Amritanagar, Coimbatore – 641 112, Tamil Nadu, India

M.Sc., APPLIED STATISTICS AND DATA ANALYTICS

Regulations, Curriculum and Syllabus

(Academic Year 2024-25 onwards)

M.Sc., APPLIED STATISTICS AND DATA ANALYTICS
(Academic Year 2024-25 onwards)

Program Outcomes

PO1 **Knowledge in Statistics and Data Analytics:** Understand the basic concepts, fundamental principles and the scientific theories related to Statistics and Data Analytics.

PO2 **Abstract thinking**: Ability to absorb and understand the abstract concepts that lead to various advanced theories in mathematics and Statistics.

PO3 **Modelling and solving**: Ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods.

PO4 **Advanced theories and methods**: Understand advanced theories and methods to design solutions for complex statistical problems in Data Science.

PO5 **Applications in Engineering and Sciences**: Understand the role of statistics and apply the same to solve the real life problems in various fields of study.

PO6 **Modern software tool usage**: Acquire the skills in handling scientific tools towards solving problems and solution analysis in Data Science.

PO7 **Environment and sustainability**: Understand the significance of preserving the environment towards sustainable development.

PO8 **Ethics**: Imbibe ethical, moral and social values in personal and social life leading to highly cultured and civilized personality. Continue to enhance the knowledge and skills in applied statistics and data analytics for constructive activities and demonstrate highest standards of professional ethics.

PO9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 **Communication**: Develop various communication skills such as reading, listening, speaking and discussing which will help in expressing ideas and views clearly and effectively.

PO11 **Project management and Research**: Demonstrate knowledge, understand the scientific and management principles and apply these to one's own work, as a member/ leader in a team to manage projects and multidisciplinary research environments. Also use the research-based knowledge to analyse and solve advanced problems in data sciences.

PO12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

M.Sc., APPLIED STATISTICS AND DATA ANALYTICS
Curriculum
(effective from the academic year 2024 - 2025)

Semester I

Course code	Course	L T P	Credit
24ASD501	Data Structures and Algorithms	3 0 2	4
24ASD502	Introduction to Data Analytics with R Programming	3 0 2	4
24ASD503	Linear Algebra	3 0 2	4
24ASD504	Optimization Techniques	3 1 0	4
24ASD505	Probability Theory and Estimation	3 0 2	4
24ASD506	Python Programming	3 0 2	4
22ADM501	Glimpses of Indian Culture	2 0 1	P/F
	Total		**24**

Semester II

Course code	Course	L T P	Credit
24ASD511	Big Data Analytics and Hadoop	3 0 2	4
24ASD512	Database Management	3 0 2	4
24ASD513	Data Mining	3 1 0	4
24ASD514	Machine Learning	3 0 2	4
24ASD515	Multivariate Statistics and Regression Analysis	3 0 2	4
24ASD516	Statistical Inference and Design of Experiments	3 0 2	4
	Amrita Value Programme	1 0 0	1
22AVP103	Mastery Over Mind	1 0 2	2
	Total		**27**

Semester III

Course code	Course	L T P	Credit
24ASD601	SQC and Reliability Theory	3 0 2	4
24ASD602	Deep Learning	3 0 2	4
	Elective I	3 0 0	3
	Elective II	3 0 0	3
	Elective II	3 0 0	3
	Total		**17**

Semester IV

Course code	Course	L T P	Credit
24ASD699	Dissertation		10
	Total		**10**

Total credits for the programme: 78

ELECTIVES

Course code	Course	L T P	Credit
24ASD631	Business Analytics	2 0 2	3
24ASD632	Categorical Data Analysis	2 0 2	3
24ASD633	Computational Biology	2 0 2	3
24ASD634	Computer aided drug designing	2 0 2	3
24ASD635	Demography and Actuarial Statistics	2 0 2	3
24ASD636	Healthcare Analytics	2 0 2	3
24ASD637	Market Analytics	2 0 2	3
24ASD638	Mining of Massive Datasets	2 0 2	3
24ASD639	Official Statistics	2 0 2	3
24ASD640	Parallel and Distributed Systems	3 0 0	3
24ASD641	Pattern Recognition	2 0 2	3
24ASD642	Queuing Theory	2 0 2	3
24ASD643	Reinforcement Learning	2 0 2	3
24ASD644	Social Network Analytics	2 0 2	3
24ASD645	Special Distribution Functions	2 0 2	3
24ASD646	Stochastic Process	3 0 0	3
24ASD647	Survival Analysis	2 0 2	3
24ASD648	Thinking with Data	2 0 2	3
24ASD649	Time Series	2 0 2	3

**Amrita Value Programme			
22ADM502	Vedanta in day-to-day life	1-0-0	1
22AVP506	Message of Swami Vivekananda	1-0-0	1
22AVP508	Indian Arts and Literature	1-0-0	1
22AVP510	Appreciation of Kerala Mural Arts Forms	1-0-0	1
22AVP501	Message of Śrī Mātā Amritanandamayi Devi	1-0-0	1
22AVP502	Insights from the Ramayana	1-0-0	1
22AVP503	Insights from the Mahabharata	1-0-0	1
22AVP504	Insights from the Upanishads	1-0-0	1
22AVP505	Insights from Bhagavad Gita	1-0-0	1
22AVP512	Ancient Indian Science and Technology	1-0-0	1
22AVP507	Great Spiritual Teachers of India	1-0-0	1
22AVP509	Yoga and Meditation 1	1-0-0	1

Evaluation Pattern:

S.No	Course Type	Theory / Lab	Mid Term marks	CA marks	End Semester marks
1	3- 1- 0- 4 / 4- 0- 0 – 4 / 3- 0 – 3 - 3	Theory	30	20	50
2	3- 0- 2- 4 / 2- 0 2 – 3/ 1- 0- 2 -2	Theory & Lab	30	40	30
3	0- 0- 2- 1	Lab	-	60	40

Semester I

24ASD501 Data Structures and Algorithms 3 0 2 4

Course Outcomes:

CO1: Understand the various basic data types and trees.
CO2: Gain knowledge about standard data structures like Stack, Queue, list - array, linked list.
CO3: Know the importance of priority queue - Heaps; heap-based implementations; applications of heaps - sorting; Search Tree - Binary search tree.
CO4: To understand the basic concepts of time complexity and classes of time complexity.
CO5: To gain knowledge about same graph algorithms like shortest path algorithm and minimal spanning tree algorithms.

Unit – I: Abstraction - Abstract data types; Data Representation; Elementary data types; Basic concepts of data Structures; Mathematical preliminaries - big-Oh notation; efficiency of algorithms; notion of time and space complexity; performance measures for data structures. ADT array - Computations on arrays.

Unit – II: ADT Stack, Queue, list - array, linked list, cursor based implementations of linear structures. ADT Tree - tree representation, properties traversal of trees; ADT- Binary Trees – properties and algorithms.

Unit – III: ADT Priority Queue - Heaps; heap-based implementations; applications of heaps - sorting; Search Tree - Binary search tree; balanced binary search trees - AVL tree; Applications of Search Trees - TRIE; 2-3-4 tree; concept of B-Tree. ADT Dictionary - array based and tree based implementations; hashing - definition and application.

Unit – IV: Sorting and Searching Algorithms: Merge Sort, Quick-Sort, Insertion Sort, Bin Sort, Bucket-Sort and Radix-Sort Selection Sort, Comparison of Sorting Algorithms. Introduction to time complexity. Bio-O, worst case complexity, polynomial classifications. Satisfiability, NP Complete and NP Hard (Definitions only).

Unit – V: Graphs algorithms: ADT- Data structure for graphs - Graph traversal- Transitive Closure- Directed Acyclic graphs - Weighted graphs – Shortest Paths - Minimum spanning tree – Greedy Methods for MST. Travelling salesman problem.

Text Books /Reference Books:

1. Goodrich M T, Tamassia R and Michael H. Goldwasser, "Data Structures and Algorithms in Python++", Wiley publication, 2013.
2. Goodrich M T and Tamassia R, "Data Structures and Algorithms in Java", Fifth edition, Wiley publication, 2010.
3. Tremblay J P and Sorenson P G, "An Introduction to Data Structures with Applications", Second Edition, Tata McGraw-Hill, 2002.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	2					1	1
CO2	3	3	3	2	2	2	2					1	1
CO3	3	3	3	2	2	3	2					1	1
CO4	3	2	3	2	2	2	2					1	1
CO5	2	2	2	1	1	2	1					1	1

24ASD502 Introduction to Data Analytics with R Programming 3 0 2 4

Course Outcomes:

CO1: Understanding the fundamentals of R software
CO2: Exploring and implementing graphical visualization using R
CO3: Exploring and implementing basic Statistics using R
CO4: Understanding correlation and regression and visualising them using R
CO5: Exploring and implementing supervised learning through classification/regressions using R

Unit – I : R Programming Basics: Conditional expressions, For, if else, do and while loops, defining functions, Vectorization and functionals, Data Frames, R Scripts, list, repeats, vector indexing, sorting and ordering, factors, creating matrices and basic matrix operations in R, 2d/3d plotting.

Unit – II: Data Handling: Creating, importing/exporting and merging of datasets, Data Collection, Sampling methods, classification of data, Dealing with missing values. Data Visualization: Bar and Pie charts – histogram, frequency polygon – Box plot – Stem and leaf plot.

Unit – III: Data Analysis: Measures of Central tendency and dispersion - Mean, median, mode, absolute, quartile and standard deviations, skewness and kurtosis for both grouped and ungrouped data. Association of attributes. Generating random samples from standard distributions (such as Bernoulli, Poisson, Normal, Exponential etc.).

Unit – IV: Curve fitting and interpolation - Fitting of straight lines and curves - Correlation, regression, fitting of simple linear lines, polynomials and logarithmic functions - Interpolation and extrapolation methods - Binomial expansion, Newton and Gauss methods.

Unit – V: Supervised Learning using R(Regression/Classification): Naïve Bayes, Linear models: Linear Regression, Logistic Regression, Generalized Linear Models – Case Study.

Text Books /Reference Books:

1. Rafael A. Irizarry, Introduction to Data Science: Data Analysis and Prediction Algorithms with R, CRC Press, 2019.
2. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005.
3. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
4. Data Science and big data analytics: Discovering, analyzing, visualizing and presenting data, EMC Education Services, John Wiley 2015.
5. John Hopcroft and Ravi Kannan, “Foundations of Data Science”, eBook, Publisher, 2013.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	2					3	2
CO2	3	3	3	2	2	2	2					3	2
CO3	3	3	3	2	2	3	3					3	2
CO4	3	2	3	2	2	2	3					3	2
CO5	2	2	2	2	3	2	3					3	2

24ASD503 **Linear Algebra** **3 0 2 4**

Course Outcomes:

CO-1: To understand the axioms in the definition of a vector space through examples; to understand Subspaces, basis and its relevance.

