Syllabus Research Methods

Credits: 4
Duration: 20 weeks

Course Objectives:

1. To understand the principles and philosophy underlying scientific research.
2. To develop skills in designing and conducting research studies.
3. To learn appropriate methods for collecting, analyzing, and interpreting data.
4. To understand ethical issues in scientific research.
5. To enhance skills in scientific communication and reporting

Outcome:

By the end of this course, students will have a solid foundation in the principles and practices of scientific research, equipping them with the skills to undertake independent research projects and effectively communicate their findings.

Unit 1: Research - An Introduction

- Definition and characteristics of scientific research.
- Steps in the scientific method.
- Importance of objectivity, reliability, and validity.

Unit 2: Types of Research (Classification, Applications, Examples)

- Definitions and characteristics.
- Basic vs. applied research.
- Quantitative vs. qualitative research
- Exploratory, descriptive, and explanatory research.
- Longitudinal and cross-sectional research.
- Correlational vs. Experimental Designs.

Unit 3: Reference Formatives Indexing, Citations, Impact Factor, H-Index

- Referencing styles: APA, MLA, Chicago, etc.
- Tools for referencing: EndNote, Zotero, Mendeley.
- Managing bibliographies effectively.
- Importance of citations.
- Metrics: Impact factor, h-index, i10-index.

- Indexing databases: Scopus, Web of Science.

Unit 4: Research Problem Identification and Formulation

- Sources of research problems.
- Techniques for defining a problem statement.
- Characteristics of a good research problem.

Unit 5: Literature Review

- Purpose and importance of literature reviews.
- Searching and organizing literature.
- Writing a literature review: Synthesis and critical analysis.

Unit 6: Data Collection Methods (Quantitative)

- Surveys, experiments, observations, and structured interviews.
- Designing and validating data collection instruments.
- Sampling techniques and sample size determination.

Unit 7: Data Collection Methods (Qualitative)

- Ethnography, interviews, focus groups, and case studies.
- Observational techniques and fieldwork.
- Ensuring trustworthiness in qualitative research.

Unit 8: Data Collection Methods (Instrumentation, Scale & Measurement Tools)

- Developing and validating scales.
- Reliability and validity of measurement tools.
- Examples: Likert scales, semantic differential scales.

Unit 9: Data Collection in Interdisciplinary Research

- Methods specific to botany, zoology, physics, chemistry, and social sciences.
- Challenges and integration of techniques across disciplines.

Unit 10: Ancient Indian Knowledge System and Research

- Contributions to mathematics, astronomy, and medicine.
- Traditional knowledge in agriculture and ecology.
- Integration of traditional and modern research methods.

Unit 11: Data Handling in Research

- Data organization and analysis.
- Functions and formulas.
- Advanced features: Pivot tables, macros.

Unit 12: Ethical Guidelines

- Guidelines from organizations (e.g., APA, UNESCO).
- Informed consent and confidentiality.
- Institutional Review Boards (IRBs).

Unit 13: Misconduct in Research

- Types: Plagiarism, falsification, fabrication.
- Consequences and detection tools.
- Case studies.

Unit 14: Scientific Writing and Communication: (Structure of a Research Paper)

- IMRaD structure: Introduction, Methods, Results, and Discussion.
- Abstracts and keywords.
- Structuring arguments and findings.

Unit 15: Scientific Writing and Communication: (Writing for Journals Formatting and Submission Guidelines)

- Choosing the right journal.
- Formatting requirements.
- Common reasons for rejection.

Unit 16: Research Presentation

- Designing posters.
- Preparing oral presentations.
- Multimedia tools for effective communication.

Unit 17: Peer Review Process

- Importance and stages of peer review.
- Responding to reviewers' comments.
- Revising and resubmitting manuscripts.

Unit 18: ICT Tools

- **Scholar**: Searching for academic papers, citation alerts research paper database.
- **Cloud Storage:** Drive File storage, sharing, and collaboration, one drive
- **Docs, Sheets, and Slides**: Collaborative writing, data analysis, and presentations, office 365 and office tools.
- **Forms**: Designing surveys and questionnaires, Monkey survey
- **Google Calendar**: Scheduling and time management for research.

