ST. XAVIER'S COLLEGE, RANCHI

(An Autonomous college under Ranchi University)

NEP FYUGP CURRICULUM

DATA SCIENCE HONOURS

Implemented w.e.f.

Academic Session 2026-27 & onwards

AIMS OF BACHELOR'S DEGREE PROGRAMME IN DATA SCIENCE

The broad aims of the Bachelor's Degree Programme in Data Science are as follows:

1. Traditionally, Data Science has been defined as a body of scientific methods that combines Mathematics, Statistics, Computer Science, and domain expertise to extract actionable insights from raw data originating from diverse fields.
2. The success of the subject, therefore, lies in its application. Perhaps there is no branch of scientific knowledge where Data Science has not left its imprint.
3. To imbibe a strong foundation of Data Science in students.
4. To familiarize students with basic to high-level Data Science tools and concepts.
5. To update students with mathematical and statistical tools that aid in analyzing data.
6. To teach and strengthen students' knowledge of spreadsheets, programming languages, and statistical packages.
7. To promote application-oriented pedagogy by exposing students to real-world data.
8. To make students undertake projects that prepares them for jobs and industry requirements.

PROGRAM LEARNING OUTCOMES

The broad learning outcomes of the Bachelor's Degree Programme in Data Science are:

1. This course exposes students to the beautiful world of Data Science and demonstrates how it affects each and every aspect of our daily life.
2. The course is designed to equip students with all the major concepts of Data Science along with the tools required to implement them.
3. Introduction to computer software helps students in the analysis of data by making optimum use of time and resources.
4. These software tools provide the necessary support and an added advantage while progressing towards professional careers.
5. Exposure to a plethora of real-life data helps in honing students' analytical skills.
6. Having a practical component with every paper invokes the exploratory side of students and fine-tunes their interpretation abilities.
7. Such pedagogy goes a long way in giving students the required impetus and confidence for consultancy, startups, and employment opportunities in the near future.
8. The structure of the course also motivates and helps students pursue careers in related disciplines, especially Computer Science, Financial Statistics, and Actuarial Sciences.

Semester - wise Course Code and Credit Points of Major Courses in Data Science

Semester	Courses		Examination Structure			
	Code	Courses in NEP FYUGP Syllabus of Data Science Session 2026-27 & onwards	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Principles of Data Science	4	25	75	---
	SEC-1	Foundations of Statistics	3	---	75	---
II	MJ-2	Probability Theory	4	25	75	---
	SEC-2	Python Programming	3	---	75	---
III	MJ-3	R Programming and Statistical Modelling	4	25	75	---
	MJ-4	Practical - I	4	---	---	100
	SEC-3	Data Structures	3	---	75	---
IV	MJ-5	IKS in Data Science	4	25	75	---
	MJ-6	Sampling Distributions	4	25	75	---
	MJ-7	Practical - II	4	---	---	100
V	MJ-8	Survey Sampling	4	25	75	---
	MJ-9	Statistical Inference	4	25	75	---
	MJ-10	Database Management System	4	25	75	---
	MJ-11	Practical - III	4	---	---	100
VI	MJ-12	Statistical Quality Control & Reliability	4	25	75	---
	MJ-13	Linear Models & Regression Analysis	4	25	75	---
	MJ-14	Introduction to Machine Learning and Artificial Intelligence	4	25	75	---
	MJ-15	Practical - IV	4	---	---	100
VII	MJ-16	Research Methodology	4	25	75	---
	MJ-17	Multivariate Statistical Analysis	4	25	75	---
	MJ-18	Practical - V	4	---	---	100
	AMJ-1	Data Analytics and Visualization	4	25	75	---
VIII	MJ-19	Business Analytics	4	25	75	---
	MJ-20	Practical - VI	4	---	---	100

	AMJ-2	Object Oriented Programming Using JAVA	4	25	75	---
	AMJ-3	Practical - VII	4	---	---	100

Semester - wise Course Code and Credit Points of Minor Courses in Data Science

Courses		Examination Structure			
Code	**Minor Courses in NEP FYUGP Syllabus of Data Science** Session 2026-27& onwards	**Credits**	**Mid Semester Theory (F.M.)**	**End Semester Theory (F.M.)**	**End Semester Practical/ Viva (F.M.)**
MN - A	Discrete Mathematics	4	25	75	---
MN - B	Reliability & Survival Analysis	4	25	75	---
MN - C	Demography & Vital Statistics	4	15	60	25
MN - D	Linear Algebra & Optimization Techniques	4	15	60	25
MN - E	Applied Regression Analysis	4	15	60	25
MN - F	Times Series Analysis	4	15	60	25
MN - G	Econometrics	4	15	60	25
MN - H	Stochastic Processes & Queuing Theory	4	15	60	25

SEMESTER - I

MAJOR COURSE - MJ 1: PRINCIPLES OF DATA SCIENCE

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Understand the fundamental concepts of data science.
2. Evaluate the data analysis techniques for applications handling large data and demonstrate the data science process.
3. Understand concept of machine learning used in the data science process.
4. Visualize and present the inference using various tools.
5. Learn to think through the ethics surrounding privacy, data sharing.

Course Content:

UNIT I

Data Evolution: Data to Data Science – Understanding data: Introduction – Type of Data, Data Evolution – Data Sources. Preparing and gathering data and knowledge - Philosophies of data science - data all around us: the virtual wilderness - Data wrangling: from capture to domestication - Data science in a big data world - Benefits and uses of data science and big data - facets of data.

UNITII

Digital Data - An Imprint: Introduction to Big Data: - Evolution of Big Data - What is Big Data – Sources of Big Data. Characteristics of Big Data 5 Vs – Big Data - Challenges of Conventional Systems- - – Data Processing Models – Limitation of Conventional Data Processing Approaches – Big Data. Big Data Exploration- The Big data Ecosystem and Data science. Overview of the data science process - retrieving data - Cleansing, integrating, and transforming data.

UNIT III

Machine learning – Modelling Process – Training model – Validating model – Predicting new observations – Supervised learning, Unsupervised learning, Semi - supervised learning. Exploratory data analysis.

UNIT IV

First step in big data- Distributing data storage and processing with frame works - Case study:

Assessing risk when loaning money - Join the No SQL movement - Introduction to No SQL- Case Study. The rise of graph data bases- Introducing connected data and graph databases.

UNITV

Ethics and Data Science- Doing Good Data Science, Data Ownership, The Five Cs, Implementing the Five Cs, Ethics and Security Training, Developing Guiding Principles, Building Ethics into a Data - Driven Culture, Regulation, Building Our Future, Case Study.

Reference Books:

1. Introducing Data Science, Davy Cielen, Arno D. B. Meysman and Mohamed Ali, Manning Publications, 2016.
2. Think Like a Data Scientist, Brian Godsey, Manning Publications, 2017.
3. Ethics and Data Science, Mike Loukides, Hilary Mason and D J Patil, O'Reilly, 1 st edition, 2018.

SKILL ENHANCEMANT COURSE - SEC 1: FOUNDATIONS OF STATISTICS

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Provide basic information about variables in a dataset and to highlight potential relationships between variables.
2. The concept of index numbers will enable students to provide a value useful for comparing magnitudes of aggregates of related variables to each other, and to measure the changes in these magnitudes over time.
3. The concept of index numbers will enable students to provide a value useful for comparing magnitudes of aggregates of related variables to each other, and to measure the changes in these magnitudes over time.
4. Various methods of graphical representation of statistical data.
5. Construct of various index numbers including consumer price index.

Course Content:

UNIT - I

Definition, Importance, scope and limitations of Statistics, concepts of statistical population and sample. Scales of measurement- nominal, ordinal, interval and ratio. Theory of attributes, consistency of data, independence and association of attributes, measures of association.

UNIT - II

Data: quantitative and qualitative, attributes, variables. Primary and Secondary data, Methods of collection of Primary and Secondary data. Presentation of data: tabular and graphical, including histogram and ogives. Measures of Central Tendency: mathematical and positional, their relative merits and demerits Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

UNIT - III

Bivariate data: Definition, scatter diagram, Karl Pearson product moment correlation coefficient and its properties, rank correlation, partial and multiple correlation (3 variables only). Simple linear regression, properties of regression coefficients, principle of least squares and fitting of polynomials & exponential curves.

UNIT - IV

Index Numbers: Definition, construction of index numbers and problems there of for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth - Marshall and Fisher's. Time reversal and factor reversal tests, Chain index numbers, conversion of fixed based to chain based index numbers and vice - versa. Consumer price index numbers.