CO-2: To understand inner products and compute the angle/length of a vector and the orthonormal basis.

CO-3: To understand the concepts of Linear Transformations and Matrices for Linear Transformation

CO-4: To understand the concepts of Eigen Values, Eigen Vectors & Diagonalization form.

CO-5: Decompositions : LU,QR and SVD

Unit – I: Vector Spaces: Vector spaces - Sub spaces - Linear independence - Basis – Dimension.

Unit – II: Inner Product Spaces**:** Inner products - Orthogonality - Orthogonal basis - Gram Schmidt Process - Change of basis - Orthogonal complements - Projection on subspace - Least Square Principle.

Unit – III: Linear Transformations: Positive definite matrices - Matrix norm and condition number - - Linear transformation - Relation between matrices and linear transformations - Kernel and range of a linear transformation - Trace and Transpose, Determinants, Symmetric and Skew Symmetric Matrices.

Unit – IV: Eigen values and Eigen vectors: Problems in Eigen Values and Eigen Vectors, Diagonalization, Orthogonal Diagonalization, Quadratic Forms, Diagonalizing Quadratic Forms.

Unit – V: Decomposition of matrices: LU, QR and SVD

Text Books / Reference Books:

1) Howard Anton and Chris Rorres, "Elementary Linear Algebra", 10th Edition, John Wiley & Sons, 2010.
2) Linear Algebra, Arnold J. Insel, Lawrence E. Spence, and Stephen H. Friedberg, 5th Edition, Pearson Education, 2014.
3) Nabil Nassif, Jocelyne Erhel, Bernard Philippe, Introduction to Computational Linear Algebra, CRC press, 2015.
4) Sheldon Axler, Linear Algebra Done Right, Springer, 2014.

5) Gilbert Strang, "Linear Algebra for Learning Data", Cambridge press, 2019.
6) Kenneth Hoffmann and Ray Kunze, Linear Algebra, Second Edition, Prentice Hall, 1971.
7) Mike Cohen, Practical Linear Algebra for Data Science, Oreilly Publisher, 2022.
8) I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1					2	2
CO2	3	3	2	2	2	1					2	1
CO3	3	3	2	2	3	1					2	1
CO4	3	2	2	2	2	1					2	1
CO5	3	2	2	1	2	1					2	1

24ASD504 Optimization Techniques 3 1 0 4

CO1: To learn Linear Programming Problems.
CO2: To learn single variable optimization techniques
CO3: To understand the basics of unconstrained optimization problems and direct search, unidirection search methods for multivariable problems.
CO4: To learn the various unconstrained optimization techniques for multivariable.
CO5: To understand and solve the nonlinear optimization problem with equality and inequality constrained problems and to learn theory of few significant genetic evolutionary algorithms.

Unit – I: Introduction to LPP: Lines and hyperplanes, Convex sets, Convex hull, Formulation of a Linear Programming Problem, Linear Programming Problem; Graphical Method; Simplex method; Dual problem, Duality theory, Dual simplex method, Revised simplex method.

Unit – II: Introduction to optimization: classical optimization, Optimality criteria – Necessary and sufficient conditions for existence of optimum point. Fundamental Region Elimination Rules to eliminate a region. One dimensional Search methods: Golden search method, Fibonacci method, Newton's Method, Secant Method, Remarks on line Search Sections.

Unit – III: Unconstrained Multivariable optimization: Introduction, Necessary and sufficient conditions for existence of extreme point. Conditions for local minimization. Direct search methods: unidirectional search, box evolutionary search method.

Unit – IV: Gradient-based methods- introduction, the method of steepest descent, analysis of Gradient Methods, Convergence, Convergence Rate. Analysis of Newton's Method, Newton's Method for Nonlinear Least-Squares. Introduction -The Conjugate Direction Algorithm, The Conjugate Gradient Algorithm for unconstrained optimization problems.

Unit – V: Nonlinear Equality Constrained Optimization- Introduction, Problems with equality constraints Problem Formulation, Lagrange Multiplier Method - Nonlinear Inequality Constrained Optimization: - Problems with

inequality constraints: Kuhn-Tucker conditions. Specific Search Algorithms: Hill Climbing, Simulated Annealing, Genetic Algorithms, Ant Colony Optimization.

Text Books/ Reference Books:

1. Edwin K.P. Chong, Stanislaw H. Zak, "An Introduction to Optimization", 2nd edition, Wiley, 2013.
2. Mokhtar S. Bazarra, Hamit D Sherali, C.M. Shetty, "Nonlinear programming Theory and applications", 2nd edition, Wiley , 2004.
3. Mohan C. Joshi and Kannan M. Moudgalya, Optimization: Theory and Practice, Narosa Publishing House, New Delhi, 2004 (Reference)
4. Kalyanmoy Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India, New Delhi, 2004.
5. S.S. Rao, "Optimization Theory and Applications", Second Edition, New Age International (P) Limited Publishers, 1995.
6. Bertsimas, Dimitris, and John Tsitsiklis. *Introduction to Linear Optimization*. Belmont, MA: Athena Scientific, 1997.

CO-PO Mapping:

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CO1	3	3	3	2	2	2					1	1
CO2	3	3	3	2	2	2					1	1
CO3	3	3	3	2	3	2					1	1
CO4	3	2	3	2	2	2					1	1
CO5	2	2	2	1	2	1					1	1

24ASD505 Probability Theory and Estimation 3 0 2 4

Course Outcomes:

CO1: Understand the basics of probability, random variables and distribution functions.
CO2: Know the importance of two dimensional random variables and correlation studies
CO3: Gain knowledge about standard statistical distributions and their properties
CO4: To gain knowledge point estimation and properties
CO5: To gain knowledge about sampling distributions interval estimations

Unit – I: Review of probability concepts - conditional probability- Bayes theorem. Random Variable and Distributions: Introduction to random variable – discrete and continuous random variables and its distribution functions- mathematical expectations – moment generating function and characteristic function.

Unit – II: Joint, marginal and conditional probability distributions for discrete and continuous cases, stochastic independence, expectation of two dimensional random variables, conditional mean and variance, correlation and introduction to regression.

Unit – III: Standard distributions - Binomial, Multinomial, Poisson, Uniform, exponential, Weibull, Gamma, Beta, Normal. Mean, variance and applications of these distributions- Chebyshev's theorem and central limit theorem.

Unit – IV: Point estimation, properties, methods of estimating a point estimator, minimum risk estimators Sampling distributions of mean and variance, distributions of t, F and ChiSquare distribution. Central limit theorem.

Unit - V: Interval estimation- Confidence interval for one mean, difference of two means, single proportion, difference of two proportions, single variance, ratio of two variances.

Text Books /Reference Books:

1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005.
2. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.
3. Ravichandran, J: Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.
4. Hoel, P.G., Port, S.C., and Stone, C.J., Introduction to Probability Theory, Universal Book Stall, New Delhi, 1998

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	1					3	2
CO2	3	3	3	2	2	1					3	2
CO3	3	3	3	2	2	1					3	2
CO4	3	2	3	2	2	1					3	2
CO5	3	2	3	1	1	1					3	2

24ASD506 **Python Programming** **3 0 2 4**

Course Outcomes:

CO-1: Understand the basic data types, operators, expressions, conditions and looping statements

CO-2: Understand and apply data structure concepts and function calls in Python.

CO-3: Familiarise with functions, modules, packages and libraries in Python

CO-4: Execute the Python programme for data cleaning and reading data from different file formats.

CO-5: Understand and apply various Data Visualization plots

Unit – I: Introduction: History of Python, Need of Python Programming, Applications Basicsof Python Programming, Running Python Scripts, Installing Python on Your Computer, Using the Terminal Command Prompt, IDLE, and Other IDEs, Variables, Assignment, Keywords, Input-Output, Indentation.Types, Operators and Expressions: Types - Integers, Strings, Booleans; Operators- Arithmetic Operators, Comparison (Relational) Operators, Assignment Operators, Logical Operators, Bitwise Operators, Membership Operators, Identity Operators, Expressions and order of evaluations Control Flow- if, if-elif-else, for, while, break, continue, pass .Case Study: An Investment Report and Approximating Square Roots.

Unit – II: Data Structures: Lists - Operations, Slicing, Methods; Tuples, Sets, Dictionaries, Sequences Comprehensions. Case Study: Nondirective Psychotherapy.

Unit – III: Functions: Defining Functions, Calling Functions, Passing Arguments, Keyword Arguments, Default Arguments, Variable-length arguments, Anonymous Functions, Fruitful Functions (Function Returning Values), Scope of the Variables in a Function - Global and Local Variables.
Modules: Creating modules, import statement, from. Import statement, name spacing. Python packages: Introduction to PIP, Installing Packages via PIP, Using Python Packages. Text Files: Text Files and Their Format, Writing Text to a File, Writing Numbers to a File, Reading Text from a File, Reading Numbers from a File, Accessing and Manipulating Files and Directories on Disk. Case Study: Gathering Information from a File System

Unit – IV: Data Gathering and Cleaning: Cleaning Data, Checking for Missing Values, Handling the Missing Values, Reading and Cleaning CSV Data, Merging and Integrating Data, Reading Data from the JSON Format.
Regular expressions: Character matching in regular expressions, Extracting data using regular expressions, Combining searching and extracting and Escape character. Case Study: Detecting the e-mail addresses in a text file.

Unit – V: Popular Libraries for Data Visualization in Python: Matplotlib, Seaborn, Plotly, Geoplotlib, and Pandas. Data Visualization: Direct Plotting, Line Plot, Bar Plot, Pie Chart, Box Plot, Histogram Plot, Scatter Plot, Seaborn Plotting System, Strip Plot, Box Plot, Swarm Plot, Joint Plot, Matplotlib Plot, Line Plot Bar Chart, Histogram Plot, Scatter Plot, Stack Plot and Pie Chart.
Coding Simple GUI-Based Programs: Windows and Labels, Displaying Images, CommandButtons and Responding to Events, Viewing the Images of Playing Cards, Entry Fields for theInput and Output of Text, and Using Pop-up Dialog Boxes. Case Study: A GUI-Based ATM

Text Books/ Reference Books:

1. Chun, W. (2006) Core python programming. Prentice Hall Professional.
2. Embarak, O. (2018). Data Analysis and Visualization Using Python: Analyze Data to Create Visualizations for BI Systems. Apress.
3. Lambert, K. A. (2011). Fundamentals of Python: First Programs. Cengage Learning.
4. Severance, C. (2013). Python for informatics: Exploring information. Create Space.
5. https://www.w3schools.com/python
6. Learning Python, Mark Lutz, Orielly
7. Python Programming: A Modern Approach, Vamsi Kurama, Pearson
8. VanderPlas, J. (2016). Python data science handbook: Essential tools for working withdata. " O' Reilly Media, Inc.".

