art of Computer Programming, Vol.1: Fundamental Algorithms, Donald E Knuth, Addison-Wesley, 1997.
4. Data Structures using C & C++: Langsam, Augenstein & Tanenbaum, Pearson, 1995
5. Algorithms + Data Structures & Programs:, N.Wirth, PHI
6. Fundamentals of Data Structures in C++: Horowitz Sahni & Mehta, Galgotia Pub.
7. Data structures in Java:, Thomas Standish, Pearson Education Asia

### Online Learning Resources:

1. [https://www.tutorialspoint.com/advanced\\_data\\_structures/index.asp](https://www.tutorialspoint.com/advanced_data_structures/index.asp)
2. <http://peterindia.net/Algorithms.html>
3. Abdul Bari, [1. Introduction to Algorithms \(youtube.com\)](#)

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## II Year I Semester

### **OBJECT-ORIENTED PROGRAMMING THROUGH JAVA**

#### **Course Objectives**

- Identify Java language components and understand their integration within applications.
- Learn the fundamentals of object-oriented programming in Java, including creation of classes, method invocation, and utilization of class libraries.
- Explore the concepts of inheritance and dynamic binding in Java, and gain proficiency in using exception handling for robust application development.
- Understand the design principles for developing threaded applications in Java.
- Gain proficiency in utilizing Java APIs for effective program development and integration.

#### **Course Outcomes**

- Apply Object-Oriented Programming Principles in Java (L3-Apply).
- Analyze Java Programming Constructs and Control Statements (L4-Analyze).
- Evaluate Advanced Java Features: Packages, Generics, and Exception Handling(L5-Evaluate).
- Apply Multithreading and Synchronization in Java (L3-Apply).
- Implement Java Database Connectivity (JDBC) and GUI Development(L3-Apply)

#### **UNIT-I**

**Introduction to OOP and Java:** Overview of OOP, Object oriented programming paradigms, Features of Object-Oriented Programming, Java Buzzwords, Java Virtual Machine (JVM) , Java Run-time environment(JRE).

**Program Structure in Java:** Introduction, Writing Simple Java Programs, Elements or Tokens, in Java Programs, Java Statements, Command Line Arguments, User Input to Programs, Escape Sequences Comments, Programming Style.

**Data Types, Variables and Arrays:** Primitive types, Floating-Point types, Characters, Booleans, Literals, Variables, Type Conversion and Casting, Automatic type promotion in expressions. **Arrays-** 1D arrays, Multidimensional arrays, Basics of Strings.

**Operators**-Arithmetic operators, bit0wise operators, Relational operators, Boolean Logical Operators, Assignment operator. The ? operator, operator precedence.

**Control Statements:** Selection statements, Iteration statements, Jump statements,

#### **UNIT-II**

**Classes and Objects:** Introduction, Class Declaration and Modifiers, Class Members, Declaration of Class Objects, Assigning One Object to Another, Access Control for Class

Members, Accessing Private Members of Class, Constructor Methods for Class, Overloaded Constructor Methods, Nested Classes, Final Class and Methods, Passing Arguments by Value and by Reference, Keyword this.

**Methods:** Introduction, Defining Methods, Overloaded Methods, Overloaded Constructor Methods, Class Objects as Parameters in Methods, Access Control, Recursive Methods, Nesting of Methods, Overriding Methods, Attributes Final and Static.

**Inheritance:** Introduction, Process of Inheritance, Types of Inheritances, Universal Super Class-Object Class, Inhibiting Inheritance of Class Using Final, Access Control and Inheritance, Multilevel Inheritance, Application of Keyword Super, Constructor Method and Inheritance, Method Overriding, Dynamic Method Dispatch, Abstract Classes, Interfaces and Inheritance.

### **UNIT-III**

**Packages and Java Library:** Introduction, Defining Package, Importing Packages and Classes into Programs, Path and Class Path, Access Control, Packages in Java SE, Java.lang Package and its Classes, Class Object, Enumeration, class Math, Wrapper Classes, Autoboxing and Auto-unboxing, Java util Classes and Interfaces,

**Exception Handling:** Introduction, Hierarchy of Standard Exception Classes, Keywords throws and throw, try, catch, and finally Blocks, Multiple Catch Clauses, Class Throwable, Unchecked Exceptions, Checked Exceptions.

### **UNIT-IV**

**I/O, Generics, String Handling: I/O Basics** – Reading and Writing Console I/O – Reading and Writing Files, Object Serialization.

**String Handling:** Introduction, Interface Char Sequence, Class String, Methods for Extracting Characters from Strings, Comparison, Modifying, Searching; Class String Buffer.

**Multithreaded Programming: The Java Thread Model**-Thread Priorities, Synchronization, Messaging, The Thread Class and the Runnable interface. The Main Thread, **creating a Thread**-Implementing Runnable, Extending Thread, **Creating Multiple Threads, Thread Priorities, Synchronization-Basics**.

### **UNIT-V**

**Java Database Connectivity:** Introduction, JDBC Architecture, Installing MySQL and MySQL Connector/J, JDBC Environment Setup, Establishing JDBC Database Connections, Result Set Interface.

**Java FX GUI:** Java FX Scene Builder, Java FX App Window Structure, displaying text and image, event handling, laying out nodes in scene graph, mouse events.

#### **Text Books:**

- 1) JAVA one step ahead, Anitha Seth, B.L.Juneja, Oxford.
- 2) Joy with JAVA, Fundamentals of Object-Oriented Programming, Debasis Samanta, Monalisa Sarma, Cambridge, 2023.
- 3) JAVA 9 for Programmers, Paul Deitel, Harvey Deitel, 4th Edition, Pearson.

- 4) Thinking in Java by Bruce Eckel
- 5) The complete Reference Java, 11th edition, Herbert Schildt, TMH

**Reference Books:**

- 1) Introduction to Java programming, 7th Edition, Y Daniel Liang, Pearson.
- 2) Learning Java, Pat Niemeyer Jonathan Knudsen Publisher: O'Reilly.

**Online Resources:**

- 1) <https://nptel.ac.in/courses/106/105/106105191/>
- 2) [https://infyspringboard.onwingspan.com/web/en/app/toc/lex\\_auth\\_012880464547618816347\\_shared/overview](https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_012880464547618816347_shared/overview)

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<b>0</b>	<b>0</b>	<b>3</b>	<b>1.5</b>

## II Year I Semester

### **DATA SCIENCE LAB**

#### **Course Objectives:**

- The main objective of the course is to inculcate the basic understanding of Data Science and its practical implementation using Python.