Unit 19: Data Privacy & Intellectual Property Rights

- Data protection laws (e.g., GDPR).
- Patents, trademarks, and copyrights.
- Challenges in maintaining data privacy.

Unit 20: Scientific Methods

- Observation, hypothesis formulation, experimentation, and analysis.
- Role of critical thinking and skepticism.
- Case studies of scientific breakthroughs.

Unit 21: Research Objective, Hypothesis, and Research Question

- Definitions and examples of objectives, hypotheses, and questions.
- Types of hypotheses: Null, alternative, directional, non-directional.
- Aligning objectives with hypotheses.

Unit 22: Artificial Intelligence Tools in Scientific Research

- AI for literature review, data analysis.
- Tools: ChatGPT, Co-pilot, Gemini, Anuvadini, Deepseek, Bard, AI-driven statistical software.

Paper MAT-403 : Research Reflections and Reviews

Course Objectives: The objectives of this course are to:

1. **Develop a comprehensive understanding of research tools, software, and computational platforms used in modern research.**
2. **Equip learners with practical skills in statistical analysis, data handling, visualization, and numerical methods using R, Python, SPSS, and MATLAB.**
3. **Provide a strong foundation in sampling theory, sampling designs, and estimation techniques essential for empirical research.**
4. **Enable learners to apply advanced statistical methods for data interpretation, modelling, and evidence-based decision making.**
5. **Familiarize learners with LaTeX for scientific writing, mathematical documentation, bibliographic management, and academic presentations.**
6. **Introduce the principles and practices of Open Science, emphasizing reproducibility, transparency, and pre-registration of studies.**
7. **Enhance critical thinking, problem-solving ability, and analytical skills required for reviewing, reflecting, and reporting research outcomes.**
8. **Prepare learners for independent research, higher studies, and professional research-oriented careers.**

Unit 1: Software Tools (R) – Introduction

- **Introduction to R and RStudio**
- **Data types, variables, and operators**
- **Vectors, matrices, and data frames**
- **Control structures: if-else, loops, and user-defined functions**

Unit 2: Software Tools (R) – Plotting and Visualization

- **Data import and export (CSV, Excel, text files)**
- **Basic statistical analysis using R**
- **Data visualization using ggplot2**

Unit 3: Software Tools (R) – Mathematical Operations

- **Linear algebra and matrix operations in R**
- **Introduction to important R packages: dplyr, tidyr, stats**
- **Case studies: solving mathematical problems using R**

Unit 4: Software Tools (SPSS)

- **Introduction to SPSS environment**
- **Data entry, coding, and management**
- **Descriptive and inferential statistical analysis**

Unit 5: Software Tools (Python) – Introduction

- **Python syntax and programming basics**
- **Variables and data types**
- **Control flow: if-else statements, loops, and functions**

Unit 6: Python – Mathematical Operations

- **NumPy arrays and matrix operations**
- **Linear algebra applications**
- **Symbolic mathematics using SymPy (calculus, algebra, equation solving)**

Unit 7: Python – Plotting and Visualization

- **Introduction to Matplotlib and Seaborn**
- **Graphing mathematical functions**
- **Data visualization techniques**

Unit 8: Python – Numerical Methods

- **Root-finding techniques**
- **Numerical solutions of differential equations**
- **Visualization of numerical results**

Unit 9: Software Tools (MATLAB) – Introduction

- **MATLAB environment: Workspace, Command Window, Editor, and Help**
- **Variables, data types, scripts, and M-files**
- **Control statements and user-defined functions**

Unit 10: MATLAB – Linear Algebra Operations

- **Vector and matrix creation and manipulation**
- **Matrix arithmetic operations**
- **Solving systems of linear equations using built-in functions**

Unit 11: MATLAB – Plotting

- **Two-dimensional and three-dimensional plots**

- **Surface and contour plots**
- **Editing, annotating, and exporting figures**

Unit 12: MATLAB – Numerical Methods

- **Numerical differentiation and integration**
- **Root-finding methods: Bisection, Newton–Raphson, and related techniques**