Reference Books:

1. Gun A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8 th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7 th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3 rd Edn., (Reprint), Tata Mc Graw - Hill Pub. Co. Ltd.
4. Fundamentals of Mathematical Statistics, S. C. Gupta & V.K. Kapoor
5. Fundamentals of Applied Statistics, S. C. Gupta & V.K. Kapoor

SEMESTER II

MAJOR COURSE- MJ 2: PROBABILITY THEORY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Learn the concept of various approaches of probability.
2. Calculate probabilities using probability laws and theoretical results.
3. Understand the concept of random variable and probability distributions.
4. Identify an appropriate probability distribution for a given random variable and use its properties to calculate probabilities.
5. Experience the real life application of the underlying probability distributions.
6. Fit appropriate probability distribution to the data.

Course Content:

UNIT I

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic., laws of addition and multiplication, independence and mutual independence of events, Theorem of total probability, conditional probability, Bayes' theorem and its applications.

UNIT II

Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations with illustrations.

UNIT II

Mathematical Expectation: Expectation of univariate and bivariate random variables and its properties. Conditional expectations.

UNIT IV

Moments and Cumulants, moment generating function, cumulant generating function, characteristic function and probability generating functions and their properties. Uniqueness and inversion theorems (without proof) along with applications.

UNIT V

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, Cauchy, beta and gamma along with their properties and limiting/approximation cases.

Reference Books:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7 th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi
4. Fundamentals of Mathematical Statistics, S. C. Gupta & V.K. Kapoor
5. An Introduction to the Probability and Statistics, V. K. Rohatgi and E. Saleh.

SKILL ENHANCEMANT COURSE - SEC 2: PYTHON PROGRAMMING

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives:

The objective of this course is to provide comprehensive knowledge of python programming paradigms. Course Outcomes: Upon completion of the course the student should be able to

1. To know the basics of algorithmic problem solving

2. To develop Python programs with conditionals and loops.

3. To use Python data structures - lists- tuples- dictionaries.

4.To do input/output with files in Python.

Course Content:

Unit I

Python Introduction- Technical Strength of Python- Introduction to Python Interpreter and program execution- Using Comments- Literals- Constants- Python's Built - in Data types- Numbers (Integers- Floats- Complex Numbers- Real- Sets)- Strings (Slicing- Indexing- Concatenation- other operations on Strings)- Accepting input from Console- printing statements- Simple 'Python' programs.

Unit II

Algorithms- building blocks of algorithms (statements- state- control flow- functions)- notation (pseudo code- flow chart- programming language)- algorithmic problem solving- simple strategies for developing algorithms (iteration- recursion).

Unit III

Assignment statement- expressions- Arithmetic- Relational- Logical- Bitwise operators and their precedence- Conditional statements: if- if - else- if - elif - else; simple programs- Notion of iterative computation and control flow – range function- While Statement- For loop- break statement- Continue Statement- Pass statement- else- assert.

Unit IV

Lists: list operations- list slices- list methods- list loop- mutability- aliasing- cloning lists- list parameters - Slicing- Indexing- Concatenation- other operations on Sequence data type; Tuples: tuple assignment- tuple as return value; Dictionaries: operations and methods; advanced list processing – list comprehension; Examples to include finding the maximum- minimum- mean; linear search on list/tuple of numbers- and counting the frequency of elements in a list using a dictionary.

Reference Books:

1. Python Programming using problem solving Approach by Reema Thareja, Oxford University, Higher Education Oxford University Press; First edition 2017.

2. Y Daniel Liang “Introduction to Programming using Python” Pearson

3. Robert Sedgewick, Kevin Wayne, Robert Dondero, “Introduction to Programming in Python” Pearson.

4.Mrak Litz, “Learning Python”, O’ Reilly.

SEMESTER III

MAJOR COURSE- MJ 3: R PROGRAMMING AND STATISTICAL MODELLING

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. This course is used to provide an introduction to R programming language and environment.
2. The course covers the basics of R for statistical computation, exploratory analysis, and modelling.
3. This course also enables students to understand and develop programs in the R environment.
4. Perform data handling in R.
5. Perform exploratory data analysis using R.
6. Perform statistical modelling using R.

UNIT I

Introduction to R- Installation of R- Getting Started with R interface- Entering Input - Evaluation. R objects- Numbers- Attributes- Creating Vectors - Mixing Objects Explicit Coercion- Matrices- Lists- Missing Values - Data Frames- Names- Reading and Writing Data into R- Introduction to read.table ().

UNIT II

Managing Data Frames with dplyr package- Data Frames- dplyr package- dplyr grammar- Installing dplyr- functions – select - filter - arrange - rename - mutate - group by. Control Structures- Functions and Debugging- If - else- for loops - Nested for loops - while loops- repeat Loops - next break.

UNIT III

Statistical Modelling using R: Diagrammatic and graphical representation. Exploratory data analysis - generating random numbers - fitting of discrete and continuous distributions.

Descriptive statistics in r: Writing an R script to find basic descriptive statistics using summary, str, quartile function on data sets; Writing an R script to find subset of data set by using subset (), aggregate () functions on a dataset.

UNIT IV

Visualizations using R: Finding the data distributions using box and scatterplot; finding the outliers using plot; Plotting the histogram, bar chart and pie chart on sample data.

UNIT V

Correlation using R: Find the correlation matrix; Plot the correlation plot on the data set and visualize giving an overview of relationships among data on iris data; Regression using R: apply regression model techniques to predict the data on given data set. Hypothesis Testing using R: one sample testing, two sample Testing.

Reference Books:

1. W. N. Venables, D. M. Smith, An Introduction to R, R Core Team, 2018.
2. Maria Dolores Ugarte, Ana F. Militino, Alan T. Arnhold. Probability and Statistics with R - 2 nd ed.-CRC Press, 2016.
3. John Verzani, simple R - Using R for Introductory Statistics-2 nd ed. CRC Press-Taylor & Francis Group - 2018.
4. Bharti Motwani - Data Analytics with R-1 sted. – Wiley-2019.
5. R for Data Science, Hadley Wickham and Garrett Gorlemund, O'Reilly
6. Discovering Statistics using R, Andy Field, Sage Publications Ltd.
7. R for Data Science, Hadley Wickham and Garrett Gorlemund, O'Reilly
8. Discovering Statistics using R, Andy Field, Sage Publications

MAJOR COURSE- MJ 4: PRACTICAL -I

Marks: Pr (ESE: 6Hrs) = 100	**Pass Marks: (ESE) = 40**

(Credits: Theory-04)**120 Hours**

Instruction to question Setter for

End Semester Examination (ESE)

There will be one Practical Examination of 3 Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 Marks

Practical record notebook = 15 Marks

Viva – voce = 25 Marks

Practicals:

1. Creating vectors and performing operations on vectors.
2. Creating Matrices and performing operations on matrix.
3. Usage of select - filter - arrange - rename - mutate - group by functions.
4. Programming using control statements.
5. Diagrammatic and graphical representation.
6. Doing exploratory data analysis.
7. Correlation and Regression analysis
8. Generate random numbers from discrete distributions.
9. Generate random numbers from continuous distributions.
10. Fitting of discrete probability distribution.
11. Fitting of continuous probability distribution.
12. Understand and develop Computational Thinking concepts.
13. Describe python programs that appropriately utilize built - in functions and control flow statements.
14. Represent compound data using Python lists- tuples- dictionaries
15. Write a program to implement various operators in python.
16. Write a program to implement various conditional statements in python.
17. Write a program to implement various looping statements in python.
18. Write a program to implement various string operations.
19. Write a program to demonstrate list & related functions in python.
20. Write a program to demonstrate tuple & related functions in python.

21. Write a program to demonstrate Dictionary & related functions in python.
22. Write a program to read and write from a file, and copy a file.
23. Write a program to implement numpy and pandas packages.
24. Apply scaling mechanism by considering the employee data (based on the given data set).
25. Apply at least 3 sampling techniques to get the best data from the population.
26. Demonstrate the missing value imputations. Demonstrate the usage of outlier detection.
27. Apply various data summarization techniques in student data.
28. Demonstrate the techniques to handle the imbalanced data sets.

NOTE:LAB WORK TO BE CARRIED OUT USING PYTHON/R/MS EXCEL .

SKILL ENHANCEMENT COURSE- SEC-3: DATA STRUCTURES

Marks: 75 (ESE: 3Hrs) = 75	Pass Marks: Th (ESE) = 30

(Credits: Theory-03) **45 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Explain the fundamental concepts of data analytics
2. Choose appropriate data analysis techniques for handling large data
3. Develop various machine learning algorithms used in data analytics process
4. Demonstrate the visualization and present the inference using various tools
5. Discuss the ethics surrounding privacy and algorithmic decision - making

UNIT I

Models of Computation; representations of algorithms; performance of algorithms: space and time complexity measures, asymptotics, worst case and average case analyses, lower and upper bounds; Operations on data.