#### **List of Experiments**

1. Creating a NumPy Array
  - a. Basic ndarray
  - b. Array of zeros
  - c. Array of ones
  - d. Random numbers in ndarray
  - e. An array of your choice
  - f. Imatrix in NumPy
  - g. Evenly spaced ndarray
2. The Shape and Reshaping of NumPy Array
  - a. Dimensions of NumPy array
  - b. Shape of NumPy array
  - c. Size of NumPy array
  - d. Reshaping a NumPy array
  - e. Flattening a NumPy array
  - f. Transpose of a NumPy array
3. Expanding and Squeezing a NumPy Array
  - a. Expanding a NumPy array
  - b. Squeezing a NumPy array
  - c. Sorting in NumPy Arrays
4. Indexing and Slicing of NumPy Array
  - a. Slicing 1-D NumPy arrays
  - b. Slicing 2-D NumPy arrays
  - c. Slicing 3-D NumPy arrays
  - d. Negative slicing of NumPy arrays
5. Stacking and Concatenating Numpy Arrays
  - a. Stacking ndarrays

- b. Concatenating ndarrays
- c. Broadcasting in Numpy Arrays
6. Perform following operations using pandas
  - a. Creating dataframe
  - b. concat()
  - c. Setting conditions
  - d. Adding a new column
7. Perform following operations using pandas
  - a. Filling NaN with string
  - b. Sorting based on column values
  - c. groupby()
8. Read the following file formats using pandas
  - a. Text files
  - b. CSV files
  - c. Excel files
  - d. JSON files
9. Read the following file formats
  - a. Pickle files
  - b. Image files using PIL
  - c. Multiple files using Glob
  - d. Importing data from database
10. Demonstrate web scraping using python
11. Perform following preprocessing techniques on loan prediction dataset
  - a. Feature Scaling
  - b. Feature Standardization
  - c. Label Encoding
  - d. One Hot Encoding
12. Perform following visualizations using matplotlib
  - a. Bar Graph
  - b. Pie Chart
  - c. Box Plot
  - d. Histogram
  - e. Line Chart and Subplots
  - f. Scatter Plot

**Web References:**

1. <https://www.analyticsvidhya.com/blog/2020/04/the-ultimate-numpy-tutorial-for-data-science-beginners/>
2. <https://www.analyticsvidhya.com/blog/2021/07/data-science-with->

[pandas-2-minutes- guide-to-key-concepts/](#)

3. <https://www.analyticsvidhya.com/blog/2020/04/how-to-read-common-file-formats- python/>
4. <https://www.analyticsvidhya.com/blog/2016/07/practical-guide-data-preprocessing- python-scikit-learn/>

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## II Year I Semester

### OBJECT-ORIENTED PROGRAMMING THROUGH JAVA LAB

#### Course Objectives:

The aim of this course is to

- Practice object oriented programming in the Java programming language
- implement Classes, Objects, Methods, Inheritance, Exception, Runtime Polymorphism, User defined Exception handling mechanism
- Illustrate inheritance, Exception handling mechanism, JDBC connectivity
- Construct Threads, Event Handling, implement packages, Java FX GUI

#### Experiments covering the Topics:

- Object Oriented Programming fundamentals- data types, control structures
- Classes, methods, objects, Inheritance, polymorphism,
- Exception handling, Threads, Packages, Interfaces
- Files, I/O streams, JavaFX GUI

#### Sample Experiments:

##### Exercise - 1:

- a) Write a JAVA program to display default value of all primitive data type of JAVA
- b) Write a java program that display the roots of a quadratic equation  $ax^2+bx=0$ . Calculate the discriminate D and basing on value of D, describe the nature of root.

##### Exercise - 2

- a) Write a JAVA program to search for an element in a given list of elements using binary search mechanism.
- b) Write a JAVA program to sort for an element in a given list of elements using bubble sort
- c) Write a JAVA program using StringBuffer to delete, remove character.

##### Exercise - 3

- a) Write a JAVA program to implement class mechanism. Create a class, methods and invoke them inside main method.
- b) Write a JAVA program implement method overloading.
- c) Write a JAVA program to implement constructor.

- d) Write a JAVA program to implement constructor overloading.

### Exercise - 4

- a) Write a JAVA program to implement Single Inheritance
- b) Write a JAVA program to implement multi level Inheritance
- c) Write a JAVA program for abstract class to find areas of different shapes

### Exercise - 5

- a) Write a JAVA program give example for “super” keyword.
- b) Write a JAVA program to implement Interface. What kind of Inheritance can be achieved?
- c) Write a JAVA program that implements Runtime polymorphism

### Exercise - 6

- a) Write a JAVA program that describes exception handling mechanism
- b) Write a JAVA program Illustrating Multiple catch clauses
- c) Write a JAVA program for creation of Java Built-in Exceptions
- d) Write a JAVA program for creation of User Defined Exception

### Exercise - 7

- a) Write a JAVA program that creates threads by extending Thread class. First thread display “Good Morning “every 1 sec, the second thread displays “Hello “every 2 seconds and the third display “Welcome” every 3 seconds, (Repeat the same by implementing Runnable)
- b) Write a program illustrating **is Alive** and **join ()**
- c) Write a Program illustrating Daemon Threads.
- d) Write a JAVA program Producer Consumer Problem

### Exercise - 8

1. Write a JAVA program that import and use the user defined packages
2. Without writing any code, build a GUI that display text in label and image in an ImageView (use JavaFX)
3. Build a Tip Calculator app using several JavaFX components and learn how to respond to user interactions with the GUI

### Exercise - 9

1. Write a java program that connects to a database using JDBC
- b) Write a java program to connect to a database using JDBC and insert values into it.
- c) Write a java program to connect to a database using JDBC and delete values from it

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<b>0</b>	<b>1</b>	<b>2</b>	<b>2</b>

**II Year I Semester**  
**PYTHON PROGRAMMING**  
**(Skill Enhancement Course)**

**Course Objectives:**

The main objectives of the course are to

- a. Introduce core programming concepts of Python programming language.
- b. Demonstrate about Python data structures like Lists, Tuples, Sets and dictionaries
- c. Implement Functions, Modules and Regular Expressions in Python Programming and to create practical and contemporary applications using these

**UNTI-I:** History of Python Programming Language, Thrust Areas of Python, Installing Anaconda Python Distribution, Installing and Using Jupyter Notebook.

**Parts of Python Programming Language:** Identifiers, Keywords, Statements and Expressions, Variables, Operators, Precedence and Associativity, Data Types, Indentation, Comments, Reading Input, Print Output, Type Conversions, the type () Function and Is Operator, Dynamic and Strongly Typed Language.