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	2	2	2					3	2
CO2	2	3	2	2	2	2	2					3	2
CO3	2	3	1	2	2	3	3					3	2
CO4	2	2	1	2	2	2	3					3	2
CO5	2	2	1	2	2	2	3					3	2

22ADM501 Glimpses of Indian Culture 2 0 1 P/F

Introduction: Love is the substratum of life and spirituality. If love is absent life becomes meaningless. In the present world if love is used as the string to connect the beads of values, life becomes precious, rare and beautiful like a fragrant blossom. Values are not to be learned alone. They have to be imbibed into

the inner sprit and put into practice. This should happen at the right time when you have vitality and strength, when your hearts are open.

The present course in value education is a humble experience-based effort to lead and metamorphosis the students through the process of transformation of their inner self towards achieving the best. Amma's nectarous words of wisdom and acts of love are our guiding principles. Amma's philosophy provides an insightinto the vision of our optimistic future.

1. Invocation, Satsang and Question - Answers
2. Values - What are they? Definition, Guiding Principles with examples Sharing own experiences
3. Values - Key to meaningful life. Values in different contexts
4. Personality - Mind, Soul and Consciousness - Q and A. Body-Mind-Intellect and the Inner psycheExperience sharing
5. Psychological Significance of samskara (with e.g. From Epics)
6. Indian Heritage and Contribution and Q and A; Indian Ethos and Culture
7. Self-Discipline (Evolution and Practice) – Q and A
8. Human Development and Spiritual Growth - Q and A
9. Purpose of Life plus Q and A
10. Cultivating self-development
11. Self effort and Divine Grace - their roles – Q and A; - Vedanta and Creation –Understanding a spiritual Master
12. Dimensions of Spiritual Education; Need for change Lecture – 1; Need for PerfectionLecture - 2
13. How to help others who have achieved less - Man and Nature Q and A, Sharing ofexperiences

REFERENCES:

1. Swami Amritaswaroopananda Puri - Awaken Children (Volume VII and VIII)
2. Swami Amritaswaroopananda Puri - Amma's Heart
3. Swami Ramakrishnanda Puri - Rising Along the Razor's Edge
4. Deepak Chopra - Book 1: Quantum Healing;Book 2: Alpha and Omega of God;Book 3: Seven Spiritual Rules for Success
5. Dr. A. P. J. Abdul Kalam- 1. Ignited Minds 2. Talks (CD)
6. Swami RamakrishnandaPuri - Ultimate Success
7. Swami JnanamritanandaPuri - Upadesamritham (Trans: Malayalam)
8. Vedanta Kesari Publication - Values - Key to a meaningful life
9. Swami Ranganathananda - Eternal values for a changing society
10. David Megginson & Vivien Whitaker - Cultivating Self Development
11. Elizabeth B. Hurlock - Personality Development, Tata McGraw Hill
12. Swami Jagatatmananda - Learn to Live (Vol.1 and 2), RK Ashram, Mylapore

Semester II

24ASD511 **Big Data Analytics and Hadoop** **3 0 2 4**

Course Outcomes:
CO1: Familiarize the concepts of Big Data
CO2: Understanding the aspects of managing, cleaning and sampling of Data
CO3: Understanding Hadoop architecture and implement Map Reduce concept
CO4: Managing and querying No SQL databases
CO5: Understanding and executing HDFS using PIG and HIVE

Unit I: Introduction to Big Data: Types of Digital Data-Characteristics of Data – Evolution of Big Data - Definition of Big Data - Challenges with Big Data - 3Vs of Big Data - Non Definitional traits of Big Data - Business Intelligence vs. Big Data - Data warehouse and Hadoop environment.

Unit II: Big Data Analytics: Classification of analytics - Data Science - Terminologies in Big Data Data science process – roles, stages in data science project – working with data from files — exploring data – managing data – cleaning and sampling for modeling and validation. working with relational databases - NoSQL: Types of Databases – Advantages – NewSQL - SQL vs. NOSQL vs NewSQL.

Unit III: Introduction – distributed file system – Hadoop Components – Architecture – HDFS - algorithms using map reduce, Matrix-Vector Multiplication by Map Reduce – Hadoop - Understanding the Map Reduce architecture - Writing Hadoop Map Reduce Programs - Loading data into HDFS - Executing the Map phase - Shuffling and sorting - Reducing phase execution. Hadoop 2 (YARN): Architecture - Interacting with Hadoop Eco systems.

Unit IV: No SQL databases: Mongo DB: Introduction – Features - Data types - Mongo DB Query language - CRUD operations – Arrays - Functions: Count – Sort – Limit – Skip – Aggregate - Map Reduce. Cursors – Indexes - Mongo Import – Mongo Export. Cassandra: Introduction – Features - Data types – CQLSH - Key spaces - CRUD operations – Collections – Counter – TTL - Alter commands - Import and Export - Querying System tables

Unit V: Hadoop Eco systems: Hive – Architecture - data type - File format – HQL – SerDe - User defined functions - Pig: Features – Anatomy - Pig on Hadoop - Pig Philosophy - Pig Latin overview - Data types - Running pig - Execution modes of Pig - HDFS commands - Relational operators - Eval Functions - Complex data type - Piggy Bank - User defined Functions - Parameter substitution - Diagnostic operator.

Text Books / Reference Books:
1. Seema Acharya, Subhashini Chellappan, “Big Data and Analytics”, Wiley Publication, 2015.
2. Judith Hurwitz, Alan Nugent, Dr. Fern Halper, Marcia Kaufman, “Big Data for Dummies”, John Wiley & Sons, Inc., 2013.
3. Data Science and big data analytics : Discovering, analyzing , visualizing and presentating data, EMC Education Services, John Wiley 2015
4. Tom White, “Hadoop: The Definitive Guide”, O’Reilly Publications, 2011.
5. Kyle Banker, “Mongo DB in Action”, Manning Publications Company, 2012.
6. Russell Bradberry, Eric Blow, “Practical Cassandra A developers Approach“, Pearson Education, 2014.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	2	2	2					2	2
CO2	2	2	2	2	2	2	2					2	2

CO3	2	2	2	2	2	3	2					2	2
CO4	2	2	1	2	2	2	2					1	2
CO5	1	2	1	1	1	2	2					1	2

24ASD512 **Database Management** **3 0 2 4**

Course Outcomes:

CO1: Understand the basics database systems, relational models and database schema
CO2: Gain knowledge about various database design processes and entity relationship models
CO3: To understand the intermediate SQL and advanced SQL queries
CO4: To understand the normal forms, database decomposition and functional dependencies
CO5: To understand Transaction management and concurrency control in DBMS

Unit – I: Introduction to DBMS: Database System Vs File system, Database systems applications,Purpose of database systems - Data models. Relational models: Structure of relational databases – database schema keys – schema diagrams.

Unit – II: Relational Query Languages – fundamental relational algebra operations – additional relational algebra operations.Introduction to SQL – Background – SQL data definition –structure of SQL queries – set operations – null values - aggregate functions – modifications to the database.

Unit – III: Database design - overview of the design process – the entity-relationship model – constraints – entity-relationship diagrams – reduction to relation schemas - Entity-relationshipdesign issues – weak entity sets – extended E-R features.

Unit – IV: Intermediate SQL: Nested subqueries - Join expression – Views – Transactions – integrity constraints – authorization. Advanced SQL – functions and procedures – triggers.

Unit – V: Relational database design – features of good relational designs – atomic domains andnormal forms - 1NF, 2NF, 3NF, 4NF and BCNF – decomposition using functional dependencies - functional dependency theory – Transaction Management – ACID properties of Transactions – Concurrency control.

Text Book / Reference Books:

1) Silberschatz. A., Korth, H. F. and Sudharshan, S. "Database System Concepts", 7thEdition, TMH, 2019.
2) Elmasri, R. and Navathe, S. B. "Fundamentals of Database Systems", 5th Edition,Addison Wesley, 2006
3) Date, C. J. "An Introduction to Database Systems", 8th Edition, Addison Wesley, 2003.
4) Ramakrishnan, R. and Gehrke, J. "Database Management Systems", 3rd Edition,McGrawHill, 2003.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	2	2	2	1					2	1

CO2	2	2	2	2	2	2	1					2	1
CO3	2	2	2	2	2	2	1					2	1
CO4	2	2	1	2	2	1	1					1	1
CO5	1	2	1	1	1	1	1					1	1

24ASD513

Data Mining **3 1 0 4**

Course Outcomes:

CO1: Familiarize data mining basic concepts and understand association rule mining.
CO2: Learn to implement clustering techniques on unsupervised data
CO3: Implementing various approaches for dealing with outliers
CO4: Capable of implementing dimensionality reduction techniques on massive datasets
CO5: Understanding the working process of recommendation systems

Unit – I: Introduction to Data Mining: Introduction, What is Data Mining, Definition, KDD, Challenges, Data Mining Tasks, Data Preprocessing, Data Cleaning, Missing data, Dimensionality Reduction, Feature Subset Selection, Discretization and Binaryzation, Data Transformation; Measures of Similarity and Dissimilarity- Basics.

Unit – II: Association Rules: Problem Definition, Frequent Item Set Generation, The APRIORI Principle, Support and Confidence Measures, Association Rule Generation; APRIOIRI Algorithm. Bayesian Belief Networks and Additional Topics Regarding Classification.

Unit – III: Clustering: Problem Definition, Clustering Overview, Evaluation of Clustering Algorithms, Partitioning Clustering-K-Means Algorithm, K-Means Additional issues, PAM Algorithm; Hierarchical Clustering-Agglomerative Methods and divisive methods, Key Issues in Hierarchical Clustering, Strengths and Weakness.

Unit – IV: Outlier Detection: Outliers and Outlier Analysis -What Are Outliers?, Types of Outliers ,Challenges of Outlier Detection, Outlier Detection Methods, Statistical Approaches, Parametric Methods, Nonparametric Methods, Proximity-Based Approaches, Clustering-Based Approaches, Classification-Based Approaches, Mining Contextual and Collective Outliers.

Unit – V: Dimensionality Reduction: Principal-Component Analysis, Singular-Value Decomposition, and CUR Decomposition. Link Analysis: Page Rank, Efficient Computation of Page Rank, Topic-Sensitive Page Rank, Link Spam, Hubs and Authorities. Recommendation Systems: A Model for Recommendation Systems, Content-Based Recommendations, and the Netflix Challenge.