Unit 13: MATLAB – Solving Differential Equations

- **Initial and boundary value problems**
- **BVP4C method**
- **Finite difference method**
- **Runge–Kutta (RK4) method**
- **Keller Box method**

Unit 14: Statistical Tools for Data Analysis – I

- **Descriptive statistics: measures of central tendency and dispersion**
- **Skewness and kurtosis**
- **Probability distributions: Normal, Binomial, Poisson, t, F, and Chi-square**
- **Estimation and confidence intervals**
- **Hypothesis testing: parametric and non-parametric tests**

Unit 15: Statistical Tools for Data Analysis – II

- **Correlation and regression analysis**
- **Analysis of variance: ANOVA, MANOVA, ANCOVA**
- **Multivariate analysis: factor analysis, cluster analysis, principal component analysis**

Unit 16: Advanced Statistical Methods

- **Time series analysis and forecasting**
- **Design of experiments**
- **Statistical quality control**
- **Meta-analysis in research**

Unit 17: Sampling Fundamentals – I

- **Need for sampling**
- **Basic concepts and fundamental definitions**

- **Important sampling distributions**
- **Central Limit Theorem**
- **Introduction to sampling theory**

Unit 18: Sampling Fundamentals – II

- **Concept of standard error**
- **Estimation theory**
- **Estimation of population mean**
- **Estimation of population proportion**

Unit 19: Sampling Fundamentals – III

- **Concept of sample size**
- **Determination of sample size**
- **Approaches based on precision, confidence level, and confidence interval**
- **Bayesian approach to sample size determination**

Unit 20: Open Science

- **Reproducibility and transparency in research**
- **Open science platforms: OSF, ResearchGate**
- **Pre-registration of research studies**

Unit 21: LaTeX – Introduction

- **Introduction to LaTeX and TeX systems**
- **Document structure: preamble, sections, and environments**
- **Preparation of simple documents using LaTeX**

Unit 22: LaTeX – Mathematical Operations and Bibliography

- **Mathematical typesetting: equations, arrays, matrices**
- **Theorem, definition, and proof environments**
- **Tables, figures, headers, and footers**
- **Cross-referencing and citations**
- **Bibliography creation using BibTeX and BibLaTeX**

Unit 23: LaTeX – Presentations

- **Preparing presentations using Beamer**
- **Poster design using LaTeX**

Unit 23: Open Science

- Reproducibility and transparency in research.
- Platforms: OSF, ResearchGate.
- Pre-registration of studies.

Unit 24: Research Ethics Principles

- Core ethical principles: Integrity, objectivity, and responsibility.
- Ethical dilemmas in research.
- Examples of ethical violations.

Unit 14: Sampling Fundamentals-I

- Need for Sampling
- Some fundamental Definitions
- Important Sampling Distributions
- Central Unit Theorem
- Sampling Theory.

Unit 15: Sampling Fundamentals-II

- Sandler's A-Test
- Concept of Standard Error
- Estimation
- Estimating the Population mean
- Estimating Population Proportion

Unit 16: Sampling Fundamentals-III

- Sample size and its Determination
- Determination of sample Size thoughthe Approach
- Based Level on Precision Rate and Confidence level
- Determination of Sample Size through the Approach.
- Based Bayesian Statistics.

Unit 17: Sampling Design-I

- Census and Sample Survey.

- Implications of a Sample Design.
- Steps in Sampling Design.
- Criteria of Selecting a sampling Procedure
- Characteristics of a good Sample Designs

Unit 18: Sampling Design-II

- Different Type of Sample Designs,
- How to Select a Random Sample?
- Random Sample from Universe. Infinite ais
- Complex Random Sampling Designs.
- Conclusion

Unit 1: Software Tools (R) - Introduction:

- Introduction to R and R Studio.
- Data Types, Variables, Operators.
- Vectors, Matrices, and Data Frames.
- Control Structures (if, loops, functions).