**Control Flow Statements:** if statement, if-else statement, if...elif...else, Nested if statement, while Loop, for Loop, continue and break Statements, Catching Exceptions Using try and except Statement.

**Sample Experiments:**

1. Write a program to find the largest element among three Numbers.
2. Write a Program to display all prime numbers within an interval
3. Write a program to swap two numbers without using a temporary variable.
4. Demonstrate the following Operators in Python with suitable examples.
  - i) Arithmetic Operators ii) Relational Operators iii) Assignment Operators iv) Logical Operators v) Bit wise Operators vi) Ternary Operator vii) Membership Operators viii) Identity Operators
5. Write a program to add and multiply complex numbers
6. Write a program to print multiplication table of a given number.

**UNIT-II: Functions:** Built-In Functions, Commonly Used Modules, Function Definition and Calling the function, return Statement and void Function, Scope and Lifetime of Variables, Default Parameters, Keyword Arguments, \*args and \*\*kwargs, Command Line Arguments. **Strings:** Creating and Storing Strings, Basic String Operations, Accessing Characters in String by Index Number, String Slicing and Joining, String Methods, Formatting Strings.

**Lists:** Creating Lists, Basic List Operations, Indexing and Slicing in Lists, Built-In Functions Used on Lists, List Methods, del Statement.

### Sample Experiments:

1. Write a program to define a function with multiple return values.
2. Write a program to define a function using default arguments.
3. Write a program to find the length of the string without using any library functions.
4. Write a program to check if the substring is present in a given string or not.
5. Write a program to perform the given operations on a list:
  - i. Addition
  - ii. Insertion
  - iii. slicing
6. Write a program to perform any 5 built-in functions by taking any list.

**UNIT-III: Dictionaries:** Creating Dictionary, Accessing and Modifying key:value Pairs in Dictionaries, Built-In Functions Used on Dictionaries, Dictionary Methods, del Statement.

**Tuples and Sets:** Creating Tuples, Basic Tuple Operations, tuple() Function, Indexing and Slicing in Tuples, Built-In Functions Used on Tuples, Relation between Tuples and Lists, Relation between Tuples and Dictionaries, Using zip() Function, Sets, Set Methods, Frozenset.

### Sample Experiments:

1. Write a program to create tuples (name, age, address, college) for at least two members and concatenate the tuples and print the concatenated tuples.
2. Write a program to count the number of vowels in a string (No control flow allowed).
3. Write a program to check if a given key exists in a dictionary or not.
4. Write a program to add a new key-value pair to an existing dictionary.
5. Write a program to sum all the items in a given dictionary.

**UNIT-IV:Files:** Types of Files, Creating and Reading Text Data, File Methods to Read and Write Data, Reading and Writing Binary Files, Pickle Module, Reading and Writing CSV Files, Python os and os.path Modules.

**Object-Oriented Programming:** Classes and Objects, Creating Classes in Python, Creating Objects in Python, Constructor Method, Classes with Multiple Objects, Class Attributes Vs Data Attributes, Encapsulation, Inheritance, Polymorphism.

### Sample Experiments:

1. Write a program to sort words in a file and put them in another file. The output file should have only lower-case words, so any upper-case words from source must be lowered.
2. Python program to print each line of a file in reverse order.
3. Python program to compute the number of characters, words and lines in a file.
4. Write a program to create, display, append, insert and reverse the order of the items in the array.
5. Write a program to add, transpose and multiply two matrices.
6. Write a Python program to create a class that represents a shape. Include methods to calculate its area and perimeter. Implement subclasses for different shapes like circle, triangle, and square.

**UNIT-V: Introduction to Data Science:** Functional Programming, JSON and XML in Python, NumPy with Python, Pandas.

### Sample Experiments:

1. Python program to check whether a JSON string contains complex object or not.
2. Python Program to demonstrate NumPy arrays creation using array () function.
3. Python program to demonstrate use of ndim, shape, size, dtype.
4. Python program to demonstrate basic slicing, integer and Boolean indexing.
5. Python program to find min, max, sum, cumulative sum of array
6. Create a dictionary with at least five keys and each key represent value as a list where this list contains at least ten values and convert this dictionary as a pandas data frame and explore the data through the data frame as follows:
  - a) Apply head () function to the pandas data frame
  - b) Perform various data selection operations on Data Frame
7. Select any two columns from the above data frame, and observe the change in one attribute with respect to other attribute with scatter and plot operations in matplotlib

### Reference Books:

1. Gowrishankar S, Veena A., Introduction to Python Programming, CRC Press.
2. Python Programming, S Sridhar, J Indumathi, V M Hariharan, 2<sup>nd</sup>Edition, Pearson, 2024
3. Introduction to Programming Using Python, Y. Daniel Liang, Pearson.

**Online Learning Resources/Virtual Labs:**

1. <https://www.coursera.org/learn/python-for-applied-data-science-ai>
2. <https://www.coursera.org/learn/python?specialization=python#syllabus>

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## **II Year I Semester**

### **ENVIRONMENTAL SCIENCE**

#### **Course Objectives:**

- To make the students to get awareness on environment
- To understand the importance of protecting natural resources, ecosystems for future generations and pollution causes due to the day to day activities of human life
- To save earth from the inventions by the engineers.

#### **Course Outcomes:**

- Grasp multidisciplinary nature of environmental studies and various renewable and non-renewable resources.
- Understand flow and bio-geo-chemical cycles and ecological pyramids.
- Understand various causes of pollution and solid waste management and related preventive measures.
- About the rainwater harvesting, watershed management, ozone layer depletion and waste landreclamation.
- Casus of population explosion, value education and welfare programmes.

#### **UNIT-I**

Multidisciplinary Nature Of Environmental Studies: – Definition, Scope and Importance – Need for Public Awareness.

Natural Resources: Renewable and non-renewable resources – Natural resources and associated problems – Forest resources – Use and over-exploitation, deforestation, case studies – Timber extraction – Mining, dams and other effects on forest and tribal people – Water resources – Use and over utilization of surface and ground water – Floods, drought, conflicts over water, dams – benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. – Energy resources:

### **UNIT-II**

Ecosystems: Concept of an ecosystem.—Structure and function of an ecosystem—Producers, consumers and decomposers – Energy flow in the ecosystem – Ecological succession – Food chains, food webs and ecological pyramids—Introduction, types, characteristic features, structure and function of the following ecosystem:

- a. Forest ecosystem.
- b. Grassland ecosystem
- c. Desert ecosystem
- d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Biodiversity And Its Conservation: Introduction Definition: genetic, species and ecosystem diversity—Bio-geographical classification of India—Value of biodiversity: consumptive use, Productive use, social, ethical, aesthetic and option values – Biodiversity at global, National and local levels – India as a mega-diversity nation – Hot-spots of biodiversity – Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts—Endangered and endemic species of India –Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

### **UNIT-III**

Environmental Pollution: Definition, Cause, effects and control measures of:

- a. Air Pollution.
- b. Water pollution
- c. Soil pollution
- d. Marine pollution
- e. Noise pollution
- f. Thermal pollution
- g. Nuclear hazards

Solid Waste Management: Causes, effects and control measures of urban and industrial wastes – Role of an individual in prevention of pollution – Pollution case studies – Disaster management: floods, earthquake, cyclone and landslides.