Text Books/ Reference Books and Websites:

1. Han, J., Pei, J., & Kamber, M. (2011). Data mining: concepts and techniques. Elsevier.
2. Rajaraman, A., & Ullman, J. D. (2011). Mining of massive datasets. Cambridge University Press.
3. https://nptel.ac.in/courses/106/105/106105174/
4. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/110105083/lec52.pdf
5. Ngo, T. (2011). Data mining: practical machine learning tools and technique, by ian h. witten, eibe frank, mark a. hell. ACM SIGSOFT Software Engineering Notes, 36(5), 51-52.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	2	2	2					2	2
CO2	2	2	2	2	2	2	2					2	2
CO3	2	2	2	2	2	3	2					2	2
CO4	2	2	1	2	2	2	2					1	2
CO5	1	2	1	1	1	2	2					1	2

24ASD514 Machine Learning 3 0 2 4

Course Outcomes:

CO1: To be able to formulate machine learning problems corresponding to different applications.

CO2: Exploring and implementing supervised learning through regression and decision tree learning.

CO3: Understand the instance-based learning and classification methods.

CO4: Understand the Ensemble learning methods.

CO5: Exploring and implementing unsupervised learning algorithms.

Unit – I: Introduction: Well-Posed Learning Problems, designing a Learning System, A Concept Learning Task, Concept Learning as Search, Find-S: Finding a Maximally Specific Hypothesis, Version spaces and the Candidate-Elimination algorithm, Inductive Bias. Introduction to types of learning: Supervised learning, Semi-Supervised Learning, Unsupervised learning and Reinforcement Learning.

Unit – II: Classification and Regression: Learning a class from training, linear, Nonlinear, Multi Class and Multi Label classification. Regression: Simple Linear Regression, Multiple linear regression, Logistic Regression. Decision Tree learning: Introduction, Decision tree representation, Appropriate problems for decision tree learning, The basic decision tree learning algorithm, Issues in decision tree learning, classification and regression Trees (CART).

Unit – III: Bayesian Learning: Bayes Theorem and Concept Learning, Maximum Likelihood, Minimum description length principle, Bayes Optimal Classifier, Gibbs Algorithm, Naïve Bayes classifier. Instance-Based Learning: K-Nearest Neighbour Learning, Locally Weighted Regression, Radial Basis Functions, Support Vector Machines: The Margin and Support Vectors, linear and Nonlinear Kernels.

Unit – IV: Ensemble Learning: Ensemble Learning Model Combination Schemes, Maximum Voting, Averaging, Weighted Averaging, Bagging: Random Forest Trees, Boosting: Gradient Boosting, Adaptive Boosting, Extreme Gradient Boosting, XG Boosting and Adaboost, Stacking.

Unit – V: Unsupervised Learning: Clustering: K-means/Kernel K-means. Dimensionality Reduction: PCA and kernel PCA. Matrix Factorization and Matrix Completion. Expectation Maximization, Gaussian Mixture Models, Case Study.

Text Books/ Reference Books:

1. Tom M. Mitchell, Machine Learning, McGraw Hill, 1997.

2. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, Prentice Hall of India, 3rd Edition, 2014.
3. Stephen Marsland, Machine Learning: An Algorithmic Perspective, Taylor & Francis (CRC), 2014.
4. Haroon D, Python Machine Learning Case Studies, Apress, 2017.
5. Harrington, P, Machine learning in action, Manning Publications Co., 2012.
6. Richard O. Duda, Peter E. Hart and David G. Stork, Pattern classification, John Wiley & Sons, 2001.
7. Peter Flach, Machine Learning, Cambridge University Press, 2012.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	3					2	2
CO2	3	3	3	2	2	2	3					2	2
CO3	2	3	3	2	2	3	3					2	2
CO4	2	2	3	2	2	2	3					2	2

24ASD515 Multivariate Statistics and Regression Analysis 3 0 2 4

Course Outcomes:

CO1: To understand the basics of Multivariate Data and Multivariate Normal Distributions.
CO2: To apply Multivariate Techniques for Classification of Distributions
CO3: To understand the concept of PCA and Factor Analysis
CO4: To gain knowledge on Simple Linear Regression, Estimation and testing of Model Parameters
CO5: To gain knowledge on Multiple Linear and Polynomial Regression and Estimation of Model Parameters and testing the significance of regression.

Unit – I: The organization of Data. Descriptive Statistics. Graphical Techniques. Distance. The Multivariate Normal Distribution-Introduction. The Multivariate Normal Density and its Properties. The sampling Distribution of $\bar{X}$ and S.

Unit – II: Classification for two populations, Classification with two Multivariate Normal populations, Fisher's Discriminant Functions for discriminating several population.

Unit – III: Principal Components Analysis, Dimensionality reduction, Factor Analysis- Factor Loadings using Principal Component Analysis.

Unit – IV: Simple Linear Regression- Properties, Least Squares Estimation of parameters, Hypothesis Tests in Simple Linear Regression, Test for Significance of Regression using ANOVA. Coefficient of determination.

Unit – V: Multiple Linear Regression: Estimation of model parameters. Polynomial Regression Models. Test for Significance of Regression using ANOVA. Coefficient of determination.

Text Books/ Reference Books:

1. Richard A. Johnson, Dean W. (2007). Wichern Applied Multivariate Statistical Analysis Sixth Edition. Pearson Prentie Hall.

2. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye. Probability and Statistics for Engineers and Scientists, Eighth Edition, Pearson Education Asia, 2007.
3. Anderson, T. W. (2009): An Introduction to Multivariate Statistical Analysis. Third Edition Wiley.
4. Douglas C. Montgomery and Elizabeth A. Peck and G. Geoffrey Vining 2012. Introduction to Linear Regression Analysis", Fifth Edition, John Wiley& Sons, Inc

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	3	1					3	2
CO2	3	3	3	2	2	3	1					3	1
CO3	3	3	3	2	2	3	1					2	1
CO4	3	2	3	2	2	2	1					2	1
CO5	3	2	3	2	2	2	1					2	1

24ASD516 Statistical Inference and Design of Experiments 3 0 2 4

Course Outcomes:

CO1: To understand the concept of testing of hypothesis of various parameters using single sample and apply to engineering, science, and business problems.
CO2: To understand statistical inference for two samples and apply to engineering, science and business problems.
CO3: To know to apply goodness of fit test and nonparametric tests
CO4: To develop experiments and analyse the variance to conclude on the parameters of the population involved.
CO5: To construct factorial experiments and to use for various real time problems.

Unit – I: Tests of Hypotheses for a Single Sample- Tests of Statistical Hypotheses, One-Sided and Two-Sided Hypotheses, P-Values in Hypothesis Tests, General Procedure for Hypothesis Tests, Tests on the Mean of a Normal Distribution, Variance Known- Tests on the Mean of a Normal Distribution, Variance Unknown- Tests on the Variance and Standard Deviation of a Normal Distribution.

Unit – II: Statistical Inference for Two Samples -Inference on the Difference in Means of Two Normal Distributions, Variances Known- Inference on the Difference in Means of two Normal Distributions, Variances Unknown- Paired t-Test- Inference on the Variances of Two Normal Distributions.

Unit – III: Goodness of Fit Tests –Distribution based Fitting- Categorical Data Analysis - Tests of Independence in Contingency Tables. Nonparametric Procedures -The Sign Test, The Wilcoxon Signed-Rank Test

Unit – IV: Design and Analysis of Single-Factor Experiments: The Analysis of Variance Designing Engineering Experiments, Completely Randomized Single-Factor Experiment, The Random-Effects Model, Randomized Complete Block Design. Latin Square Design.

Unit – V: Design of Experiments with Several Factors-Introduction, Factorial Experiments, Two Factor Factorial Experiments, General Factorial Experiments, 2k Factorial Designs.

Text Books /Reference Books:

1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, (2005) John Wiley and Sons Inc.
2. Sheldon. M. Ross : Probability and Statistics for Engineers and Scientists , MaGrawHill , 2004.
3. Amir D Aczel, Soundarapandian Jayavel, Complete Business statistics, Boston : McGraw-Hill/Irwin, 2009
4. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.
5. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3	3	2	2	2	1					3	2
CO2	3	3	3	2	2	2	1					3	2
CO3	3	3	3	2	2	3	1					3	2
CO4	3	2	3	2	2	2	1					3	2
CO5	3	2	3	1	1	2	1					3	2

Amrita Values Program 1 0 0 1

Amrita University's Amrita Values Program (AVP) is a new initiative to give exposure to students to the richness and beauty of the Indian way of life. India is a country where history, culture, art, aesthetics, cuisine, and nature exhibit more diversity than anywhere else in the world. Amrita Values Programs emphasize making students familiar with the rich tapestry of Indian life, culture, arts, science, and heritage which has historically drawn people from all over the world. Post-graduate students shall have to register for any one of the following courses, in the second semester, which may be offered by the respective school.

Courses offered under the framework of the Amrita Values Program:

22AVP501 Message of Śrī Mātā Amritanandamayi Devi

Amma’s messages can be put into action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks, and the guidance received in matters which we consider trivial are rich in content and touches the veryinner being of our personality. Life gets enriched by Amma’s guidance, and She teaches us theart of exemplary life skills where we become witness to all the happenings around us keepingthe balance of the mind.

22AVP502 Insights from the Ramayana

The historical significance of Ramayana, the first Epic in the world, influence of Ramayana onIndian values and culture, storyline of Ramayana, study of leading characters in Ramayana, influence of Ramayana outside India, misinterpretation of Ramayana by colonial powers and its impact on Indian life, relevance of Ramayana for modern times.

22AVP503 Insights from the Mahabharata

The historical significance of Mahabharata, the largest Epic in the world, influence of Mahabharata on Indian values and culture, storyline of Mahabharata, study of leading characters in Mahabharata, Kurukshetra War

and its significance, importance of Dharma in society, message of the Bhagavad Gita, relevance of Mahabharata for modern times.

22AVP504 Insights from the Upanishads

Introduction: Sruti versus Smrti, overview of the four Vedas and the ten Principal Upanishads,the central problems of the Upanishads, ultimate reality, the nature of Atman, the different modes of consciousness, Sanatana Dharma and its uniqueness, The Upanishads and Indian Culture, relevance of Upanishads for modern times, a few Upanishad Personalities: Nachiketas,Satyakama Jabala, Aruni, Shvetaketu.

22AVP505 Insights from Bhagavad Gita

Introduction to Bhagavad Gita, brief storyline of Mahabharata, context of Kurukshetra War, the anguish of Arjuna, counsel by Sri. Krishna, key teachings of the Bhagavad Gita, Karma Yoga, Jnana Yoga, and Bhakti Yoga, theory of Karma and Reincarnation, concept of Dharma,idea of the self and realization of the self, qualities of a realized person, concept of Avatar, relevance of Mahabharata for modern times.

22AVP506 Message of Swami Vivekananda

Brief sketch of Swami Vivekananda's life, meeting with Guru, disciplining of Narendra, travelacross India, inspiring life incidents, address at the parliament of religions, travel in the UnitedStates and Europe, return and reception India, message to Indians about our duties to the nation.