UNIT II

Elementary data structures: linked lists, arrays, matrices, stacks, queues, binary trees, trees, heaps; tree traversals; linear search and binary search; priority queues: lists and heaps; Sorting algorithms; analysis of sorting algorithms; lower bound for sorting.

UNIT III

Search Trees: binary search trees, AVL trees, B-trees; Graphs: representations, depth-first search, breadth-first search, connectivity, shortest paths, matching; Hashing: separate chaining, linear probing, quadratic probing.

UNIT IV

Algorithm design techniques: the greedy method, divide-and-conquer, dynamic programming, backtracking, branch and bound, local search; Priority Queues: heaps, binomial heaps. Numerical algorithms; Complexity classes P, NP, PSPACE; reducibility, NP-hard and NP-complete problems.

Reference readings

1. M. A. Weiss, Data Structures and Algorithm Analysis in C++, 4th Edition, Pearson, 2014.

2. T. H. Cormen, C. F. Leiserson, R. L. Rivest, C. Stein, Introduction to Algorithms, 3rd Edition, MIT Press, Prentice Hall of India, 2009.

3. A. V. Aho, J. Hopcroft, J. D. Ullman, Data Structures and Algorithms, Addison- Wesley, 1983.

4. A. V. Aho, J. Hopcroft, J. D. Ullman, The Design and Analysis of Algorithms, Addison-Wesley, 1974..

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SEMESTER IV

MAJOR COURSE- MJ 5: IKS IN DATA SCIENCE

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

1. To introduce students to the evolution of statistical thinking within the Indian Knowledge System (IKS).
2. To understand the role of statistics in ancient Indian texts, astronomy, architecture, medicine, economics and governance.
3. To explore indigenous methods of data collection, inference, and measurement.
4. To connect traditional statistical wisdom with modern statistical theories and applications.

Course Content:

UNIT I

Introduction to Indian Knowledge System: philosophy, domains, and interdisciplinary nature. Early evidence of statistical thought in Indian civilization (Indus Valley inscriptions, trade records, population counts).

UNIT II

Concept of Ankana (enumeration), Parimana (measurement), Ganita (computation) in Vedic and classical texts. Role of mathematics and Statistics in Sulbasutras and Vedang Jyotisha.

UNIT III

Statistics in ancient Indian texts: enumeration and combinatorics in Pingala's Chandas Shastra (prosody and binary system). Use of probability concepts in games of dice (Aksha Shastra, Mahabharata references).

UNIT IV

Statistical thinking in Kautilya's Arthshastra – census, revenue, estimation, population surveys, and economic planning

UNIT V

Quantification and inference in Ayurveda (Charaka Samhita and Sushruta Samhita): clinical observations, data-based diagnosis.

Reference Books:

1. K.V.Sarma, A History of the Kerala School of Hindu Astronomy.
2. S. Balachandra Rao, Indian Mathematics and Astronomy: Some Landmarks.
3. Debiprasad Chattopadhyaya, History of Science and Technology in Ancient India.
4. Michel Danino, Indian Knowledge Systems.
5. Original passages from Arthashastra, Pingala's Chandas Shastra, Charaka Samhita, and Sulbasutras.

MAJOR COURSE- MJ 6: SAMPLING DISTRIBUTIONS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Determine the probability of an event based on data from a small group within a large population.
2. Establish representative results of small samples of a comparatively larger population.
3. Apply the central limit theorem to calculate approximate probabilities for sample means and sample proportions.
4. Experience the real life application of the underlying distribution of the population, the statistic being considered, the sampling procedure employed and the sample size used.
5. Analytical considerations to be based on sampling distribution of a statistic rather than on the joint probability distribution of all the individual sample values.

Course Content:

UNIT I

Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations. Chebyshev's inequality, W.L.L.N., and their applications, De - Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T. and Liapunov Theorem (without proof).

UNIT II

Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.

UNIT III

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p - value approaches.

UNIT IV

Exact sampling distribution: Definition and derivation of p.d.f. of $\chi 2$ using m.g.f., mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on $\chi 2$ distribution.

UNIT V

Exact sampling distributions: Student's and Fishers t - distribution, Derivation of its p.d.f., mean, variance, moments and limiting form of t distribution. Snedecore's F - distribution: Derivation of

p.d.f., mean, variance and mode. Distribution of 1/F (n 1, n 2). Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence Intervals based on t and F distributions.

Reference Books:

1. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4 th Edn. World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2 nd Edn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics - Principles and Methods, 4 th Edn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3 rd Edn. (Reprint).
6. Tata Mc Graw - Hill Pub. Co. Ltd.
7. Fundamentals of Mathematical Statistics, S. C. Gupta & V.K. Kapoor

MAJOR COURSE- MJ 7: PRACTICAL -II

Marks:Pr (ESE: 3Hrs) = 100	Pass Marks: Pr(ESE) = 40

(Credits: Theory-04) **120 Hours**

Instruction to question Setter for

End Semester Examination (ESE)

There will be one Practical Examination of 3 Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 Marks

Practical record notebook = 15 Marks

Viva – voce = 25 Marks

Practicals:

Practical/Lab to be performed on a computer using R/PYTHON programming:

1. Performance Analysis of Algorithms: Time and Space Complexity
2. Implementation of Basic Data Structures: Arrays, Linked Lists, Stacks, and Queues
3. Matrix Operations and Data Representation Techniques
4. Implementation and Traversal of Binary Trees
5. Linear Search and Binary Search Algorithms
6. Implementation and Analysis of Sorting Algorithms
7. Priority Queues and Heap Data Structures
8. Implementation of Binary Search Trees, AVL Trees, and B-Trees
9. Graph Representation and Traversal using Depth-First Search (DFS) and Breadth-First Search (BFS)
10. Graph Algorithms: Connectivity, Shortest Paths, and Matching
11. Hashing Techniques: Separate Chaining, Linear Probing, and Quadratic Probing
12. Algorithm Design Techniques: Greedy Method, Divide-and-Conquer, Dynamic Programming, Backtracking, Branch and Bound, and Local Search
13. Practicals based on large sample theory
14. Practicals based on exact sampling distributions.

Reference Books

1. M. A. Weiss, Data Structures and Algorithm Analysis in C++, 4th Edition, Pearson, 2014.

2. T. H. Cormen, C. F. Leiserson, R. L. Rivest, C. Stein, Introduction to Algorithms, 3rd Edition, MIT Press, Prentice Hall of India, 2009.

SEMESTER - V

MAJOR COURSE- MJ 8: SURVEY SAMPLING

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Draw valid conclusions about the larger group.
2. Check the characteristics of population in less time through less effort and least cost.

3. Determine the accuracy of research/survey result.
4. Select members from a target population to be in a sample for a sample survey.

Course Content:

UNIT I

Concept of population and sample, complete enumeration versus sampling, sampling and non - sampling errors. Types of sampling: non - probability and probability sampling, basic principle of sample survey.

UNIT II

Simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

UNIT III

Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision, post stratification and its performance. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=nxk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

UNIT IV

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS.

UNIT V

Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation.

Reference Books:

1. Cochran W.G. (1984): Sampling Techniques (3 rd Ed.), Wiley Eastern.
2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C. (1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.

5. Gun A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Fundamentals of Applied Statistics, S. C. Gupta & V.K. Kapoor.

MAJOR COURSE- MJ 9: STATISTICAL INFERENCE

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Estimate the sample to sample variation or uncertainty.

2. Provide estimates of unknown parameters from sample statistics.
3. Make an inference about the population of interest on the basis of a random sample taken from that population.
4. Hypothesize various advanced statistical techniques for modeling and exploring practical situations.

Course Content:

UNIT I

Estimation: Problem of estimation, Properties of a good estimator - unbiasedness, consistency, efficiency and sufficiency.

UNIT II

Factorization theorem. Cramer - Rao inequality and MVB estimators (statement and applications), Minimum variance unbiased estimator (MVUE), Rao - Blackwell theorem, Complete statistic, Lehmann - Scheffe theorems and their applications.

UNIT III

Methods of Estimation: Method of moments, method of maximum likelihood, method of minimum Chi - square, basic idea of Bayes estimators. Properties of maximum likelihood estimators (without proof).

UNIT IV

Testing of hypothesis: Null and alternative hypotheses, simple and composite hypotheses, Type - I and Type - II errors, critical region, level of significance, size and power of a test, best critical region.

UNIT V

Most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).

Reference Books:

1. Gun A.M., Gupta M.K.: Das Gupta. B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2 nd Edn. (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6 th addition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M, Graybill F.A. and Boes D.C, : Introduction to the Theory of Statistics, Mc Graw Hill.
6. Fundamentals of Mathematical Statistics, S. C. Gupta & V.K. Kapoor
7. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4 th Edition. Marcel Dekker, CRC.