### **UNIT-IV**

Social Issues and the Environment: From Unsustainable to Sustainable development—Urban problems related to energy – Water conservation, rain water harvesting, watershed management – Resettlement and rehabilitation of people; its problems and concerns. Case studies – Environmental ethics: Issues and possible solutions—Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies – Wastel and reclamation. – Consumerism and waste products. – Environment Protection Act. – Air (Prevention and Control of Pollution) Act. – Water (Prevention and control of Pollution) Act – Wild life Protection Act – Forest Conservation Act – Issues involved in enforcement of

environment legislation–Public awareness.

### UNIT-V

Human Population And The Environment: Population growth, variation among nations. Population explosion – Family Welfare Programmes. – Environment and human health – Human Rights – Value Education-HIV/AIDS-Women and Child Welfare–Role of information Technology in Environment and human health–Case studies. Field Work:Visit to a local area to document environmental assets River/ forest grassland/ hill/ mountain – Visit to a local polluted site-Urban/Rural/Industrial/Agricultural Study of common plants,insects, and birds–river, hills slopes,etc..

#### Text books:

1. Text book of Environmental Studies for Undergraduate Courses ErachBharucha for University Grants Commission,Universities Press.
2. Palaniswamy, "Environmental Studies", Pearson education
3. S.AzeemUnnisa, "Environmental Studies" Academic Publishing Company
4. K.RaghavanNambiar, "Text book of Environmental Studies for Undergraduate Courses as per UGC model syllabus", Scitech Publications (India), Pvt.Ltd.

#### Reference Books:

1. DeekshaDaveandE.SaiBabaReddy, "Text book of Environmental Science", Cengage Publications.
2. M.AnjiReddy, "Text book of Environmental Sciences and Technology", BSPublication.
3. J.P.Sharma, Comprehensive Environmental studies, Laxmi publications.
4. J.GlynnHenryandGaryW.Heinke, "Environmental Sciences and Engineering", Prentice Hall of India Private limited
5. G.R.Chatwal, "A Text Book of Environmental Studies" Himalaya Publishing House
6. Gilbert M.Masters and WendellP.Ela, "Introduction to Environmental Engineering and Science", Prentice Hall of India Private limited.

**II Year II Semester**

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## **OPTIMIZATION TECHNIQUES**

**Pre-requisite:**

**Course Objectives:**

1. To define an objective function and constraint functions in terms of design variables, and then state the optimization problem.
2. To state single variable and multi variable optimization problems, without and with constraints.
3. To explain linear programming technique to an optimization problem, define slack and surplus variables, by using Simplex method.
4. To state transportation and assignment problem as a linear programming problem to determine Simplex method.
5. To study and explain nonlinear programming techniques, unconstrained or constrained, and define exterior and interior penalty functions for optimization problems.

**Course Outcomes:** At the end of the course, student will be able to

- State and formulate the optimization problem, without and with constraints, by using design variables from an engineering design problem.
- Apply classical optimization techniques to minimize or maximize a multi-variable objective function, without or with constraints, and arrive at an optimal solution.
- Apply and Solve transportation and assignment problem by using Linear programming Simplex method.
- Apply gradient and non-gradient methods to nonlinear optimization problems and use interior or exterior penalty functions for the constraints to derive the optimal solutions
- Formulate and apply Dynamic programming technique to inventory control, production planning, engineering design problems etc. to reach a final optimal solution from the current optimal solution.

### **UNIT I: Introduction and Classical Optimization Techniques:**

Statement of an Optimization problem, design vector, design constraints, constraint surface, objective function, objective function surfaces, classification of Optimization problems.

**Classical Optimization Techniques:** Single variable Optimization, multi variable Optimization without constraints, necessary and sufficient conditions for minimum/maximum, multivariable Optimization with equality constraints. Solution

by method of Lagrange multipliers, multivariable Optimization with inequality constraints, Kuhn – Tucker conditions

### **UNIT II: Linear Programming :**

Standard form of a linear programming problem, geometry of linear programming problems, definitions and theorems, solution of a system of linear simultaneous equations, pivotal reduction of a general system of equations, motivation to the simplex method, simplex algorithm.

### **UNIT III: Transportation Problem:**

Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method, testing for optimality of balanced transportation problems, Special cases in transportation problem.

### **UNIT IV: Nonlinear Programming:**

Unconstrained cases, One – dimensional minimization methods: Classification, Fibonacci method, Univariate method, steepest descent method. Constrained cases– Characteristics of a constrained problem, Classification, Basic approach of PenaltyFunction method, Basic approaches of Interior and Exterior penalty function methods,

### **UNIT V: Dynamic Programming:**

Dynamic programming multistage decision processes, types, concept of sub optimization and the principle of optimality, computational procedure in dynamic programming, examples illustrating the calculus method of solution, examples illustrating the tabular method of solution.

#### **Textbooks:**

1. "Engineering optimization: Theory and practice", S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. "Introductory Operations Research", H.S. Kasene& K.D. Kumar, Springer (India), Pvt.LTd.

#### **Reference Books:**

1. "Optimization Methods in Operations Research and systems Analysis", by K.V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Operations Research, Dr.S.D.Sharma, Kedarnath, Ramnath& Co

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## II Year II Semester

### **STATISTICAL METHODS FOR DATA SCIENCE**

#### **Course Objectives:**

- To familiarize the students with the foundations of probability and statistical methods
- To impart probability concepts and statistical methods in various applications Engineering

**Course Outcomes:** Upon successful completion of this course, the student should be able to

1. Classify the concepts of data science and its importance (L2)
2. Interpret the association of characteristics and through correlation and regression tools (L4)
3. Apply discrete and continuous probability distributions (L3)
4. Design the components of a classical hypothesis test (L6)
5. Infer the statistical inferential methods based on small and large sampling tests (L4)

#### **Unit - I: Descriptive statistics and methods for data science:**

Data science – Statistics Introduction – Population vs Sample –Collection of data – primary and secondary data – Type of variable: dependent and independent Categorical and Continuous variables – Data visualization – Measures of Central tendency – Measures of Variability – Skewness – Kurtosis.