Unit 2: Software Tools (R) – Plotting and Visualization:

- Data Import/Export (CSV, Excel, etc.)
- Basic Statistical Analysis in R.
- Data Visualization using ggplot2.

Unit 3: Software Tools (R) - Mathematical Operations:

- Using R for Linear Algebra and Matrix Operations.
- Introduction to R Packages(e.g., dplyr, tidyr, stats).
- Case Studies: Solving Mathematical Problem Using R.

Unit 3: Software Tools (SPSS)

- Basics
- Descriptive and inferential statistics
- Data entry and analysis

Unit 4: Software (Python) - Introduction

- Python Syntax, Variables, Data Types.
- Control Flow (if-else, loops), functions.

Unit 5: Python – Mathematical Operations

- **NumPy** arrays and matrices.
- Matrix operations, linear algebra problems.
- Using **SymPy** for calculus, algebra, equations solving.

Unit 6: Python – Plotting and Visualization

- Introduction to Matplotlib and Seaborn.
- Graphing functions, visualizing data sets.

Unit 7: Python – Numerical Methods

- Solving differential equations.
- Root findings, visualizing data sets.

Unit 8: Software (MATLAB) - Introduction

- Workspace, Command Window, Editor, and Help features.
- Variables, Data type, Scripits, M-files.
- Control statements (if, for, while), functions

Unit 9: MATLAB – Linear Algrbra Operations

- Vector and Matrix creation, manipulation, and arithmetic.
- Solving systems of equations using built-in functions.

Unit 10: MATLAB – Plotting

- 2D and 3D plots, surface plots.
- Editing of plots.
- Annotating and exporting figures.

Unit 11: MATLAB – Numerical Methods

- Numerical differentiations and integration.
- Roots finding (e.g., bisection, Newton-Raphson methods etc).

Unit 12: MATLAB – Solving Differential Equations

- BVP4C method
- Finite difference method
- RK4 method
- Keller Box Method

Unit 13: Statistical Tools for Data Analysis

- Descriptive statistics: Measure of central tendency, dispersion, skewness, kurtosis.
- Probability Distributions (Normal, Bionormal, Poission, t. F, Chi-square test).
- Estimation and Confidence intervals.
- Hypothesis testing: Parametric and Non- Parametric tests.

Unit 14: Statistical Tools for DataAnalysis

- Correlation and Regression analysis.
- Analysis of variance (ANOVA, MANOVA, ANCOVA).
- Multivartate analysis: Factor analysis, Cluster analysis, Principal component analysis.

Unit 15: Advanced Statistical Methods

- Time Series analysis and forecasting.
- Design of Experiments.
- Statistical Quality Control.
- Meta-analysis in research.

Unit 16: LaTeX – Introduction

- Introduction to LaTex and Tex systems.
- Document structure: Premble, sections, environments.
- Small doucumentation with LaTex.

Unit 17: LaTeX - Mathematical Operations

- Writing mathematical formulas and notation.
- Aligning equations, cases, arrays, and matrices.
- Theorems, definition, and proof environments.
- Text formatting (Header and footer).
- Creatings tables and including figures.
- Referencing equations, theorems, and sections.

Unit 18: LaTeX – Bibliographies

- Creating bibliographies with
    - BibTex
    - BibLatex

Unit 19: LaTeX - Presentation

- PPT presentation in LaTex.
- Poster in LaTex.

Unit 20: Bio mechanics - I.

- Fundamental concepts of Biomechanics.
- Cardiovascular system: Basic concepts about blood, blood vessels, governing equations, models on blood flow, flow in large blood vessels, microcirculation, pulsatile flow, stenotic region flow.

Unit 21: Bio mechanics - II.

- Peristalsis: Basic concepts, governing equations, peristaltic transport under long wave length approximation, peristaltic flow for small amplitudes and small Reynold's number.
- Flow in Renal tubules: Basic concepts, governing equations, ultra filteration, flow through proximal tubules, flow through tubes with varying cross section.