MAJOR COURSE- MJ 10: DATABASE MANAGEMENT SYSTEM

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

To learn the fundamentals of data models and to conceptualize and depict a database system using ER diagrams, to improve database designing by normalization techniques, to implement the design of the tables in DBMS, to construct queries to get optimized outputs, NOSQL. Course Outcomes: Upon completion of the course the student should be able to

1. Apply the fundamental concepts of databases and Entity - Relationship (E - R) model.

2. Apply query processing techniques to automate the real-time problems of database.
3. Compare and contrast different file organization concepts and applying the transaction management principles on Relational databases.

Course Content:

UNIT I

Introduction & DBMS Architecture

Introduction- Data- Database- Database management system- Characteristics of the database approach - Role of Database administrators- Role of Database Designers - End Users - Advantages and limitations of Using a DBMS and When not to use a DBMS. DBMS Architecture – Data Models – Categories of Data models - Schemas - Instance and Database states- DBMS Architecture and Data Independence – The Three schema architecture- Data Independence- DBMS language and interface - Classifications of Database Management Systems.

UNIT II

Data Modelling Using Entity - Relationship Model

Using high level conceptual Data models for Database Design- Example Database Applications. Entity types- Entity Sets- Attributes and Keys. Relationships- Relationship types- Roles and Structural constraints. Weak Entity Types and Drawing E- R Diagrams- SQL: DDL- DML- DCL TCL.

UNIT III

Database Design

Functional dependencies and Normalization for Relational Databases - Normalization on concepts- first, second, third normal forms - BCNF. PL/SQL: Basics - procedures- functions- triggers.

UNIT IV

Transaction Processing Concepts and Concurrency Control

Transaction and System concepts – Desirable properties of Transactions – Schedules and Recoverability. Lock - Based Protocols – Locks - Granting of Locks and Two- phase locking protocol.

UNIT V

Database Connectivity and No SQL

Introduction and implementation of database connectivity - Introduction to No SQL -Advantages and disadvantages - Types.

Reference Books:

1. E. Ramez and N. Shamkant, Fundamentals of Database Systems- Addison- Wesley, 7 th Ed.- 2016. 2. J. R. Groff and P. N. Weinberg, SQL: The Complete Reference- 3 rd Edition- 2009.

2. A. Silberschatz, H. F. Korth, S. Sudarshan- Database System Concepts- 6 Ed.- Mc Graw Hill- 2011.

3. O. Patrick and, and O. Elizabeth- Database Principles, Programming and Performance- 2 nd Ed.- Margon Kaufmann Publishers Inc.- 2008.

4. R. Ramakrishnan- Database Management System- Tata Mc Graw - Hill Publishing Comp.- 2003.

5. Elmasri, R., &Navathe, S. (2010). Fundamentals of database systems. Addison - Wesley Publishing Company.

6. Silberschatz, A., Korth, H. F. &Sudarshan, S. Database System Concepts, 6 th Edition. Mc Graw Hill.

7. Date, C. (2012). Database Design and Relational Theory: Normal Forms and All That Jazz. O'Reilly Media, Inc.

MAJOR COURSE- MJ 11: PRACTICAL - III

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to question Setter for

End Semester Examination (ESE)

There will be one Practical Examination of 3 Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 Marks

Practical record notebook = 15 Marks

Viva – voce = 25 Marks

List of Programs:

1. Draw E - R diagram and convert entities and relationships to a relation table for a given scenario. a. Two assignments shall be carried out i.e. consider two different scenarios (eg. bank, college).

2. Design a database schema for the two different scenarios.

3. Design and Develop My SQL DDL statements which demonstrate the use of SQL objects such as Table, View, Index, Sequence.

4. Write My SQL queries using logical operations and operators.

5. Design My SQL queries for suitable database applications using DML statements: Insert, Select, Update, Delete with operators, functions, and set operators.

6. Design My SQL queries for suitable database application using DML statements: all types of Join, Sub - Query.

7. Create three related tables and perform the following:

Simple Queries, Simple Queries with Aggregate functions, Queries with group by and having clause, Queries involving-

Date Functions, String Functions, Math Functions.

8. Write a PL/SQL block to calculate the grade of minimum 10 students.

9. Write a PL/SQL block to implement application - based commands.

10. Write a PL/SQL block to implement trigger.

SEMESTER - VI

MAJOR COURSE- MJ 12: STATISTICAL QUALITY CONTROL & RELIABILITY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Understand the meaning of quality.
2. Understand the control of a process.
3. Statistical process control tools - control charts for variable, attributes.
4. Understand about the capability of a process.
5. Statistical product control tools - sampling inspection plans.

6. Know about the Organizational structure of Six sigma.

Course Content:

UNIT I

Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub - grouping.

UNIT II

Control charts for variables: X - bar & R - chart, X - bar & s - chart. Control charts for attributes: np - chart, p - chart, c - chart and u - chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.

UNIT III

Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

UNIT IV

Introduction to Six - Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans- Selection Criteria for Six - Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection. Critical to Quality (CTQ).Introduction to DMAIC using one case study: Define Phase, Measure Phase, Analyse Phase, Improve Phase and Control Phase.

UNIT V

Reliability: Different types and modes of failure, causes of failure in electronic components, reliability theory, hazard rate, failure density function, availability, maintainability, mean time to failure and repair system structures: series, parallel, K - type, Fault tree analysis.

Reference Books:

1. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6 th Edition, Wiley India Pvt. Ltd.

2. Gun A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8 th Edn. The World Press, Kolkata.
3. Mukhopadhyay, P (2011): Applied Statistics, 2 nd edition revised reprint, Books and Allied (P) Ltd.
4. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3 rd Edition reprint, Wiley India Pvt. Ltd.
5. Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2 nd Edition, St. Lucie Press.
6. Hoyle, David (1995): ISO Quality Systems Handbook, 2 nd Edition, Butterworth Heinemann Publication.
7. Fundamentals of Applied Statistics, S. C. Gupta & V.K. Kapoor

MAJOR COURSE- MJ 13: LINEAR MODELS & REGRESSION ANALYSIS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Develop a deeper understanding of the linear regression model.
2. Define the explanatory variable as the independent variable (predictor), and the response variable as the dependent variable (predicted).
3. When describing the association between two numerical variables, evaluate
    a. direction: positive (x ↑, y ↑), negative (x ↓, y ↑)
    b. form: linear or not
    c. strength: determined by the scatter around the underlying relationship.
4. Define correlation as the linear association between two numerical variables.
5. Define the least squares line as the line that minimizes the sum of the squared residuals, and list conditions necessary for fitting such line: (1) linearity, (2) nearly normal residuals, (3) constant variability.
6. Plot the explanatory variable (x) on the x - axis and the response variable (y) on the y - axis, and fit a linear regression model
7. $y = \beta 0 + \beta 1\ x$
8. where, β0 is the intercept and β1 is the slope.
9. Note that the point estimates (estimated from observed data) for β0 and β1 are b 0 and b 1, respectively.

Course Content:

UNIT I

Gauss - Markov set - up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss - Markov theorem, Estimation of error variance.

UNIT II

Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models, Concept of model matrix and its use in estimation.

UNIT III

Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one - way classified data for fixed effect models,

UNIT IV

Analysis of variance and covariance in two way classified data with one observation per cell for fixed effect models.

UNIT V

Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile - quantile plots.

Reference Books:

1. Weisberg, S. (2005). Applied Linear Regression (Third edition). Wiley.
2. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.
4. Fundamentals of Applied Statistics, S. C. Gupta & V.K. Kapoor
5. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4 th Edition, Mc Graw Hill Companies.
6. Johnston, J. (1972): Econometric Methods, 2 nd Edition, Mc Graw Hill International.
7. Koutsoyiannis, A. (2004): Theory of Econometrics, 2 nd Edition, Palgrave Macmillan Limited.
8. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4 th Edition, John Wiley & Sons.

MAJOR COURSE- MJ 14: INTRODUCTION TO MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Describe Machine Learning fundamentals and various models of Machine Learning.
2. Demonstrate various ML techniques of Supervised and Unsupervised learning algorithms.
3. Applicability of various techniques of Artificial Intelligence Strategies.

The main objective of this course is to provide fundamental knowledge of Machine Learning Algorithms and Artificial Intelligence. On successful completion of the course- students will acquire fundamental knowledge of Machine Learning Algorithms such as Supervised- Unsupervised- Ensemble learning along with AI strategies.

Course Content:

UNIT I

Introduction to Machine Learning, AI, ML and Data Science, Training and Testing- Algorithm and Model, ML importance and techniques, Various Application areas of ML, Inferential and Descriptive models with example implementations, performance tuning techniques in the model fit.