#### **UNIT – II: Correlation and Regression:**

Correlation – Correlation coefficient – Rank correlation.

Linear Regression: Straight line – Multiple Linear Regression - Regression coefficients and properties – Curvilinear Regression: Parabola – Exponential – Power curves.

#### **UNIT – III: Probability and Distributions:**

Probability– Conditional probability and Baye's theorem – Random variables – Discrete and Continuous random variables – Distribution functions – Probability mass function, Probability density function and Cumulative distribution functions – Mathematical Expectation and Variance – Binomial, Poisson, Uniform and Normal distributions.

**UNIT – IV: Sampling Theory:**

Introduction – Population and Samples – Sampling distribution of Means and Variance (definition only) – Point and Interval estimations – Maximum error of estimate – Central  $\chi^2$  limit theorem (without proof) – Estimation using t,  $\chi^2$  and F-distributions.

**UNIT – V: Tests of Hypothesis:**

Introduction – Hypothesis – Null and Alternative Hypothesis – Type I and Type II errors – Level of significance – One tail and two-tail tests – Test of significance for large samples and Small Samples: Single and difference means – Single and two proportions – Student's t- test, F-test,  $\chi^2$ -test.

**Text Books:**

- **Miller and Freund's**, Probability and Statistics for Engineers, 7/e, Pearson, 2008.
- **S. C. Gupta and V.K. Kapoor**, Fundamentals of Mathematical Statistics, 11/e, Sultan Chand & Sons Publications, 2012.

**Reference Books:**

- **Shron L. Myers, Keying Ye, Ronald E Walpole**, Probability and Statistics Engineers and the Scientists, 8<sup>th</sup> Edition, Pearson 2007.
- **Jay L. Devore**, Probability and Statistics for Engineering and the Sciences, 8<sup>th</sup> Edition, Cengage.
- **Sheldon M. Ross**, Introduction to probability and statistics Engineers and the Scientists, 4<sup>th</sup> Edition, Academic Foundation, 2011.
- **Johannes Ledolter and Robert V. Hogg**, Applied statistics for Engineers and Physical Scientists, 3<sup>rd</sup> Edition, Pearson, 2010.

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## II Year II Semester

### **DATA ENGINEERING**

#### **Course Objectives:**

- Explain basic concepts of Data Engineering
- Discuss bout Data Engineering Life Cycle
- How to design Good Data Architecture

**UNIT-I: Introduction to Data Engineering:** Definition, Data Engineering Life Cycle, Evolution of Data Engineer, Data Engineering Versus Data Science, Data Engineering Skills and Activities, Data Maturity, Data Maturity Model, Skills of a Data Engineer, Business Responsibilities, Technical Responsibilities, Data Engineers and Other Technical Roles.

**UNIT-II: Data Engineering Life Cycle:** Data Life Cycle Versus Data Engineering Life Cycle, Generation: Source System, Storage, Ingestion, Transformation, Serving Data.

**Major undercurrents across the Data Engineering Life Cycle:** Security, Data Management, DataOps, Data Architecture, Orchestration, Software Engineering.

**UNIT-III: Designing Good Data Architecture:** Enterprise Architecture, Data Architecture, Principles of Good Data Architecture, Major Architecture Concepts.

**Data Generation in Source Systems:** Sources of Data, Files and Unstructured Data, APIs, Application Databases (OLTP), OLAP, Change Data Capture, Logs, Database Logs, CRUD, Source System Practical Details.

**UNIT-IV: Storage:** Raw Ingredients of Data Storage, Data Storage Systems, Data Engineering Storage Abstractions, Data warehouse, Data Lake, Data Lakehouse.

**Ingestion:** Data Ingestion, Key Engineering considerations for the Ingestion Phase, Batch Ingestion Considerations, Message and Stream Ingestion Considerations, Ways to Ingest Data

**UNIT-V: Queries, Modeling and Transformation:** Queries, Life of a Query, Query Optimizer, Queries on Streaming Data, Data Modelling, Modeling Streaming Data, Transformations, Streaming Transformations and Processing.

**Serving Data for Analytics, Machine Learning and Reverse ETL:** General Considerations for serving Data, Business Analytics, Operational Analytics, Embedded Analytics, Ways to serve data for analytics and ML, Reverse ETL.

**Text Books:**

1. Joe Reis, Matt Housley, Fundamentals of Data Engineering, O'Reilly Media, Inc., June 2022, ISBN: 9781098108304

**Reference Books:**

1. Paul Crickard , Data Engineering with Python,Packt Publishing, October 2020.
2. Ralph Kimball, Margy Ross, The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, Wiley, 3rd Edition, 2013
3. James Densmore, Data Pipelines Pocket Reference: Moving and Processing Data for Analytics, O'Reilly Media, 1st Edition, 2021

**II Year II Semester**

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**DATABASE MANAGEMENT SYSTEMS**

**Course Objectives:**

The main objectives of the course is to

- Introduce database management systems and to give a good formal foundation on the relational model of data and usage of Relational Algebra
- Introduce the concepts of basic SQL as a universal Database language
- Demonstrate the principles behind systematic database design approaches by covering conceptual design, logical design through normalization
- Provide an overview of physical design of a database system, by discussing Database indexing techniques and storage techniques

**UNIT I: Introduction:** Database system, Characteristics (Database Vs File System), Database Users, Advantages of Database systems, Database applications. Brief introduction of different Data Models; Concepts of Schema, Instance and data independence; Three tier schema architecture for data independence; Database system structure, environment, Centralized and Client Server architecture for the database.

**Entity Relationship Model:** Introduction, Representation of entities, attributes, entity set, relationship, relationship set, constraints, sub classes, super class, inheritance, specialization, generalization using ER Diagrams.

**Unit II: Relational Model:** Introduction to relational model, concepts of domain, attribute, tuple, relation, importance of null values, constraints (Domain, Key constraints, integrity constraints) and their importance, Relational Algebra, Relational Calculus. BASIC SQL:Simple Database schema, data types, table definitions (create, alter), different DML operations (insert, delete, update).

**UNIT III: SQL:** Basic SQL querying (select and project) using where clause, arithmetic & logical operations, SQL functions(Date and Time, Numeric, String conversion).Creating tables with relationship, implementation of key and integrity constraints, nested queries, sub queries, grouping, aggregation, ordering, implementation of different types of joins, view(updatable and non-updatable), relational set operations.

**UNIT IV: Schema Refinement (Normalization):** Purpose of Normalization or schema refinement, concept of functional dependency, normal forms based on functional dependencyLossless join and dependency preserving decomposition, (1NF, 2NF and 3 NF), concept of surrogate key, Boyce-Codd normal form(BCNF), MVD, Fourth normal form(4NF), Fifth Normal Form (5NF).