22AVP507 Great Spiritual Teachers of India

Sri Rama, Sri Krishna, Sri Buddha, Adi Shankaracharya, Sri Ramanujacharya, Sri Madhvacharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri Ramana Maharshi, Mata Amritanandamayi Devi

22AVP508 Indian Arts and Literature:

The aim of this course is to present the rich literature, culture of ancient India, and help studentsappreciate their deep influence on Indian life, Vedic culture, the primary source of Indian culture, brief introduction, and appreciation of a few of the art forms of India, arts, music, dance, theatre, paintings, sculpture and architecture, the wonder language, Sanskrit, and ancientIndian Literature.

22AVP509 Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and AshtangaYoga. The coverage also includes the effect of yoga on integrated personality development.

22AVP510 Appreciation of Kerala's Mural Art Forms:

A mural is any piece of artwork painted or applied directly on a wall, ceiling, or another largepermanent surface. In the contemporary scenario, Mural painting is not restricted to permanentstructures and is being done even on canvas. A distinguishing characteristic of mural paintingis that the architectural elements of the given space are harmoniously incorporated into the picture. Kerala mural paintings are frescos depicting mythology and legends, which are drawnon the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches, and places in Kerala, South India, display an abounding tradition of mural paintingsmostly dating back to the 9th to 12th centuries CE when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objectiveof this course.

22AVP512 Ancient Indian Science and Technology

Science and technology in ancient and medieval India covered all the major branches of humanknowledge and activities, including mathematics, astronomy, physics, chemistry, medical science and surgery, fine arts, mechanical, civil engineering, architecture, shipbuilding, and navigation. Ancient India was a land of sages, saints, and seers as well as a land of scholars and scientists. The course gives awareness of India's contribution to science and technology.

Course Outcomes (CO)

CO1: Relate to the causes of stress in one's life.
CO2: Experiment with a range of relaxation techniques
CO3: Model a meditative approach to work, study, and life.
CO4: Develop appropriate practice of MA-OM technique that is effective in one's life
CO5: Inculcate a higher level of awareness and focus.
CO6: Evaluate the impact of a meditation technique

Unit 1 (4 hours)

Causes of Stress: The problem of not being relaxed. Need for meditation -basics of stress management at home and workplace. Traditions and Culture. Principles of meditation– promote a sense of control and autonomy in the Universal Human Value System. Different stages of Meditation. Various Meditation Models. Various practices of Meditation techniques in different schools of philosophy and Indian Knowledge System.

Unit 2 (4 hours)

Improving work and study performance. Meditation in daily life. Cultivating compassion and good mental health with an attitude of openness and acceptance. Research and Science of Meditation: Significance of practising meditation and perspectives from diverse fields like science, medicine, technology. philosophy, culture, arts, management, sports, economics, healthcare, environment etc. The role of meditation for stress and anxiety reduction in one's life with insights based on recent cutting-edge technology. The effect of practicing meditation for the wholesome wellbeing of an individual.

Unit 3 (4 hours)

Communications: principles of conscious communication. Relationships and empathy: meditative approach in managing and maintaining better relationships in life during the interactions in the world, role of MAOM in developing compassion, empathy and responsibility, instilling interest, and orientation to humanitarian projects as a key to harness intelligence and compassion in youth. Methodologies to evaluate effective awareness and relaxation gained from meditation. Evaluating the global transformation through meditation by instilling human values which leads to service learning and compassion driven research.

Text Books /References Books:

1. Mata Amritanandamayi Devi, "Cultivating Strength and vitality," published by Mata Amritanandamayi Math, Dec 2019
2. Swami Amritaswarupananda Puri ,"The Color of Rainbow " published by MAM, Amritapuri.
3. Craig Groeschel, "Winning the War in Your Mind: Change Your Thinking, Change Your Life" Zondervan Publishers, February 2019
4. R Nagarathna et al, "New Perspectives in Stress Management "Swami Vivekananda Yoga Prakashana publications, Jan 1986
5. Swami Amritaswarupananda Puri "Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation", August 2019
6. Swami Amritaswarupananda Puri "From Amma's Heart - Amma's answer to questions raised during world tours" March 2018
7. Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.
8. Mata Amritanandamayi Devi "Compassion :The only way to Peace:Paris Speech", MA Center, April 2016.
9. Mata Amritanandamayi Devi "Understanding and collaboration between Religions",

MA Center, April 2016.
10. Mata Amritanandamayi Devi "Awakening of Universal Motherhood: Geneva Speech" M A center, April 2016.

CO – PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	3	3	2			2	3		3		3	
CO2	3	3	3	2	2		2	3	3	3		3	
CO3	3	3	2	2	2	2	2	3	3	3		3	
CO4	3	3	3	2		2	3	3	3	3		3	
CO5	3	2	2	2		2		3	2	2		2	
	3	2	2	2	3	2		3	2	2		2	

Semester III

24ASD601 SQC and Reliability Theory 3 0 2 4

Course Outcomes:

CO1: To understand the basic concepts of quality control and to construct variable and attribute control charts.
CO2: To understand and construct EWMA and CUSUM charts, analyse the process capability and Six Sigma quality metrics.
CO3: To gain knowledge about acceptance sampling methods and their properties
CO4: To gain knowledge about reliability and properties
CO5: To study reliability distributions and analyse reliability of systems and maintenance

Unit – I: Basic concept of quality control, process control and product control, Statistical process control, theory of control charts, Shewhart control charts for variables: X-bar, R and s charts – Shewhart control charts for attributes: p, np, c, u charts, modified control charts.

Unit – II: Performance of control charts – operating characteristic (OC) curves and average run lengths (ARL) of control charts, moving average control charts, EWMA charts, CUSUM charts, – two sided and one sided procedures – V – mask technique, process capability analysis, process capability indices – C_p and C_{pk}, Six Sigma quality metrics.

Unit – III: Acceptance sampling plans for attributes, single sampling plans, double sampling plans - performance of the sampling plans- operating characteristic (OC) curves, acceptable quality level – lot tolerance proportion defective (LTPD), average outgoing quality (AQL) and average time for inspection (ATI) –curves based on these characteristics.

Unit – IV: Introduction to Reliability and its needs; Different Approaches to Reliability Analysis, Application Areas, State Variable, Time to Failure, Failure Rate Function, Hazard rate function - Mean Time to Failure, Relationship between the Functions F(t), f'(t), R(t), and z(t), Bath tub curve, Mean time to failure, Residual time.

Unit – V: Parametric families of some common life distributions –Exponential, Weibull and Gamma and its Characterization-Reliability estimation of parameters in these models. Fault Tree Analysis, Reliability Block Diagrams, Systems of Independent Components -System Reliability, Nonrepairable Systems, Quantitative Fault Tree Analysis, Reliability of Maintained Systems -Types of Maintenance, Downtime and Downtime Distributions, System Availability Assessment

Text Books/References Books:

1. Montgomery D. C. (2005) Introduction to Statistical Quality control, 5th edition, Wiley.
2. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.
3. Schilling E. G. (1982) Acceptance Sampling in Quality Control, Marcel Decker.
4. Marvin Rausand and Arnljot Hoyland ,(2003): System Reliability Theory : Models, Statistical methods and applications, 2nd edition, John Wiley and Sons Inc., publications.

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	3	3	2	2	2	2						3	1
CO 2	3	2	2	2	2	2						3	1
CO 3	3	2	2	2	2	3						3	1
CO 4	3	2	1	2	2	2						3	1
CO 5	2	2	2	2	2	2						2	1

24ASD602 Deep Learning 3 0 2 4

Course Outcomes

1. To understand the theoretical foundations, algorithms, and methodologies of Neural Network
2. To design and develop an application using specific deep-learning models
3. To provide practical knowledge in handling and analyzingreal-world applications
4. To select and use the appropriate Optimization techniques for deep learning models

Unit – I: Deep Learning Architectures, Machine Learning and Deep Learning, Representation Learning, Width and Depth of Neural Networks, Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Back Propagation Learning Algorithm, binary and multiclass classification using neural networks, self-organizing maps, Restricted Boltzmann Machines, Auto Encoders, Deep Learning Applications

Unit– II: Convolutional Neural Networks, Architectural Overview, Motivation, Convolutional Layers, Filters, Parameter sharing, Regularization Methods, optimization techniques used in Deep Learning

(Gradient Descent, Stochastic-GD, Batch-SGD, Momentum, NAG, Adagrad, Adadelta, RMSprop, and Adam), Popular CNN Architectures: ResNet, AlexNet – Applications of image processing

Unit – III: Transfer Learning, Transfer learning Techniques, Variants of CNN: DenseNet, PixelNet, ImageNet. Applications of using these learning techniques.

Unit – IV: Auto Encoders, Under complete Autoencoder, Regularized Autoencoder, stochastic Encoders, and Decoders, Contractive Encoders - generative adversarial network (GAN).

Unit – V: Sequence Modelling – Recurrent And Recursive Nets, Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence Architectures - BPTT for training RNN, Long Short Term Memory Networks, Case Studies: Deep Learning for any sequential or time series data applications

Text Books/ Reference Books:

1. Ian Goodfellow, YoshuaBengio and Aaron Courville, " Deep Learning", MIT Press, 2017.
2. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017
3. Umberto Michelucci "Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks" Apress, 2018.
4. Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012.
5. EthemAlpaydin,"Introduction to Machine Learning", MIT Press, Prentice Hall of India, ThirdEdition 2014.
6. Giancarlo Zaccone, Md. RezaulKarim, Ahmed Menshawy "Deep Learning with TensorFlow:Explore neural networks with Python", Packt Publisher, 2017.
7. Antonio Gulli, Sujit Pal "Deep Learning with Keras", Packt Publishers, 2017.
8. Francois Chollet "Deep Learning with Python", Manning Publications, 2017.

CO PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		2		2	3		2			3	
CO2		2	2	1	1		2	2	2	2		2
CO3				3		1		1		3		3
CO4	1	3	1	1	2	2	3		3		2	
CO5	3					3	1	3		1		1

ELECTIVES

24ASD631 **Business Analytics** **2 0 2 3**

Course Outcomes:

CO1: Understanding the Role of Business Analyst and Data Science in business.
CO2: Understanding the basic concept of data management and data mining techniques
CO3: To understand the basic concept of machine learning
CO4: To understand the application of business analysis.

Introduction: What is business analytics? Historical Overview of data analysis, Data Scientist vs. Data Engineer vs. Business Analyst, Career in Business Analytics, What is data science, Why Data Science, Applications for data science, Data Scientists Roles and Responsibility

Data: Data Collection, Data Management, Big Data Management, Organization/sources of data, Importance of data quality, Dealing with missing or incomplete data, Data Visualization, Data Classification Data Science Project Life Cycle: Business Requirement, Data Acquisition, Data Preparation.