UNIT II

Supervised Learning approach- Characteristics of Supervised learning- K - fold cross validation - Classification Techniques: KNN- Naive Bayes- Support Vector Machine and Logistic Regression- Regression Techniques: Simple Linear Regression- Multiple Linear Regression- Lasso- Ridge and Elastic Net Regression- Types.

UNIT III

Unsupervised Learning approach- characteristics of unsupervised learning- Apriori Algorithm- Association Rule generation- Dimensionality Reduction with Principal Component Analysis- Various Clustering Methods - K-means- Hierarchical Regularization and Penalization techniques.

UNIT IV

Introduction to Artificial Intelligence, Background and Applications, Turing Test and Rational Agent approaches to AI, Problems, Problem Spaces, Search: State space search – Production Systems – Problem Characteristics – Issues in design of Search.

UNIT V

Problem Characteristics, Production Systems, Control Strategies, Breadth First Search, Depth First Search, Hill climbing and its Variations, Heuristics Search Techniques: Best First Search, Constraint Satisfaction Problem, Means - End Analysis.

Reference Books

1. O. Theobald- Machine Learning for Absolute Beginners: A Plain English Introduction- Scatterplot Press- 2 nd Ed.- 2017.

2. J. D. Kelleher- Fundamentals of Machine Learning for Predictive Data Analytics- MIT Press- 2020.

3. Elaine Rich and Kelvin Knight, Artificial Intelligence, TMH, 2 nd Edition, 2018.

4. DAN.W. Patterson, Introduction to A.I and Expert Systems – PHI, 2007.

5. M. J. Paul -Machine Learning (in Python and R) For Dummies- Wiley India Pvt.Ltd- 1 st Edition.

6. P. Flach- Machine Learning: The Art and Science of Algorithms that Make Sense of Data- Cambridge University Press- 1 st Ed.-2012.

7. E. Rich and K. Knight- Artificial Intelligence-3 rd Ed.- New York: TMH- 2019.

MAJOR COURSE- MJ 15: PRACTICAL - IV

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to question Setter for

End Semester Examination (ESE)

There will be one Practical Examination of 3 Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 Marks

Practical record notebook = 15 Marks

Viva – voce = 25 Marks

List of Practicals:

1. Demonstrate the descriptions observed from the given data set.
2. Implement K - Nearest Neighbour implementation.
3. Demonstrate the implementation of Naive Bayes technique.
4. Apply the linear and multiple regression and justify the results.
5. Apply the logistic regression and justify the results.
6. Implement K - Means clustering algorithm.
7. Implement hierarchical clustering algorithm.
8. Demonstrate the usage of BFS search strategy in AI.
9. Demonstrate the usage of DFS search strategy in AI.
10. Apply the A* algorithm on a data set and justify the results.
11. Apply AO* algorithm on a data set and justify the results.
12. Implement the principal component analysis.
13. Implement the decision tree algorithm.
14. Demonstrate the usage of Random Forest and justify results.

Reference Books

1. O. Theobald- Machine Learning for Absolute Beginners: A Plain English Introduction- Scatterplot Press- 2 nd Ed.- 2017.

2. J. D. Kelleher- Fundamentals of Machine Learning for Predictive Data Analytics- MIT Press- 2020.

3. Elaine Rich and Kelvin Knight, Artificial Intelligence, TMH, 2 nd Edition, 2018.

4. DAN.W. Patterson, Introduction to A.I and Expert Systems – PHI, 2007.

5. M. J. Paul -Machine Learning (in Python and R) For Dummies- Wiley India Pvt. Ltd- 1 st Edition.

6. P. Flach- Machine Learning: The Art and Science of Algorithms that Make Sense of Data- Cambridge University Press- 1 st Ed.- 2012.

7. E. Rich and K. Knight- Artificial Intelligence- 3 rd Ed.- New York: TMH- 2019.

SEMESTER - VII

MAJOR COURSE- MJ 16: RESEARCH METHODOLOGY

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Understand the fundamentals of research and its methodologies.
2. Formulate research problems and hypotheses.
3. Design appropriate research strategies.
4. Understand methods of data collection and sampling.
5. Analyze data using statistical tools.
6. Interpret and communicate research findings effectively.
7. Prepare structured research reports and project proposals

Course Content

UNIT I

Meaning and objectives of research, Types of research: basic, applied, quantitative, qualitative, Scientific method and research process, Role of statistics in research Identifying and defining research problems, Review of literature, Research questions and objectives, Formulation of hypotheses, Types of hypotheses: null and alternative

UNIT II

Concepts of research design, features of a good design, Types of research design: exploratory, descriptive, experimental, cross - sectional, longitudinal. Control, randomization, replication

UNIT III

Types of data: primary vs secondary, qualitative vs quantitative, Data collection tools: questionnaires, interviews, observation. Construction of questionnaires and schedules. Scaling techniques: nominal, ordinal, interval, and ratio. Reliability and validity

UNIT IV

Editing, coding, tabulation. Descriptive statistics: tables, charts, measures of central tendency and dispersion. Inferential statistics: estimation, testing of hypotheses. Use of software (e.g., Excel, R, SPSS) in data analysis

UNIT V

Interpretation of results, Structure of a research report, Referencing styles: APA/MLA, Common errors in report writing, Use of LaTeX or Word for writing research reports.

Reference Books:

1. R. Kothari & Gaurav Garg, Research Methodology: Methods and Techniques

2. Ranjit Kumar, Research Methodology: A Step - by - Step Guide for Beginners
3. Panneerselvam R., Research Methodology

MAJOR COURSE- MJ 17: MULTIVARIATE STATISTICAL ANALYSIS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) 60 Hours

Course Objectives & Learning Outcomes:

This course will enable the students to:

4. The understanding of basic concepts associated with Multivariate Normal Distributions and their properties with special emphasis on Bivariate Normal Distribution.
5. Analyzing Multivariate data using data reduction techniques like Principal Component Analysis, Factor Analysis.
6. Classification method namely Discriminant Analysis.
7. Analyzing Multivariate data using data reduction techniques like Principal Component Analysis, Factor Analysis.
8. Classification method namely Discriminant Analysis.
9. Understand about fundamentals concepts of stochastic processes and Use notions of long - time behaviour including transience, recurrence and equilibrium in applied situations.
10. Testing of hypothesis using Non - Parametric test like Median test, Run test, Kruskal Wallis test etc.

Course Content:

UNIT I

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.

UNIT II

Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.

UNIT III

Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance- covariance matrix. Multiple and partial correlation coefficient and their properties.

UNIT IV

Applications of Multivariate Analysis: Discriminant Analysis, Principal Components Analysis and Factor Analysis. MANOVA.

UNIT V

Non - parametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function. Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon - Mann - Whitney test, Kruskal - Wallis test.

Reference Books:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3 rd Edn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972): Multivariate Analysis, 1 st Edn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6 th Edn., Pearson & Prentice Hall
5. Mukhopadhyay, P.: Mathematical Statistics.
6. Gun A.M., Gupta M.K.: Das Gupta. B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
7. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2 nd Edn. (Reprint) John Wiley and Sons.

MAJOR COURSE- MJ 18: PRACTICAL V

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to question Setter for

End Semester Examination (ESE)

There will be one Practical Examination of 3 Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 Marks

Practical record notebook = 15 Marks

Viva – voce = 25 Marks

List of Practicals:

1. Basic data manipulation operations.
2. Write a program to Implement inferential analytics.
3. Create Vectors and operations on them.
4. Create Lists and perform Operations on them.
5. Create Arrays and perform operations on them.
6. Create 2-D Arrays and perform operations on matrices.
7. Create Data Frames and perform operations on them.
8. Demonstrate the usage of various charts in the visualization.
9. Create Dual Axis Map Charts.
10. Visual Analytics – Grouping, Sorting, Tool Tips, Hierarchies, Clustering.
11. Forecasting and Trend Lines.
12. Joining Multiple Datasets with different Join Types and preparing appropriate charts.
13. Enhancing Views with Filters, Groups.
14. Prepare a Story comprising of multiple Dashboards and Convey an appropriate story based on the give dataset.

* preferred tools are R/python/Tableau

ADVANCED MAJOR COURSE- AMJ 1: DATA ANALYTICS AND VISUALIZATION

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1: Describe Data Analytics fundamentals and Business Intelligence.

2: Demonstrate the usage of data warehousing- mining and importance in analytics.

3: Applicability of various exploratory data visualization techniques and various interactive methods.

UNIT I

Wholeness of the data

Analytics- important of analytics - Business Intelligence- Pattern Recognition- Data Processing Chain- Business Intelligence Concepts and Applications- BI for Better Decisions- BI Tools- BI Skills- BI Applications- Data Analytics Life Cycle- R- Features of R.

UNIT II

Sources of Analytics

Data warehousing Architecture- Data Sources- ETL process- Data warehouse Best practices- gathering and selecting the data- data cleansing and preparation- data mining best practices- Types of charts- tips for data visualization.