**UNIT V: Transaction Concept:** Transaction State, ACID properties, Concurrent Executions, Serializability, Recoverability, Implementation of Isolation, Testing for Serializability, lock based, time stamp based, optimistic, concurrency protocols, Deadlocks, Failure Classification, Storage, Recovery and Atomicity, Recovery algorithm.

**Introduction to Indexing Techniques:** B+ Trees, operations on B+Trees, Hash Based Indexing:

### Text Books:

- 1) Database Management Systems, 3<sup>rd</sup> edition, Raghurama Krishnan, Johannes Gehrke, TMH (For Chapters 2, 3, 4)
- 2) Database System Concepts, 5<sup>th</sup> edition, Silberschatz, Korth, Sudarsan, TMH (For Chapter 1 and Chapter 5)

### Reference Books:

1. Introduction to Database Systems, 8<sup>th</sup> edition, C J Date, Pearson.
2. Database Management System, 6<sup>th</sup> edition, Ramez Elmasri, Shamkant B. Navathe, Pearson
3. Database Principles Fundamentals of Design Implementation and Management, Corlos Coronel, Steven Morris, Peter Robb, Cengage Learning.

### Web-Resources:

1. <https://nptel.ac.in/courses/106/105/106105175/>
2. [https://infyspringboard.onwingspan.com/web/en/app/toc/lex\\_auth\\_01275806667282022456\\_shared/overview](https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_01275806667282022456_shared/overview)

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## II Year II Semester

### **DIGITAL LOGIC & COMPUTER ORGANIZATION**

#### **Course Objectives:**

- Develop a deep understanding of digital logic design principles, encompassing binary number systems, logic gates, and sequential circuits.
- Explore the fundamental concepts of computer organization, including Von Neumann architecture, bus structures, and the role of various functional units.
- Describe and analyze memory hierarchy concepts, including RAM, ROM, cache memories, and virtual memory systems, to understand their impact on system performance.
- Explain the principles and mechanisms of input/output (I/O) systems, including interrupts, DMA, and standard interfaces, and their integration with CPU and memory for efficient data transfer and system operation.

#### **Course Outcomes:**

- Analyze Data Representation and Digital Logic Concepts (L4-Analyze).
- Analyze Sequential and Combinational Circuits (L4-Analyze).
- Evaluate Computer Architecture and Instruction Set Design (L5-Evaluate)
- Evaluate Performance Considerations in Memory and I/O Systems (L5-Evaluate).
- Evaluate the Forms of Parallel Processing in Large Computer Systems (L5-Evaluate).

#### **UNIT-I**

**Data representation:** Signed Binary Numbers, Binary Codes, Decimal Codes, Error Detection code, Gray Code, Fixed-Point representation, Floating-Point Representation, Character Representation.

**Digital Logic Circuits-I:** Basic Logic Functions, Logic gates, universal logic gates, Minimization of Logic expressions. K-Map Simplification (2,3,4, and 5 variables), Combinational Circuits, Decoders, Multiplexers.

### UNIT-II

**Digital Logic Circuits-II:** Sequential Circuits, Flip-Flops, Binary counters, Registers, Shift Registers, Ripple counters.

**Introduction to Computer Architecture:** Functional blocks of a computer: CPU, memory, input-output subsystems, control unit. Instruction set architecture of a CPU: Registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set. Outlining instruction sets of some common CPUs.

### UNIT-III

**Computer Arithmetic:** Integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication – shift-and add, Booth multiplier, carry save multiplier, etc. Division restoring and non-restoring techniques, floating point arithmetic, IEEE 754 format.

**CPU Control Unit Design:** Hardwired and micro-programmed design approaches, design of a simple hypothetical CPU. Memory system design: Semiconductor memory technologies, memory organization.

### UNIT-IV

**The Memory Organization:** Basic Concepts, Semiconductor RAM Memories, Read-Only Memories, Speed, Size and Cost, Cache Memories, Performance Considerations, Virtual Memories, Memory Management Requirements, Secondary Storage.

**Peripheral Devices and Their Characteristics:** Input-output subsystems, I/O device interface, I/O transfers – program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes – role of interrupts in process state transitions, I/O device interfaces – SCII, USB.

### UNIT-V

**Pipelining:** Basic Concepts, Data Hazards, Instruction Hazards, Influence on Instruction Sets.

**Large Computer Systems:** Forms of Parallel Processing, Array Processors, The Structure of General-Purpose multiprocessors, Interconnection Networks.

**Text Books:**

1. Computer Organization, Carl Hamacher, ZvonkoVranesic, SafwatZaky, 6th edition, McGraw Hill
2. Digital Design, 6th Edition, M. Morris Mano, Pearson Education.
3. Computer Organization and Architecture, William Stallings, 11thEdition, Pearson.

**Reference Books:**

1. Computer Systems Architecture, M.Moris Mano, 3rdEdition, Pearson
2. John P. Hayes, Computer Architecture and Organization, McGraw-Hill, 1998.
3. Computer Organization and Design, David A. Paterson, John L.Hennessy, Elsevier
4. Fundamentals of Logic Design, Roth, 5thEdition, Thomson

**Online Learning Resources:**

1. <https://nptel.ac.in/courses/106/103/106103068/>

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## II Year II Semester

### **DATA ENGINEERING LAB**

#### **Course Objective:**

- The main objective of this course is to teach how build data engineering infrastructure and data pipelines.

#### **Course Outcomes:**

At the end of the course student will be able to:

1. Build our Data Engineering Infrastructure
2. Demonstrate Reading and Writing files
3. Build Data Pipelines and integrate with Dashboard
4. Deploy the Data Pipeline in production

#### **Experiments:**

1. Installing and configuring Apache NiFi, Apache Airflow
2. Installing and configuring Elasticsearch, Kibana, PostgreSQL, pgAdmin 4
3. Reading and Writing files
  - a. Reading and writing files in Python
  - b. Processing files in Airflow
  - c. NiFi processors for handling files
  - d. Reading and writing data to databases in Python
  - e. Databases in Airflow
  - f. Database processors in NiFi
4. Working with Databases
  - a. Inserting and extracting relational data in Python
  - b. Inserting and extracting NoSQL database data in Python
  - c. Building database pipelines in Airflow
  - d. Building database pipelines in NiFi
5. Cleaning, Transforming and Enriching Data
  - a. Performing exploratory data analysis in Python
  - b. Handling common data issues using pandas