Introduction to Data Mining, The origins of Data Mining, Data Mining Tasks, OLAP and Multidimensional data analysis, Basic concept of Association Analysis and Cluster Analysis.

Application of Business Analysis: Retail Analytics, Marketing Analytics, Financial Analytics, Healthcare Analytics, Supply Chain Analytics.

Text Books / Reference Books:

1. Essentials of Business Analytics: An Introduction to the methodology and its application, Bhimasankaram Pochiraju, SridharSeshadri, Springer
2. Introduction to Machine Learning with Python: A Guide for Data Scientists 1st Edition, by Andreas C. Müller, Sarah Guido, O'Reilly
3. Introduction to Data Science, Laura Igual Santi Seguí, Springer
4. Introduction to Data Mining, Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Pearson Education India
5. An Introduction to Business Analytics, Ger Koole, Lulu.com, 2019.

CO-PO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
CO 1	2	2	2	2	2	2	-	-	-	-	1	1	
CO 2	3	3	2	2	2	2	-	-	-	-	1	1	
CO 3	2	2	3	2	2	2	-	-	-	-	1	1	

24ASD632 Categorical Data Analysis 2 0 2 3

Course Outcomes:

CO1: Understand the Categorical Data-nominal and ordinal random variables.
CO2: Understand the two-way contingency tables.
CO3: Understand the three-way contingency tables.
CO4: Understand the basic of Generalized Linear Models

Categorical Data-nominal and ordinal random variables.
Two-way contingency tables: Table structure for two dimensions. Ways of comparing proportions. Measures of associations-odds ratio. Sampling distributions. Goodness-of-fit tests, testing of independence. Exact and large sample inference.

Three-way contingency tables, Partial associations, Cochran-Mantel-Haenszel methods. Conditional association and related inference.
Generalized Linear Models (GLMs): components of a GLM. Logisitc regression models for binary data, inference for logistic regression models, multiple logistic regression with qualitative predictors, exact inference for logistic regression, sample size and power of test.
Loglinear models for two-way and three-way contingency tables, inference for loglinear models, the connection between loglinear-logit regression models. Multicategory logit models for nominal responses, cumulative logit models for ordinal responses.

Text Books / Reference Books:

1. Agresti, A., Categorical Data Analysis, 3rd Edition, Wiley, New York, 2013.
2. Agresti, A., An Introduction to Categorical Data Analysis, 3rd Edition, Wiley, New York, 2019.
3. Andersen, E.B., The Statistical Analysis of Categorical Data, Springer-Verlag, Berlin, 1994.
4. Santner, T.J. and Duffy, D., The Statistical Analysis of Discrete Data, Springer-Verlag, New York, 1989.

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	2	2	2	2	2	2	-	-	-	-	1	1	
CO 2	3	3	2	2	2	2	-	-	-	-	1	1	
CO 3	2	2	3	2	2	2	-	-	-	-	1	1	
CO 4	3	3	3	2	2	2	-	-	-	-	1	1	

24ASD633 Computational Biology 2 0 2 3

Course Outcomes:

CO1: Understand the basics of bioinformatics.
CO2: Gain knowledge about primary and secondary databases for bioinformatics.
CO3: Understand the sequence alignment methods.
CO4: To gain knowledge on UPGMA and other algorithms for maximum parsimony.

Introduction to Bioinformatics - applications of Bioinformatics - challenges and opportunities - introduction to NCBI data model- Various file formats for biological sequences.
Bioinformatics resources – Importance of databases - Biological databases- Primary & Secondary databases.

Sequence alignment methods: Sequence analysis of biological data-Significance of sequence alignment- pairwise sequence alignment methods- Use of scoring matrices and gap penalties in

sequence alignments- PAM and BLOSUM Scoring Matrices. Introduction to Dynamic Programming, Global alignments: Needleman Wunsch Algorithm, Local Alignments: Smith Waterman Algorithm, Gap Penalties.
Multiple sequence alignment methods – Tools and application of multiple sequence alignment. Sequence alignment tools Phylogenetic analysis algorithms: Maximum Parsimony, UPGMA, Transformed Distance, Neighbors-Relation, Neighbor-Joining, jackknife.

Text Books/ References Books

1. Higgins,Des and Willie Taylor: B*ioinformatics: Sequence , Structure and databanks*, Oxford , University Press,2000.
2. Baxenvants, AD., Bioinformatics: *A practical guide to the analysis of genes and protein*s, Third edition, John wiley &
3. Sons ,2005
4. Teresa Attwood*, Introduction To Bioinformatics* ,Pearson Education Singapore Pte Ltd, 2007
5. S.C. Rastogi et al, *Bioinformatics: Methods and Applications*: (Genomics, Proteomics and Drug Discovery) Kindle Edi

CO-PO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
CO 1	2	2	2	2	2	1						2	1
CO 2	2	2	2	2	2	1						2	1
CO 3	2	2	2	2	2	1						2	1
CO 4	2	2	1	2	2	1						2	1

24ASD634 Computer Aided Drug Designing 2 0 2 3

Course Outcomes:

CO1: To understand the basics of molecular modelling.
CO2: To understand the quantitative structure and activity relationship.
CO3: Understand and apply PCA in molecular design.
CO4: To understand important drug databases, designing Lipinski's rule of five.

Introduction to Molecular Modeling: Molecular Modeling and Pharmacoinformatics in Drug Design, Phases of Drug Discovery, Target identification and validation
Protein Structure Prediction and Analysis: Protein Structure prediction methods: Secondary Structure Prediction, Tools for Structure prediction; Protein structural visualization; Structure validation tools; Ramachandran Plot.

QSAR : Quantitative Structure and Activity Relationship - Historical Development of QSAR, Tools and Techniques of QSAR, Molecular Structure Descriptors.

Multivariate Statistical methods in QSAR -Principal Component Analysis (PCA) and Hierarchical Cluster Analysis(HCR). Regression analysis tools - Pincipal Component Regression (PCR), Partial Least Squares (PLS) - Case studies.

High Throughput / Virtual screening- Introduction, Basic Steps, Important Drug Databases, Designing Lipinski's Rule of Five, ADMET screening
Docking Studies- Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking.

Molecular visualization tools: RasMol and Swiss-Pdb Viewer
Molecular docking tools: AutoDock and ArgusLab.

Text Books/ References Books:

1. Leach Andrew R., Valerie J. Gillet, An introduction to Chemoinformatics. Publisher: Kluwer academic , 2003. ISBN: 1402013477.
2. Gasteiger Johann, Handbook of Chemoinformatics: From Data to Knowledge (4 Volumes), 2003. Publisher: Wiley-VCH. ISBN:3527306803.
3. Opera Tudor I,Ed. , Chemoinformatics in drug discovery, Wiley-VCH Verlag,2005.
4. Bunin Barry A. Siesel Brian,Morales Guillermo,Bajorath Jürgen. Chemoinformatics: Theory, Practice, & Products Publisher:New York, Springer. 2006. ISBN: 1402050003.
5. Gasteiger Johann, Engel Thomas. Chemoinformatics: A Textbook. Publisher: WileyVCH; 1st edition. 2003. ISBN: 3527306811.
6. Kenneth M Merz, Jr, Dagmar Ringe, Charles H. Reynolds , Drug design: Structure and ligand based approaches (2010) publisher : Cmabridge University press

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1
CO2	3	3	2	2	2	2	-	-	-	-	1	1
CO3	2	2	3	2	2	2	-	-	-	-	1	1
CO4	3	3	3	2	2	2	-	-	-	-	1	1

24ASD635 Demography and Actuarial Statistics 2 0 2 3

Course Outcomes:

CO1: Understand the basics of content errors and fertility levels.
CO2: Gain knowledge about life table and life annuities.
CO3: Know the importance of life insurance.
CO4: To gain knowledge about contingent functions.

Demographic data – Sources, Coverage and Content errors in demographic data. Measures of fertility period and cohort measures. Use of birth order Statistics and child - Woman ratio. Brass technique to estimate current-fertility levels Estimation of TFR age pattern of fertility. Measures of mortality -

standard death rates, neo-natal, perinatal death rates, maternal and infant mortality rates standardization of mortality rates.

Life table: Basic definitions, probabilities, construction of life tables, life expectancy, Life annuities: calculating annuity premium, interest and survivorship discount unction, guaranteed payments, deferred annuities.

Life insurance: Introduction, calculation of life insurance premiums, types of life insurance, combined benefits, insurances viewed as annuities, Insurance and annuity reserves: General pattern reserves, recursion, detailed analysis of an insurance.

Contingent Functions: Contingent probabilities, assurances. Decrement tables. Pension funds: Capital sums on retirement and death, widow's pensions, benefits dependent on marriage.

Text Books:

1. Ramkumar. R : Technical Demography, Wiley eastern Ltd, New Delhi,1986.
2. Rogers.A : Introduction to Mathematical Demography, Johnwiley,New york,1975
3. Biswas.S. : Stochastic processes in Demography and applications,Wiley eastern limited,1988
4. Atkinson, M.E. and Dickson, D.C.M.: An Introduction to Actuarial Studies, Elgar Publishing,2000
5. Philip, M. et. al : Modern Actuarial Theory and Practice, Chapman and Hall,1999.

CO-PO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
CO 1	2	2	2	2	2	1						2	1
CO 2	2	2	2	2	2	1						2	1
CO 3	2	2	2	2	2	1						2	1
CO 4	2	2	1	2	2	1						2	1

24ASD636 Healthcare Analytics 2 0 2 3

Course Outcomes:

CO1: Understand the basics of healthcare data analytics.
CO2: Gain knowledge about phenotyping algorithms.
CO3: Know the importance of clinical trials and prediction models.
CO4: To gain knowledge pervasive health analysis.

Introduction to Healthcare Data Analytics- Electronic Health Records–Components of EHR- Coding Systems- Benefits of EHR- Barrier to Adopting HER Challenges- Phenotyping Algorithms. Challenges in Healthcare Data Analysis, Acquisition Challenges, Pre-processing, Transformation, Social Media Analytics for Healthcare.

Advanced Data Analytics for Healthcare: Review of clinical trials, Prediction Models. Statistical Prediction Models, Alternative Clinical Prediction Models, Survival Models, Predictive Models for

Integrating Clinical and Genomic Data, Data Analytics for Pervasive Health, Fraud Detection in Healthcare, Pharmaceutical Discoveries and Clinical Decision Support Systems.

Text Books/ References Books:

1. Chandan K. Reddy and Charu C Aggarwal, "*Healthcare data analytics*", Taylor & Francis, 2015
2. Hui Yang and Eva K. Lee, "*Healthcare Analytics: From Data to Knowledge to Healthcare Improvement*, Wiley, 2016.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	1						2	1
CO2	2	2	2	2	2	1						2	1
CO3	2	2	2	2	2	1						2	1
CO4	2	2	1	2	2	1						2	1

24ASD637 Market Analytics 2 0 2 3

Course Outcomes:

CO1: Understand the basics of business analytics.
CO2: Gain knowledge about auto-correlations and time series analysis.
CO3: To understand the linear time series models.
CO4: To gain knowledge about sYule Walker estimation for AR processes.