UNIT III

Exploratory data Analysis

Descriptive Analytics- Prescriptive analytics and Predictive Analytics- Feature Selection- Feature Scaling and Normalization techniques- Confusion Matrix- Area Under Curve- Receiver operating characteristic Curve- Statistical methods for Evaluation- Correlation and Regression.

UNIT IV

Introduction to Data Visualization

Definition – Methodology – Seven Stages of Data Visualization - Data Visualization Tools. Visualizing Data: Mapping Data onto Aesthetics – Visualizing Amounts - Visualizing Distributions: Histograms and Density Plots – Visualizing Propositions: – Visualizing

Associations: Among Two or More Quantitative Variables – Visualizing Time Series and Other Functions of an Independent Variable – Trends – Visualizing Geospatial Data.

UNIT V

Visualization with Tableau Tableau Software Ecosystem, Toolbar Icons, Data Window and Aggregation, Connect to Data, Sorting Data, Measure Names, Number of Records & Measures, Cross - tabulation, Heat Maps, Tree maps, Bar Chart, Line Chart, Pie Chart, Scatter Plot, Histogram, Boxplot.

Reference Books:

1. A. Maheshwari- Data Analytics made Accessible - Seattle: Amazon Digital Services- 2015.

2. EMC Education Services- Data Science and Big Data Analytics: Discovering- Analyzing- Visualizing and Presenting Data- Wiley- 2015.

3. Ben Fry, “Visualizing Data: Exploring and Explaining Data with the Processing Environment”, O'Reilly, 1 st Edition, 2008.

4. Dan Murray, Christian Chabot, ” Tableau Your Data!: Fast and Easy Visual Analysis with Tableau Software”, Wiley 2013.

5. V Granville- Developing Analytic Talent: Becoming a Data Scientist- John Wiley & Sons- 2014.

SEMESTER -- VIII

MAJOR COURSE- MJ 19: BUSINESS ANALYTICS

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Can use Prediction and interpretation by using a data set.
2. Effectively use and interpret the results from Statistical Learning and Machine Learning.
3. Adopt the appropriate Predictive Modelling Process.

Course Content:

UNIT -I: Introduction, Prediction Versus Interpretation, Key Ingredients of Predicting Models. Statistical Learning, Supervised Versus Unsupervised Learning, Regression Versus Classification Problem, Machine Learning, Statistical Methodology and Data Mining Methodology, Cross-Validation, Overfitting, Bias-Variance Trade -off, Balancing the Training Data Set.

UNIT -II: Predictive Modelling Process, Pre-process the Data Cleaning, Handling Missing Data, Identifying Misclassification, Graphical Methods for Identifying Outliers.

UNIT III Measure of Central and Spread, Data Transformation, Min-Max Normalization, Z-Score Standardization, Decimal Scaling, Transformation to Achieve Normality, Numerical Methods for Identifying Outliers.

UNIT-IV: Dimension – Reduction in Data Mining, Process of applying Principal Components Analysis, Profiling the Principal Components, Validation of the Principal Components, Application of Factor Analysis.

UNIT -V: Classification Models: Measuring Performance in Classification Models, Discriminant Analysis. Decision Trees -Requirements for using Decision Trees CART Algorithms.

Reference Books:

1. Bishop, C. (2010). Pattern Recognition and Machine Learning Springer.

2. Harrington, P. (2012). Machine Learning in Action. Dreamtech Press.
3. Hastie, T.,Tibshirani, R., and Friedman,.I.(2008). The Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer, Second Edition.

MAJOR COURSE- MJ 20: PRACTICAL – VI

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

List of Practicals:

1. Problem based on Statistical Learning and Supervised Versus Unsupervised Learning.
2. Problem based on Regression Versus Classification Problem.
3. Problem based on over fitting, Bias – Variance Trade -off, Balancing the Training Data Set.
4. Problem based on Predictive Modelling.
5. Problem based on Dimension – Reduction in Data Mining.
6. Problem based on Principal Component Analysis and Factor Analysis.
7. Problem based on Classification and Regression Trees.

Note:
1. MS Excel/ or Any Statistical Software and Computer System may be provided by the Institution.
2. However, Use of Smartphone or Wed is restricted in the Examination

Reference Books:

1. Bishop, C. (2010). Pattern Recognition and Machine Learning Springer.
2. Harrington, P. (2012). Machine Learning in Action. Dreamtech Press.
3. Hastie, T.,Tibshirani, R., and Friedman,.I.(2008). The Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer, Second Edition.

ADVANCED MAJOR COURSE- AMJ 2: OBJECT ORIENTED PROGRAMMING USING JAVA

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

• This course teaches students how to develop java applications. Course gives an overview of the difference between C++ and Java. Students will be developing and testing java applications as a practical course work.

• The course introduces the concept of UI design in java using SWING.

• Demonstrate their ability to understand the concepts of Object - oriented programming and will model the real - world applications using Object Oriented Programming concepts.

• Apply the concept of Multithreading in concurrent programming.

• Able to design GUI applications using SWING and Event Handling.

UNIT I

Java Fundamentals: Object oriented programming concepts – Benefits of OOPS - The origins of java - java's lineage C and C++ - how java impacted the internet - java bytecode - a first simple program - the java keywords - identifiers in java - the java class libraries. Introducing data types and operators Why data types are important - java's primitive types - literals - a closer look at variables - the scope and lifetime of variables - operators - type conversion in assignments - casting incompatible types - operator precedence -expressions. Program control statements Input characters from the keyboard - if statement - switch statement - for loop - the enhanced for loop - the while loop - the do - while loop – break – continue - nested loops.

UNIT II

One dimensional array - multidimensional arrays - irregular arrays - alternative array declaration syntax - assigning array references - using the length member- the for each style for loop – command line arguments. Class fundamentals - how objects are created - reference variables and assignment - methods returning a value - using parameters - constructors - parameterized constructors - the new operator revisited - garbage collection - this keyword - controlling access

to class members - method overloading -overloading constructors - understanding static - introducing nested and inner classes

UNIT III

Inheritance basic - member access and inheritance - constructors and inheritance - using super to call superclass constructors - using super to access superclass members - creating a multilevel hierarchy - superclass references and subclass objects - method overriding - using abstract classes -using final - the object class. Strings Constructing strings - operating on strings - arrays of strings - strings are immutable - using a string to control a switch statement - different string handling functions. Exception handling The exception hierarchy - exception handling fundamentals - the consequences of an uncaught exception - using multiple catch statements - catching subclass exceptions - try blocks can be nested - throwing an exception - using finally -using throws - java's built in exceptions - creating exception subclasses.

UNIT IV

Packages - packages and member access - understanding protected members -importing packages - Interfaces - implementing interfaces - using interface references - variables in interfaces - interfaces can be extended - default interface methods - use static methods in an interface.

Java's I/O is built upon streams - byte streams and character streams - the byte stream classes - the character stream classes - the predefined streams using the byte streams - reading and writing files using byte streams - reading and writing binary data, using java's character - based streams - file I/O using character streams.

UNIT V

Introducing swing - the origins and design philosophy of swing - components and containers - layout managers - swing event handling - use of JButton -work with JText Field - create a JCheck Box - work with JList. Self Study Advanced SWING components.

Reference Books:

1. S. Herbert- Java: The Complete Reference- Tata Mc Graw- Hill- 10 th Ed.-2017.

2. Dr.Rao - Nageswara -Core Java - An Integrated Approach -New Edition Kongent Solutions Inc.- 2009.

3. S. Herbert- Java ™ A Beginner's Guide- Mc Graw - Hill Education- 8 th Ed.- 2017

ADVANCED MAJOR COURSE- AMJ 3: PRACTICAL – VII

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instruction to question Setter for

End Semester Examination (ESE)

There will be one Practical Examination of 3 Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 60 Marks

Practical record notebook = 15 Marks

Viva – voce = 25 Marks

List of Practicals:

1. To implement different entry controlled and exit controlled looping statements.
2. To Implement nesting of switch statement.
3. To Implement single and multi - dimensional arrays.
4. To implement constructor overloading and method overloading.
5. To implement static keyword.
6. To Implement multilevel inheritance.
7. To implement super and this keyword.
8. To implement abstract and final keyword.
9. To implement methods of String class.
10. To Implement exception handling and custom exceptions.
11. To implement package and interface.
12. To implement File Stream classes.