- c. Cleaning data using Airflow
6. Building the Data Pipeline
7. Building a Kibana Dash Board
8. Perform the following operations
  - a. Staging and validating data
  - b. Building idempotent data pipelines
  - c. Building atomic data pipelines
9. Version Control with the NiFi Registry
  - a. Installing and configuring the NiFi Registry
  - b. Using the Registry in NiFi
  - c. Versioning your data pipelines
  - d. Using git-persistence with the NiFi Registry
10. Monitoring Data Pipelines
  - a. Monitoring NiFi in the GUI
  - b. Monitoring NiFi using processors
  - c. Monitoring NiFi with Python and the REST API
11. Deploying Data Pipelines
  - a. Finalizing your data pipelines for production
  - b. Using the NiFi variable registry
  - c. Deploying your data pipelines
12. Building a Production Data Pipeline
  - a. Creating a test and production environment
  - b. Building a production data pipeline
  - c. Deploying a data pipeline in production

**Reference Books:**

1. Paul Crickard , Data Engineering with Python,Packt Publishing, October 2020.

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## **II Year II Semester**

### **DATABASE MANAGEMENT SYSTEMS LAB**

#### **Course Objectives:**

This Course will enable students to

- Populate and query a database using SQL DDL/DML Commands
- Declare and enforce integrity constraints on a database
- Writing Queries using advanced concepts of SQL
- Programming PL/SQL including procedures, functions, cursors and triggers,

#### **Experiments covering the topics:**

- DDL, DML, DCL commands
- Queries, nested queries, built-in functions,
- PL/SQL programming- control structures
- Procedures, Functions, Cursors, Triggers,
- Database connectivity- ODBC/JDBC

#### **Sample Experiments:**

1. Creation, altering and dropping of tables and inserting rows into a table (use constraints while creating tables) examples using SELECT command.
2. Queries (along with sub Queries) using ANY, ALL, IN, EXISTS, NOTEXISTS, UNION, INTERSET, Constraints. Example:- Select the roll number and name of the student who secured fourth rank in the class.
3. Queries using Aggregate functions (COUNT, SUM, AVG, MAX and MIN), GROUP BY, HAVING and Creation and dropping of Views.
4. Queries using Conversion functions (to\_char, to\_number and to\_date), string functions (Concatenation, lpad, rpad, ltrim, rtrim, lower, upper, initcap, length, substr and instr), date functions (Sysdate, next\_day, add\_months, last\_day, months\_between, least, greatest, trunc, round, to\_char, to\_date)
- 5.

- i. Create a simple PL/SQL program which includes declaration section, executable section and exception -Handling section (Ex. Student marks can be selected from the table and printed for those who secured first class and an exception can be raised if no records were found)
- ii. Insert data into student table and use COMMIT, ROLLBACK and SAVEPOINT in PL/SQL block.
6. Develop a program that includes the features NESTED IF, CASE and CASE expression. The program can be extended using the NULLIF and COALESCE functions.
7. Program development using WHILE LOOPS, numeric FOR LOOPS, nested loops using ERROR Handling, BUILT –IN Exceptions, USE defined Exceptions, RAISE-APPLICATION ERROR.
8. Programs development using creation of procedures, passing parameters IN and OUT of PROCEDURES.
9. Program development using creation of stored functions, invoke functions in SQL Statements and write complex functions.
10. Develop programs using features parameters in a CURSOR, FOR UPDATE CURSOR, WHERE CURRENT of clause and CURSOR variables.
11. Develop Programs using BEFORE and AFTER Triggers, Row and Statement Triggers and INSTEAD OF Triggers
12. Create a table and perform the search operation on table using indexing and non- indexing techniques.
13. Write a Java program that connects to a database using JDBC
14. Write a Java program to connect to a database using JDBC and insert values into it
15. Write a Java program to connect to a database using JDBC and delete values from it

**Text Books/Suggested Reading:**

1. Oracle: The Complete Reference by Oracle Press
2. Nilesh Shah, "Database Systems Using Oracle", PHI, 2007
3. Rick F Vander Lans, "Introduction to SQL", Fourth Edition, Pearson Education, 2007

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## **II Year II Semester**

### **EXPLORATORY DATA ANALYSIS USING PYTHON (SKILL DEVELOPMENT COURSE)**

#### **Course Objectives:**

1. This course introduces the fundamentals of Exploratory Data Analysis
2. It covers essential exploratory techniques for understanding multivariate data by summarizing it through statistical methods and graphical methods.

#### **Course Outcomes:**

1. Enumerate the fundamentals of Exploratory Data Analysis.
2. Visualize the data using basic graphs and plots.
3. Apply different Data Transformation Techniques.
4. Summarize the data using descriptive statistics.
5. Evaluate the Models and select the best model

## **UNIT-I**

**Exploratory Data Analysis Fundamentals:** Understanding data science, The significance of EDA, Steps in EDA, Making sense of data, Numerical data, Categorical data, Measurement scales, Comparing EDA with classical and Bayesian analysis, Software tools available for EDA, Getting started with EDA.

#### **Sample Experiments:**

1. a) Download Dataset from Kaggle using the following link: <https://www.kaggle.com/datasets/sukhmanibedi/cars4u>  
b) Install python libraries required for Exploratory Data Analysis (numpy, pandas, matplotlib, seaborn)
2. Perform Numpy Array basic operations and Explore Numpy Built-in functions.
3. Loading Dataset into pandas dataframe
4. Selecting rows and columns in the dataframe

## **UNIT-II**

**Visual Aids for EDA:** Technical requirements, Line chart, Bar charts, Scatter plot using seaborn, Polar chart, Histogram, Choosing the best chart

**Case Study:** EDA with Personal Email, Technical requirements, Loading the dataset, Data transformation, Data cleansing, Applying descriptive statistics, Data

refactoring, Data analysis.

**Sample Experiments:**

1. Apply different visualization techniques using sample dataset
  - a) Line Chart b) Bar Chart c) Scatter Plots d) Bubble Plot
2. Generate Scatter Plot using seaborn library for iris dataset
3. Apply following visualization Techniques for a sample dataset
  - a) Area Plot b) Stacked Plot c) Pie chart d) Table Chart
4. Generate the following charts for a dataset.
  - a) Polar Chart b) Histogram c) Lollipop chart
5. Case Study: Perform Exploratory Data Analysis with Personal Email Data

**UNIT-III**

**Data Transformation:** Merging database-style dataframes, Concatenating along with an axis, Merging on index, Reshaping and pivoting, Transformation techniques, Handling missing data, Mathematical operations with NaN, Filling missing values, Discretization and binning, Outlier detection and filtering, Permutation and random sampling, Benefits of data transformation, Challenges.