Business Analytics Basics: Definition of analytics, Evolution of analytics, Need of Analytics, Business analytics vs business analysis, Business intelligence vs Data Science, Data Analyst Vs Business Analyst, Business Analytics at the Strategic Level, Functional Level, Analytical Level, Data Warehouse Level. Market Segmentation Variables, Market Segmentation Types, Marketing Data Landscape, Analyzing the trend of data in Marketing– case studies.

Time series as a discrete parameter stochastic process, Auto - covariance, Auto-correlation functions and their properties. Exploratory time series analysis, Test for trend and seasonality, Exponential and moving average smoothing, forecasting based on smoothing.

Linear time series models: Autoregressive, Moving Average, autoregressive Moving Average models, Autoregressive Integrated Moving Average models. Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes.

Text Books / References Books:

1. GrigsbyGert H.N Laursen and Jesper Thorlund : *Business analytics for managers taking business intelligence beyond reportin*g, second edition 2016.
2. Wayne L. Winston:*Marketing Analytics: Data-Driven Techniques with Microsoft Excel*, Wiley,2014.
3. Mike Grigsby : *Marketing Analytics: A Practical Guide to Improving Consumer Insights Using Data Techniques*, Kogan Page; 2 edition ,2018
4. Mike Anderson, T.W *: The Statistical Analysis of Time Series*, John Wiley, New York, 1971.
5. Kendall, Sir Maurice and Ord, J.K. : *Time Series*, Edward Arnold, London, 1990.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1						2	1
CO2	3	2	2	2	2	1						2	1
CO3	3	2	2	2	2	1						2	1
CO4	3	2	1	2	2	1						2	1

24ASD638 Mining of Massive Datasets 2 0 2 3

Course Outcomes:

CO1: Understand the basics of data mining and its limitations.
CO2: Gain knowledge about data mining streams.
CO3: Understand the clustering techniques for data mining.
CO4: Apply the dimensionality reduction algorithm for social network analysis.

Basics of Data Mining - computational approaches - statistical limits on data mining - MapReduce - Distributed File Systems . MapReduce. Algorithms using MapReduce. Extensions to MapReduce. Mining Data Streams: The Stream Data Model - Sampling Data in a Stream - Filtering Streams. Link analysis, Frequent itemsets, Clustering, Advertising on web, Recommendation system, Mining Social-Network Graphs, Dimensionality Reduction, Large-Scale Machine Learning.

Text Books / References Books

1. Jure Leskovec , Anand Rajaraman, Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2014.
2. Tom White, Hadoop: The Definitive Guide: Storage and Analysis at Internet Scale O'Reilly Media; 4th edition, 2015.

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	2	2	2	2	2	2	-	-	-	-	1	1	
CO 2	3	3	2	2	2	2	-	-	-	-	1	1	
CO 3	2	2	3	2	2	2	-	-	-	-	1	1	
CO 4	3	3	3	2	2	2	-	-	-	-	1	1	

Course Outcomes

CO1: Understand the Indian statistical system.

CO2: Understand the CSO, NSSO and RGO.

CO3: Understand evaluation of performance of family welfare programmes and Statistics related to Industries.

CO4: To gain knowledge economic development.

Introduction to Indian Statistical systems- Role, function and activities of Central Statistical organization and State Agencies. Role of National Sample Survey Organization. General and special data dissemination systems. Scope and Contents of population census of India. statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), Registered General Office and National Statistical Commission.

Population growth in developed and developing countries, Evaluation of performance of family welfare programmes. Statistics related to Industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

Economic development: Growth in per capita income and distributive justice indices of development, human development index. National income estimation- Product approach,income approach and expenditure approach. Measuring inequality in income: Gini Coefficient, Theil's measure; Poverty measurements: Different issues, measures of incidence and intensity; Combined Measures: Indices due to Kakwani, Sen etc.

Text Books:

1. Guide to Official Statistics (CSO) 1999.
2. Principles and Accommodation of National Population Census, UNEDCO
3. CSO (1989)a: National Accounts Statistics- Sources and Methods.
4. Guide to current Indian Official Statistics, Central Statistical Office, GOI, and New Delhi.http://mospi.nic.in/

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	2	2	2	2	2	1						2	1
CO 2	2	2	2	2	2	1						2	1
CO 3	2	2	2	2	2	1						2	1
CO 4	2	2	1	2	2	1						2	1

24ASD640 Parallel and Distributed Systems 3 0 0 3

Course Outcomes:

CO1: Understand the basics of parallel computing models.
CO2: Gain knowledge about task and data parallelism.
CO3: Understand the concepts of inter process communication and internet protocols.
CO4: To gain knowledge the system models.

Introduction – parallelism and goals, parallel computing models – RAM, PRAM , CTA. Reasoning about Performance – Introduction -Basic Concepts - Performance Loss - Parallel Structure - Measuring Performance. Shared memory architecture.

Parallel Programming: Task and Data Parallelism with examples –Comparison Programming with Threads - POSIX Threads- Thread Creation and Destruction. Mutual Exclusion- Synchronization - Safety and Performance Issues – Reduction – threads Inter process communication – internet protocols – multicast communication – MPI. Remote invocation: Remote procedure call – remote method invocation -

System models : physical models, architecture models, operating system support. Distributed file systems – introduction- time and global states – synchronization of physical clocks – coordination and agreements: Mutual exclusion, election, consensus.

Text Books/ References Books:

1. George Coulouris , Jean Dollimore , Tim Kindberg , Gordon Blair: *Distributed Aystems : Concepts and Design* , Fifth Edition , Addison Wiley, 2012.
2. Calvin Lin ,Larry Snyder : *Principles of Parallel Programming*, Pearson, 2009
3. Bertil Schmidt, Jorge Gonzalez-Dominguez, Christian Hundt , Moritz Schlarb, *Parallel Programming: Concepts and Practice* First Edition, Morgan Kaufmann, 2017.
4. Ajay D. Kshemkalyani, Mukesh Singhal , *Distributed Computing: Principles, Algorithms, and Systems*, Cambridge University Press, First edition, 2008.

CO-PO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
CO 1	2	2	2	2	2	2	-	-	-	-	1	1	
CO 2	3	3	2	2	2	2	-	-	-	-	1	1	
CO 3	2	2	3	2	2	2	-	-	-	-	1	1	
CO 4	3	3	3	2	2	2	-	-	-	-	1	1	

24ASD641 PATTERN RECOGNITION 2 0 2 3

Course Outcomes:

CO01: To get an idea about pattern recognition with suitable examples

CO02: To gain knowledge about parametric classification methods using Bayesian decision making approach

CO03: To apply nonparametric techniques such as nearest neighbor, adaptive discriminant functions and decision regions based on minimum squared error

CO04: To gain knowledge about nonmetric methods, classification trees and some resampling methods

CO05: To apply study and apply various clustering methods

Unit – I : Introduction to Pattern Recognition, Introduction – Pattern recognition systems – the design cycle – learning and adaptation – Applications of Pattern recognition – statistical decision theory – Examples on pattern recognition, and image processing and analysis.

Unit – II: Parametric methods of Classification, Introduction – Bayes theorem and Bayesian decision making – classifications based on single and multiple features – conditionally independent features – discrete and continuous features - Gaussian case and general theory - discriminant functions, decision boundaries and decision regions — problems of dimensionality – components analysis and discriminants – Minimum error rate classification – Receiver Operating characteristic curves – Estimation of the composition of populations based on machine learning classification.

Unit – III: Nonparametric methods Classification, Introduction - histograms – density estimation – mixture densities - kernel and window estimators – nearest neighbor classification techniques – rules and distance metrics - single and k-nearest neighbor techniques –adaptive decision boundaries and discriminant functions – minimum squared error discriminant functions.

Unit – IV: Nonmetric methods of classification, Introduction to Nonmetric methods – decision trees and decision regions– CART methods – algorithm-independent machine learning – lack of inherent superiority of any classifier – bias and variance for regression and classification – resampling or estimating statistics – jackknife and bootstrap resampling methods.

Unit – V: Methods of Clustering, Introduction to unsupervised learning and clustering – data description and clustering – criterion functions for clustering – hierarchical clustering – single linkage algorithm, complete linkage algorithm, average linkage algorithm and Ward's algorithm – partitional clustering – Forgy's algorithm - and k-means algorithm.

Text Books/References Books:

1. Richard O. Duda, Peter E. Hart and David G. Stork*, Pattern Classification,* Second Edition, 2003, John Wily & Sons.
2. Earl Gose, Richard Johnsonbaugh and Steve Jost, *Pattern Recognition and Image Analysis,* 2002, Prentice Hall of India.

CO-PO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
CO 1	3	3	2	2	2	1						2	1
CO 2	3	2	2	2	2	1						2	1

CO 3	3	2	2	2	2	1						2	1
CO 4	3	2	1	2	2	1						2	1
CO 5	2	2	2	2	2	1						1	1

24ASD642 Queuing Theory 2 0 2 3

Course outcomes

CO1: Understand basic characteristics of Queueing models.
CO2: Learn basic concepts of Poisson models with single server.
CO3: Understand and apply the queueing modals for various problems.

Queuing Models: Basic characteristics of a Queueing Model – Role of Poisson and Exponential distributions, Stochastic Processes, Markov chains, Poisson Processes, Poisson Queuing Models with single server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, simple numerical problems on (M/M/1): (/FIFO) and (M/M/1): (N/FIFO) Models.

Poisson Queuing Models with multiple server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, simple numerical problems on (M/M/C): (/FIFO), (M/M/C): (N/FIFO) and (M/M/C): (C/FIFO) Models, M/M/G Models.

Text Books / Reference Books

1. Donald Gross&Carl M Harris(1998):Fundamentals of Queuing theory,John Wiley & Sons, Inc
2. Hamdy A.Taha(2006): Operations Research – An Introduction, 8/e , Prentice Hall of India Private Ltd., New Delhi
3. S.D.Sharma (2003)Operations Research , Kedar Nath Ram Nath & Co, Meerut, India
4. Kanthi Swarup, P.K.Gupta and Man Mohan (2004), Operations Research, Sultan Chand & Sons, New Delhi

CO-PO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
CO 1	2	2	2	2	1							1	
CO 2	2	2	2	2	1							1	
CO 3	1	2	1	2	1							1	

24ASD643 Reinforcement Learning 2 0 2 3

Course Outcomes:

CO1: Understand the basics of reinforcement learning. Its elements and limitations.
CO2: Understand the finite Markov decision process.
CO3: Understand the temporal difference learning and its advantages.
CO4: Understand the Sarsa maximization bias and double learning.