13. To Implement multithreading.
14. To implement mouse and keyboard events.
15. To implement different layout managers.
16. To design a customer registration form using advanced swing components.
17. To implement 2 D Shapes using Java FX.
18. To implement Check Box and List View events using

MINOR COURSE: MN – A
DISCRETE MATHEMATICS

Marks: 25 (05Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-03) **45 Hours**

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

1. Understand the fundamental concepts and properties of partially ordered sets (posets) and their visual representation.
2. Explore lattice structures as both posets and algebraic systems with various properties
3. Gain foundational knowledge of graph theory and its application in solving path and circuit -related problems.
4. Represent and analyze posets using hasse diagrams and determine minimal/maximal elements and bounds.
5. Identify and classify different types of lattices, including modular, distributive and complemented lattices.
6. Construct and analyze various types of graphs such as bipartite, complete and weighted graphs.
7. Apply graph algorithms, including Dijkstra's algorithm, to solve shortest path, Eulerian and Hamiltonian problems.

Course Contents:

UNIT -I: Posets -Definitions, examples and basic properties of partially ordered sets(poset), order isomorphism, hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.

UNIT – II: Lattices- Lattice as Poset, Lattice as algebraic structures, Sublattices, Products and homomorphism; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.

UNIT -III: Graph Theory- Definition, examples and basic properties of graphs, Konigsberg bridge problem: Subgraphs, Complete graphs.

UNIT-IV: **Graph Theory**- Isomorphism of graphs, Paths and circuits, Hamiltonian Cycles, Adjacency Matrix, Weighted Graph, Traveling Salesman's Problem, Shortest Path, Dijkstra's Algorithm.

Reference Books:

1. M. K. Gupta (2008). Discrete Mathematics. Krishna Prakashan.
2. Edgar G. Goodaire and Michael M. Paramenter(2003). Discrete Mathematics with Graph Theory. Pearson

MINOR COURSE-MN - B
RELIABILTY & SURVIVAL ANALYSIS

Marks: 25 (05Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) + Pr (ESE)= 40**

(Credits: Theory-03) **45 Hours**

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

1. Study the properties of measurement scales and the items that compose the scales.
2. Estimate and interpret survival and/or hazard function from the survival data.
3. Compare survival and/or hazard functions.
4. Asses the relationship of explanatory variables to survival time.

Course Content :

UNIT -I: Survival function, Hazard function, Cumulative Hazard function, reversed hazard function, nature of hazard function, class of increasing failure rate distribution, decreasing failure rate distribution theorems.

UNIT -II: Relation between survival function, probability function, hazard function, cumulative hazard function, reversed function.

UNIT-III: Elementary idea of lifetime distribution: exponential, Weibull, gamma extreme value distribution, log-normal etc.

UNIT -IV: Introduction to survival Analysis: need of survival analysis: left censoring, right censoring, interval censoring, random censoring, time censoring, order censoring, hybrid censoring. Kaplan -Meier estimator of survival function, properties of Kaplan – Meier estimator, Nelson – Aalen estimator of cumulative hazard function.

Reference Books:

1. Deshpande,J.V. and Purohit, S.G.(2005). Life Time Data: Statistical Models and Methods, World Scientific.

2. Barlow, R.E. and Proschan, F.(1975): Statistical theory of reliability and life testing. Holt, Reinhart and Winston

MINOR COURSE-MN-C

DEMOGRAPHY & VITAL STATISTICS

Marks: 15 (05 Attd+10 SIE:1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE)+Pr(ESE) = 40**

(Credits: Theory-03) 45**Hours**

Course Objectives & Learning Outcomes:

1. Distinction between Vital Statistics and Demography.
2. Population Composition and Dependency Ratio.
3. Basic measures of Mortality, Fertility, Life tables, their construction and uses, and Concept of Abridged life and their construction by Reed and Merrell method and Concept of Stable and Stationary Populations.
4. Basic measures of Fertility and Measures of Population Growth.

Course Content:

UNIT-I: Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.

UNIT-II: Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables.

UNIT-III: Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method.

UNIT -IV: Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

Reference Books:

1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
3. Ramakumar R.: Technical Demography.

4. Pathak K. B. & Ram F.: Techniques of Demographic Analysis.
5. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rdEdition. Prentice Hall of India Pvt. Ltd.
6. Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New York.
7. Fundamentals of Applied Statistics, S. C. Gupta & V.K. Kapoor

MINOR COURSE-MN-C PR:
DEMOGRPHY & VITAL STATISTICS PRACTICAL

Marks: Pr (ESE :6Hrs) = 25	**Pass Marks: Pr(ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment	*= 15 marks*
Practical record notebook	*= 05 marks*
Viva-voce	*= 05 marks*

List of Practicals:

1. Problem based on measures of Mortality.
2. To construct a complete life table.
3. Problem based on measures of Fertility.

Note:

1. MS Excel/ or Any Statistical Software and Computer System may be provided by the Institution.
2. However, Use of Smartphone or Web is restricted in the Examination.

Reference Books:

1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
3. Ramakumar R.: Technical Demography.
4. Pathak K. B. & Ram F.: Techniques of Demographic Analysis.
5. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rdEdition. Prentice Hall of India Pvt. Ltd.

6. Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New York.
7. Fundamentals of Applied Statistics, S. C. Gupta & V.K. Kapoor

MINOR COURSE-MN-D
LINEAR ALGEBRA & OPTIMIZATION TECHNIQUES

Marks: 15 (05 Attd+10SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) +Pr(ESE) = 40**

(Credits: Theory-03) 45**Hours**

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

1. Do the elementary row operations for the matrices and systems of linear equations.
2. Analyze the solution set of a system of linear equations.
3. Express a system of linear equations in a matrix form.
4. Generalize the concept of real/complex vector space to an arbitrary finite dimensional vector spaces.
5. Understand the concept of linear transformations
6. The fundamental concepts of Linear Programming.
7. Concepts Of Linear Programming.
8. Concepts of Assignment Problem.

UNIT 1: Different types of Matrices. Algebra of matrices. Different methods of finding inverse, Rank of a matrix, Echelon form of a matrix. Vector spaces, subspace, algebra of subspaces, linear combination of vectors, linear span, linear dependence and linear independence, basis and dimension, co-ordinate vector of a vector relative to a basis. Solution of a system of linear equations via matrix methods, Conditions for consistency and inconsistency.

UNIT II: Linear transformations, null space, range space, rank and nullity of a linear transformation, Sylvester law of nullity. Matrix representation of a linear transformation, algebra of linear transformations.Similarity of Matrix and Transformation. Diagonalizability and Quadratic forms.

UNIT III: Convex sets and their properties, Introduction to linear programming problem, solution by graphical method. Simplex method, optimality and unboundedness, artificial variables, two phase method, Big M method. Duality, formulation of the dual problem, primal dual relationships, economic interpretation of the dual.

UNIT IV: Transportation problem and its mathematical formulation, north-west corner method, least cost method, least cost method and Vogel approximation method for determination of initial basic solution, algorithm for solving transportation problem. Transportation problem as a linear programming problem.

Reference Books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flow, 2nd Ed, John Wiley and Sons, India, 2004.
2. F. S. Hillier and G.J Lieberman, Introduction to operations Research, 9th Ed., Tata McGraw Hill , Singapore,2009.
3. Hamdy A. Taha, Operation Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
4. Operation Research – S D Sharma.
5. Linear Programming Problems – R.K Gupta.

MINOR COURSE-MN- D PR:
LINEAR ALGEBRA & OPTIMIZATION TECHNIQUES PRACTICAL

Marks:Pr (EsE : 6Hrs) = 25	**Pass Marks: Pr(ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

List of Practicals:

1. Problem based on Linear Programming Problem.
2. Problem based on Simplex Method.
3. Problem based on two phase method.
4. Problem based on Big M method.
5. Problem based on Primal dual relationships.
6. Application problem based on Transportation problem.

Note:

1. MS Excel/ or Any Statistical Software and Computer System may be provided by the Institution.
2. However, Use of Smartphone or Wed is restricted in the Examination.

Reference Books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flow, 2nd Ed, John Wiley and Sons, India, 2004.
2. F. S. Hillier and G.J Lieberman, Introduction to operations Research, 9th Ed., Tata McGraw Hill , Singapore,2009.
3. Hamdy A. Taha, Operation Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.
4. Operation Research – S D Sharma.
5. Linear Programming Problems – R.K Gupta.

MINOR COURSE -MN-E
APPLIED REGRESSION ANALYSIS

Marks: 15 (05Attd +10SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr(ESE) = 40**

(Credits: Theory-03) 45**Hours**

Course Objectives & Learning Outcomes:

1. This course covers regression analysis, estimation using method of least squares and statistical
inference using regression models.
2. Analysis of residuals and variability will be investigated.
3. This course also covers Nonlinear regression model.
4. The course aims to provide deeper understanding about the assumptions and analysis of linear and non-linear regression models.
5. Develop a deeper understanding of the linear regression model.
6.Understand and apply appropriate regression models and test its assumptions.
7.Use appropriate criteria for model selection and evaluate the fitted model.