**Sample Experiments:**

1. Perform the following operations
  - a) Merging Dataframes
  - b) Reshaping with Hierarchical Indexing
  - c) Data Deduplication
  - d) Replacing Values
2. Apply different Missing Data handling techniques
  - a) NaN values in mathematical Operations
  - b) Filling in missing data
  - c) Forward and Backward filling of missing values
  - d) Filling with index values
  - e) Interpolation of missing values
3. Apply different data transformation techniques
  - a) Renaming axis indexes
  - b) Discretization and Binning
  - c) Permutation and Random Sampling
  - d) Dummy variables

**UNIT-IV**

**Descriptive Statistics:** Distribution function, Measures of central tendency, Measures of dispersion, Types of kurtosis, Calculating percentiles, Quartiles, Grouping Datasets, Correlation, Understanding univariate, bivariate, multivariate analysis, Time Series Analysis **Sample Experiments:**

1. Study the following Distribution Techniques on a sample data

- a) Uniform Distribution
  - b) Normal Distribution
  - c) Gamma Distribution
  - d) Exponential Distribution
  - e) Poisson Distribution
  - f) Binomial Distribution
2. Perform Data Cleaning on a sample dataset.
  3. Compute measure of Central Tendency on a sample dataset
    - a) Mean b) Median c) Mode
  4. Explore Measures of Dispersion on a sample dataset
    - a) Variance b) Standard Deviation c) Skewness d) Kurtosis
  5. a) Calculating percentiles on sample dataset  
b) Calculate Inter Quartile Range(IQR) and Visualize using Box Plots
  6. Perform the following analysis on automobile dataset.
    - a) Bivariate analysis b) Multivariate analysis
  7. Perform Time Series Analysis on Open Power systems dataset

## **UNIT-V**

**Model Development and Evaluation:** Unified machine learning workflow, Data preprocessing, Data preparation, Training sets and corpus creation, Model creation and training, Model evaluation, Best model selection and evaluation, Model deployment

**Case Study:** EDA on Wine Quality Data Analysis

### **Sample Experiments:**

1. Perform hypothesis testing using statsmodels library
  - a) Z-Test b) T-Test
2. Develop model and Perform Model Evaluation using different metrics such as prediction score, R2 Score, MAE Score, MSE Score.
22. Case Study: Perform Exploratory Data Analysis with Wine Quality Dataset

### **Text Book:**

1. Suresh Kumar Mukhiya, Usman Ahmed, Hands-On Exploratory Data Analysis with Python, Packt Publishing, 2020.

### **References:**

1. Ronald K. Pearson, Exploratory Data Analysis Using R, CRC Press, 2020
2. Radhika Datar, Harish Garg, Hands-On Exploratory Data Analysis with R: Become an expert in exploratory data analysis using R packages, 1st Edition, Packt Publishing, 2019

### **Web References:**

1. <https://github.com/PacktPublishing/Hands-on-Exploratory-Data-Analysis-with-Python>

2. <https://www.analyticsvidhya.com/blog/2022/07/step-by-step-exploratory-data-analysis-eda-using-python/#h-conclusion>
3. <https://github.com/PacktPublishing/Exploratory-Data-Analysis-with-Python-Cookbook>

**II Year II Semester**

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### **DESIGN THINKING & INNOVATION**

**Course Objectives:** The objectives of the course are to

- Bring awareness on innovative design and new product development.
- Explain the basics of design thinking.
- Familiarize the role of reverse engineering in product development.
- Train how to identify the needs of society and convert into demand.
- Introduce product planning and product development process.

#### **UNIT – I      Introduction to Design Thinking**

Introduction to elements and principles of Design, basics of design-dot, line, shape, form as fundamental design components. Principles of design. Introduction to design thinking, history of Design Thinking, New materials in Industry.

#### **UNIT - II      Design Thinking Process**

Design thinking process (empathize, analyze, idea & prototype), implementing the process in driving inventions, design thinking in social innovations. Tools of design thinking - person, costumer, journey map, brainstorming, product development

**Activity:** Every student presents their idea in three minutes, Every student can present design process in the form of flow diagram or flow chart etc. Every student should explain about product development.

#### **UNIT - III      Innovation**

Art of innovation, Difference between innovation and creativity, role of creativity and innovation in organizations. Creativity to Innovation. Teams for innovation, Measuring the impact and value of creativity.

**Activity:** Debate on innovation and creativity, Flow and planning from idea to innovation, Debate on value-based innovation.

#### **UNIT - IV      Product Design**

Problem formation, introduction to product design, Product strategies, Product value, Product planning, product specifications. Innovation towards product design Case studies.

**Activity:** Importance of modeling, how to set specifications, Explaining their own product design.

#### **UNIT – V      Design Thinking in Business Processes**

Design Thinking applied in Business & Strategic Innovation, Design Thinking principles that redefine business – Business challenges: Growth, Predictability, Change, Maintaining Relevance, Extreme competition, Standardization. Design thinking to meet corporate needs. Design thinking for Startups. Defining and testing Business Models and Business Cases. Developing & testing prototypes.

**Activity:** How to market our own product, about maintenance, Reliability and plan for startup.

#### **Textbooks:**

1. Tim Brown, Change by design, 1/e, Harper Bollins, 2009.
2. Idris Mootee, Design Thinking for Strategic Innovation, 1/e, Adams Media, 2014.

#### **Reference Books:**

1. David Lee, Design Thinking in the Classroom, Ulysses press, 2018.
2. Shrrutin N Shetty, Design the Future, 1/e, Norton Press, 2018.
3. William lidwell, Kritinaholden, &Jill butter, Universal principles of design, 2/e, Rockport Publishers, 2010.
4. Chesbrough.H, The era of open innovation, 2003.

#### **Online Learning Resources:**

- <https://nptel.ac.in/courses/110/106/110106124/>
- <https://nptel.ac.in/courses/109/104/109104109/>
- [https://swayam.gov.in/nd1\\_noc19\\_mg60/preview](https://swayam.gov.in/nd1_noc19_mg60/preview)
- [https://onlinecourses.nptel.ac.in/noc22\\_de16/preview](https://onlinecourses.nptel.ac.in/noc22_de16/preview)

#### **Course Outcomes:**

<b>COs</b>	<b>Statements</b>	<b>Blooms Level</b>
CO1	Define the concepts related to design thinking.	L1
CO2	Explain the fundamentals of Design Thinking and innovation.	L2
CO3	Apply the design thinking techniques for solving problems in various sectors.	L3
CO4	Analyse to work in a multidisciplinary environment.	L4
CO5	Evaluate the value of creativity.	L5