Introduction: Reinforcement Learning, Elements of Reinforcement Learning, Limitations and Scope, An Extended Example- Tic-Tac-Toe. Multi-armed Bandits: A k-armed Bandit Problem, Action-value Methods, The 10-armed Testbed, Incremental Implementation, Tracking a Nonstationary Problem, Optimistic Initial Values, Upper-Confidence-Bound Action Selection, Gradient Bandit Algorithms.

Finite Markov Decision Processes: The Agent–Environment Interface, Goals and Rewards, Returns and Episodes, Unified Notation for Episodic and Continuing Tasks, Policies and Value Functions, Optimal Policies and Optimal Value Functions, Optimality and Approximation.

Review of Markov process and Dynamic Programming.

Temporal-Difference Learning: TD Prediction, Advantages of TD Prediction Methods, Optimality of TD, Sarsa: On-policy TD Control, Q-learning: Policy TD Control. Expected Sarsa. Maximization Bias and Double Learning.

Text Books / References Books:

1. Richard S. Sutton and Andrew G. Barto, *Reinforcement Learning:An Introduction*, MIT Press, 2018.
2. Sudharsan Ravichandiran, *Hand-on Reinforcement Learning with Python*, Packt Publications, 2018.
3. Sayon Dutta, *Reinforcement Learning with Tensor Flow: A beginner's guide*, Packt Publications, 2018.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1	
CO2	3	3	2	2	2	2	-	-	-	-	1	1	
CO3	2	2	3	2	2	2	-	-	-	-	1	1	
CO4	3	3	3	2	2	2	-	-	-	-	1	1	

24ASD644 Social Network Analytics 2 0 2 3

Course Outcome:

CO1: Understand the levels of SNA and network measures
CO2: Familiarize with network growth models
CO3: Gain knowledge about different community structures and link prediction models
CO4: Understand cascade behavior in networks
CO5: Predict and recommend in online social networks

Unit – I:

Introduction: Applications, Preliminaries, Three Levels of SNA, Graph Visualization Tools.

Network Measures: Network Basics, Node Centrality, Assortativity, Transitive and Reciprocity, Similarity.

Network Growth Models: Properties of real-world networks, Random network model. Preferential Attachment model, Price's model – Local-world network growth model.

Unit – II:

Link Analysis: Applications, Strong and weak ties – Link analysis and algorithms, Page Rank.

Community Structure in Networks: Applications, Types of Community detection methods, Disjoint community detection, overlapping community detection, local community detection.

Unit – III:

Cascade Behavior and Network Effects: Cascade model – probabilistic cascade – Cascade prediction.

Anomaly Detection in Static Networks: Outlier vs Network-based anomalies, challenges in anomaly detection.

Graph Representation Learning: Machine Learning pipelines, Intuition behind representational learning – benefits – representational learning methods.

Case Study: Analysis of social network datasets, Modeling the spread of COVID 19, Recommendation System.

Text Books/ Reference Books:

1. Social Network Analysis, Tanmoy Chakraborty, Wiley, 2021.
2. Network Science, Albert-Lazzlo Barabasi.
3. Social Network Analysis: Methods and Applications, Stanley Wasserman, Katherine Faus.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1
CO2	3	3	2	2	2	2	-	-	-	-	1	1
CO3	2	2	3	2	2	2	-	-	-	-	1	1
CO4	3	3	3	2	2	2	-	-	-	-	1	1

24ASD645 Special Distribution Functions 2 0 2 3

Course Outcomes:

CO1: To understand the basics of different beta distributions.
CO2: To understand the distribution like Empirical and Erlang.
CO3: Know the importance of inverse Gama distribution and generalized exponential distribution.
CO4: To understand the inverse Gaussian distribution and Lognormal distribution.

Inverted Beta Distribution, Noncentral Beta Distribution, Beta Binomial Distribution, Cauchy Distribution, Noncentral Chi-Squared Distribution, Dirichlet Distribution, Empirical Distribution Function, Erlang Distribution, Error Distribution, Generalized Exponential Distributions, Noncentral F-distribution, Inverted Gamma Distribution, Normal Gamma Distribution, Generalized Gamma Distribution, Inverse Gaussian (Wald) Distribution, Lognormal Distribution, Pareto Distribution, Power Function Distribution, Power Series (Discrete) Distribution, Wishart (Central) Distribution.

Text Books /Reference Books

1. Catherine Forbes, Merran Evens, Nicholas Hastings and Brian Peacock. (2010). S*tatistical Distributions*, Fourth Edition, Wiley & Sons Publication, USA.
2. Karl Bury (1999) : Statistical distributions in Engineering , Cambridge University Press.

3. Thomopoulos, Nick T (2017): Statistical Distributions: Applications and Parameter Estimates, Springer.

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1	2	3	2	2	2	2						2	1
CO 2	2	2	2	2	2	2						2	1
CO 3	2	2	2	2	2	3						2	1
CO 4	2	2	1	2	2	2						2	1

24ASD646 Stochastic Process 3 0 0 3

Course Outcomes:

CO1: To Understand the basic concepts of Stochastic Process and Stationarity and Autocorrelation
CO2: To Understand the concepts of Special Processes
CO3: To Understand the concepts of Ergodicity and Power Spectral Density
CO4: To understand the concepts of Markov Chain and related results

Unit – I: Random processes: General concepts and Definitions - Stationarity in Random Processes – Strict Sense and Wide Sense Stationary Processes - Autocorrelation and Properties.

Unit – II: Special Processes –Poisson points, Poisson and Gaussian Processes and Properties

Unit – III: Spectrum Estimation, Ergodicity, Mean Ergodicity, Correlation Ergodicity, Power Spectrum Density functions –Properties.

Unit – IV: Markov Process and Markov Chain, Transition Probabilities, Chapman Kolmogrov Theorem, Limiting Distributions. Classification of States.

Text Books /Reference Books:

1) J. Ravichandran, "Probability and Random Processes for Engineers", First Edition, IK International, 2015
2) Roy D. Yates and David J. Goodman, "Probability and Stochastic Processes A Friendly Introduction for Electrical and Computer Engineers". Second Edition. John Wiley & Sons.INC.
3) A. Papoulis, and Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes", Fourth Edition, McGraw Hill, 2002.

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2

CO 1	3	3	2	2	2	1						2	1
CO 2	3	2	2	2	2	1						2	1
CO 3	3	2	2	2	2	1						2	1
CO 4	3	2	1	2	2	1						2	1
CO 5	2	2	2	2	2	1						1	1

24ASD647 **Survival Analysis** **2 0 2 3**

Course Outcomes:

CO1: Understand the basics of survival distributions and its applications.
CO2: Understand the censoring schemes and its applications.
CO3: Know the importance of non-parametric methods.
CO4: To gain knowledge competing risk theory.

Survival Analysis: Functions of survival times, survival distributions and their applications Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples.

Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.

Text Books/ References Books

1. Miller,R.G. *Survival analysis*, John Wiley ,1981
2. Collet, D. *Statistical analysis of life time data*,1984
3. Cox, D.R. and Oakes, D.: *Analysis of survival data*, Chapman & Hall, New York,1984
4. Gross, A.J. and Clark, V.A.: *Survival distribution: Reliability applications in the Biomedical sciences*, John Wiley and Sons,1975
5. Elandt-Johnson,R.E. Johnson, N.L. : *Survival models and data analysis*, John Wiley & sons.

CO-PO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
CO 1	2	3	2	2	2	1						1	
CO 2	2	2	2	2	2	1						1	
CO 3	2	2	2	2	2	1						1	

CO 4	2	2	1	2	2	1						1	

24ASD648 **Thinking with Data** **2 0 2 3**

Course Outcomes:
CO1: Understand the Data Classifications and qualifications. Scientific thinking.
CO2: Understand Data quality issues and data quality metrics.
CO3: Understand and apply the Ethics of data science

Data Classifications and qualifications. Scientific thinking. Creative and Logical thinking. Complexities in data. Data quality issues and data quality metrics.
Ethics in data science.

Text Books/ References Books:
1. Longbing Cao, Data Science Thinking, The Next Scientific, Technological and Economic Revolution, Springer, 2018.
2. Max Shron, Thinking with Data, How to Turn Information Into Insights, O'Reilly Media, 2014.
3. Robert Stackowiak, Tracey Kelly, Design Thinking in Software and AI Projects, Apress, 2020.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	2	2	2	-	-	-	-	1	1	
CO2	3	3	2	2	2	2	-	-	-	-	1	1	
CO3	2	2	3	2	2	2	-	-	-	-	1	1	

24ASD649 **Time Series** **2 0 2 3**

Course Outcomes:
CO1: Understand the concept of time series and its components
CO2: Understand the bases of different models of time series analysis including decomposition
CO3: To learn proper model identification and its estimation.
CO4: To learn several ways of identifying the forecasting methods with the least forecasting error.

Unit – I: Simple Descriptive Techniques: time series plots, trend, seasonal effect. Tests for trend and seasonality: estimation and elimination of trend and seasonal components. Exponential and moving average smoothing. Time Series as discrete parameter stochastic process. Stationarity, autocovariance and autocorrelation function and their properties. Partial autocorrelation function.

Unit – II: Probability Models: White noise model, random walk, linear processes, Moving Average (MA), Autoregressive (AR), ARMA and ARIMA, seasonal ARIMA models. Invertibility. ACF and PACF of these processes. Sample ACF and PACF. Model identification.

Unit – III: Model Building: Estimation of mean, autocovariance function and autocorrelation function. Estimation of AR models – Yule-Walker equations, estimation of MA model and ARMA models. Order selection in AR and MA models.

Unit – IV: Forecasting: Forecast mean square error (FMSE), Least squares prediction. BLUP. Box-Jenkins forecasting. Forecasting through exponential smoothing and Holt-Winters smoothing. Residual analysis and diagnostic checking. Nonstationary time series models and their identification.

Text Books/References Books:

1. Box, G.E.P. and Jenkins, G.M. (1976): Time series analysis—Forecasting and Control, Holden-day, San Francisco.
2. Anderson, T.W. (1971): The Statistical Analysis of Time Series, Wiley, N.Y.
3. Montgemory, D.C. and Johnson, L.A. (1977): Forecasting and Time Series Analysis, .
4. Kendall, Sir Maurice and Ord, J.K. (1990): Time Series (Third Edition), Edward Arnold.
5. Brockwell, P.J. and Davis, R.A.: Time Series: Theory and Methods (Second Edition), SpringerVerlag.
6. Fuller, W.A. (1976): Introduction to Statistical Time Series, John Wiley, N.Y.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	2	1					3	2
CO2	3	3	3	2	2	1					3	2
CO3	3	3	3	2	2	1					3	2
CO4	3	2	3	2	2	1					3	2