Unit 1: Regression Analysis

Introduction to regression analysis: Modelling a response- overview and applications of regression analysis- major steps in regression analysis. Multiple linear regression model: assumptions- ordinary least square estimation of regression coefficients- interpretation and properties of regression coefficient- significance and confidence intervals of regression coefficients.

Unit II: Criteria for Model Selection

Mean Square error criteria- R2 and Adjusted R2 criteria for model selection; Need of thetransformation of variables; Box-Cox transformation; Forward-Backward and Stepwiseprocedures, AIC-BIC model fit indices.

Unit III: Residual Analysis

Residual analysis- Departures from underlying assumptions- Effect of outliers- Multi-Collinearity- Non-constant variance and serial correlation- Departures from normality- Diagnostics and remedies.

Unit IV: Nonlinear Regression
Introduction to nonlinear regression- Least squares in the nonlinear case and estimation ofparameters- Models for binary response variables- estimation and diagnosis methods for Logisticregressions, Poisson regressions. Prediction and residual analysis.

Reference Book:
1. D.C Montgomery-E.A. Peck and G.G Vining- Introduction to Linear Regression Analysis- 5th ed.- John Wiley and Sons-Inc. NY- 2012.
2. S. Chatterjee and A. Hadi- Regression Analysis by Example- 5th ed.- John Wiley and Sons-Inc- 2012.
3. I. Pardoe- Applied Regression Modeling- 3rd ed.- John Wiley and Sons- Inc- 2020.
4. P. Mc Cullagh and J.A. Nelder- Generalized Linear Models- 2nd ed.- Chapman & Hall- 2019.

MINOR COURSE-MN-E PR:
APPLIED REGRESSION ANALYSIS PRACTICAL

Marks:Pr (EsE : 6Hrs) = 25	**Pass Marks: Pr(ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

List of Practicals:

1. Problem based on Simple Linear Regression.
2. Problem based on Multiple Regression.
3. Problem based on Bias in regression estimates.
4. Problem Based on Criteria for Model Selection.
5. Problem based on Residual Analysis.
6. Problem based on Non-Linear Regression.

Note:

1. MS Excel/ or Any Statistical Software and Computer System may be provided by the Institution.
2. However, Use of Smartphone or Web is restricted in the Examination.

Reference Book:

1. D.C Montgomery-E.A. Peck and G.G Vining- Introduction to Linear Regression Analysis- 5th ed.- John Wiley and Sons-Inc. NY- 2012.
2. S. Chatterjee and A. Hadi- Regression Analysis by Example- 5th ed.- John Wiley and Sons-Inc- 2012.
3. I. Pardoe- Applied Regression Modeling- 3rd ed.- John Wiley and Sons- Inc- 2020.
4. P. Mc Cullagh and J.A. Nelder- Generalized Linear Models- 2nd ed.- Chapman & Hall- 2019.

MINOR COURSE–MN - F:
TIME SERIES ANALYSIS

Marks: 15 (5 Attd+10SIE 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr(ESE) = 40**

(Credits: Theory-04) **45 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. The components and forecast values of a time series at future time points.
2. The concept of Moving -average(MA) process, Autoregressive(AR) process of order and two.
3. The concept of shortterm forecasting method: Brown's discounted regression, Box-Jenkins method.
4. The concepts of Stationary time series: Weak stationarity, autocorrelation function and correlogram of moving average.

Course Content:

UNIT-I: Introduction to times series data, application of time series to various fields, Components of a times series, Decomposition of a time series. Trend: Estimation of trend by free hand curve method, method of semi averages, fitting various mathematical curves, and growth curves.

UNIT-II: Trend Cont.: Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series. Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend.

UNIT-III: Seasonal Componentcont: Ratio to Moving Averages and Link Relative method, Deseasonalization. Cyclic Component: Harmonic Analysis. Some Special Processes: Moving-

average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) – Yule-Walker equations.

UNIT-IV: Random Component: Variate component method. Forecasting: Exponential smoothing methods,Short term forecasting methods: Box-Jenkins method.

Reference Books:

1. Kendall M.G. (1976): Time Series, Charles Griffin.
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
3. Mukhopadhyay P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied.
4. Fundamentals of Applied Statistics, S. C. Gupta & V.K. Kapoor

MINOR COURSE-MN-F PR:
TIME SERIES ANALYSIS PRACTICAL

Marks:Pr(ESE: 6Hrs) = 25	**Pass Marks: Pr(ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

List of Practicals:

1. Problems based on estimation of trend by free hand curve method, method of semi average, fitting various mathematical curves and growth curves.

2. Problem based on estimation of seasonal component by method of simple average, Ratio to Trend. Ratio to Moving Averages

3. Moving-average (MA) process and Autoregressive (AR) process of orders one and two

4. Estimation of the parameters of AR (1) and AR (2) – Yule Walker equations. Problem based on Forecasting

Note:

1. MS Excel/ or Any Statistical Software and Computer System may be provided by the Institution.
2. However, Use of Smartphone or Web is restricted in the Examination

Reference Books:

1. Kendall M.G. (1976): Time Series, Charles Griffin.
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
3. Mukhopadhyay P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied.
4. Fundamentals of Applied Statistics, S. C. Gupta & V.K. Kapoor

MINOR COURSE-MN - G:
ECONOMETRICS

Marks: 15 (5Attd+10 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr(ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. The fundamental concepts of econometrics
2. Specification of the model.
3. Multiple Linear Regression.
4. Multicollinearity, Heteroscedasticity and Autocorrelation.

Course Content:

UNIT-I: Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. General linear model (GLM). Estimation under linear restrictions.

UNIT-II: Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, specification error.

UNIT-III: Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

UNIT-IV: Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Autoregressive and Lag models, Dummy variables, Qualitative data.

Reference Books:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4thEdition, McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2ndEdition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2ndEdition, Palgrave Macmillan Limited.
4. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4thEdition, John Wiley & Sons.
5. Madnani GMK: Introduction to Econometrics.

MINOR COURSE-MN-G-PR: ECONOMETRICS PRACTICAL

Marks:Pr (ESE: 6Hrs) =25	**Pass Marks: Pr(ESE) = 10**

(Credits: Theory-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination(ESE):

There will be one Practical Examination of 6 Hrs duration. Evaluation of Practical Examination may be as per the follow

Experement = 15 marks
Practical record notebook = 05 marks
Viva – voce = 05 marks

List of Practicals:

1. Problems related to Multicollinearity. Difficult to isolate individual variables effects.

2. Problems related to Heteroscedasticity. Detecting Heteroscedasticity in Simple linear Regression. Comparison of Homoscedasticity and Heteroscedasticity. Correcting Heteroscedasticity using Weighted Least Square(WLS).

3. Problem based on Autocorrelation. Autocorrelation in Stock Market Prices and weather forecasting using Autocorrelation etc.

4. Problems related on tests and solution of Heteroscedasticity. Problems related toAutoregressive and Lag models, Dummy variables, Qualitative data.

Note:

1. MS Excel/ or Any Statistical Software and Computer System may be provided by the Institution.
2. However, Use of Smartphone or Wed is restricted in the Examination

Reference Books:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4thEdition, McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2ndEdition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2ndEdition, Palgrave Macmillan Limited.
4. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4thEdition, John Wiley & Sons.
5. Madnani GMK: Introduction to Econometrics

MINOR COURSE-MN-H:

STOCHASTIC PROCESSES & QUEUING THEORY

Marks: 15 (5 Attd. + 10 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-03) 45**Hours**

Course Objectives & Learning Outcomes:

This course will enable the students to:

1. Understand about fundamentals concepts of stochastic processes and Use notions of long-time behaviour including transience, recurrence and equilibrium in applied situations.
2. Understand about Markov processes, Markov chains, Stability of Morkov chains and Construct transition matrices for Markov dependent behaviour and summarize process information.
3. Understand the principles and objectives of model building based on Markov Chains.
4. Understand the concept of Queuing systems, Random walk and Classical ruin problem.

Course Content:

UNIT I

Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic

Process: Introduction, Stationary Process.

UNIT II

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach.

UNIT III

Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.

UNIT IV

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof).Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

Reference Books:

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International.

MINOR COURSE-MN-H - PR:
STOCHASTIC PROCESSES & QUEUING THEORY PRACTICAL

Marks: Pr(ESE: 6Hrs) = 25	**Pass Marks: Pr(ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instruction to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 3Hrs duration. Evaluation of Practical Examination may be as per the following guidelines:
Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

List of Practicals:

1. Problem based on Markov Chain.
2. Problem based on Stationary Process.
3. Problem based on Poisson Process.

4. Problem based on Pure Birth Process.
5. Problem based on Pure Death Process.
6. Problem based on Birth and Death Process.
7. Problem based on Queuing Model.
8. Problem based on M/M/1 with finite and infinite system capacity.

Reference Books:

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International.