Unit 22: Modeling

- Introduction, basic steps of mathematical modeling, its needs, types of models and properties, limitations, models and reality, properties of models, building a model.
- Graphical Methods: Using graphs in modeling, comparative statistics, biogeography, diversity of species on islands, stability questions.
- Biosciences: Population dynamics, mathematical ecology and mathematical niceconomics, mathematical epidemiology, mathematical genetics, mathematical biomechanics, optimization models in biology and medicine.

Unit 23: Microbial Population Models

- Microbial Population Models: Importance of microbial kinetics, stability of steady state for Chemostate, growth of microbial populations, product formation due to microbial action.

Unit 24: Single Species Non-Age-Structured Population Models

- Single Species Non-Age-Structured Population Models: Simple logistic models, logistic model with time delay effects. Stochastic models of population growth. Age Structure Population Models: Discrete-Time Discrete-Age scale population models, Continuous-Time Discrete-Age scale population models, Continuous-Time Continuous- Age scale population models, reconciliation of the three types of age structure population models.

Unit 25: Two Species Population Models:

- Two Species Population Models: A simple prey-predator model, some other prey-predator model, predator-prey models with time delay, models for competition.

Unit 26: Epidemic Model:

- Epidemic Model: Deterministic model without removal, general deterministic model with removal, general deterministic model with removal and immigration, control bf an epidemic, stochastic epidemic model without removal, other stochastic Epidemic models.

Unit 27: Models for Blood Flow:

- Models for Blood Flow: Some basic concept of fluid dynamics, basic concept about blood, cardiovascular system, and blood flows, steady non-Newtonian fluid flows in circular tubes, Newtonian pulsatile flows in rigid and elastic tubes.

Unit 28: Sequencing models.

- Solution of sequencing problem

- processing n Jobs through 2 machines
- processing n Jobs through 3 machines
- Processing 2 Jobs through m machines
- Processing n Job: through m machines.

Unit 29: Sequencing models.

- Replacement of items that deteriorate whose maintenance costs increase with time without change in the money value, replacement of items that fail suddenly, individual replacement policy, group replacement policy.

UNIT 1: Foundations of Descriptive Statistics

1.1 Introduction to Statistics

- Meaning, scope, and importance of statistics
- Types of data: qualitative and quantitative
- Levels of measurement: nominal, ordinal, interval, ratio
- Classification and tabulation of data

1.2 Measures of Central Tendency

- Arithmetic mean (simple and weighted)
- Median (ungrouped and grouped data)
- Mode (graphical and algebraic methods)
- Properties, merits, and demerits of each measure

1.3 Applications of Central Tendency

- Use in social sciences, biological sciences, economics, and quality control
- Comparison of datasets using averages
- Numerical illustrations and problem sets

UNIT 2: Measures of Dispersion and Variability

2.1 Concept of Dispersion

- Need and significance of dispersion
- Absolute vs relative measures

2.2 Measures of Dispersion

- Range and coefficient of range
- Quartile deviation and coefficient

- Mean deviation
- Variance and standard deviation

2.3 Relative Measures of Dispersion

- Coefficient of variation (CV)
- Interpretation and applications

2.4 Practical Applications

- Consistency and variability analysis
- Comparison of distributions
- Numerical problems and case studies

UNIT 3: Skewness and Kurtosis

3.1 Skewness

- Concept and types: positive, negative, and zero skewness
- Karl Pearson's coefficient of skewness
- Bowley's coefficient of skewness
- Graphical interpretation

3.2 Kurtosis

- Concept of kurtosis
- Types: leptokurtic, mesokurtic, platykurtic
- Measures of kurtosis

3.3 Interpretation and Applications

- Role in distribution analysis
- Applications in economics, psychology, and biological data
- Numerical illustrations

UNIT 4: Probability Theory and Random Variables

4.1 Basic Concepts of Probability

- Random experiment and sample space
- Events and types of events
- Classical, empirical, and axiomatic approaches

4.2 Laws of Probability

- Addition and multiplication theorems
- Conditional probability
- Bayes' theorem and applications

4.3 Random Variables

- Discrete and continuous random variables
- Probability mass function (PMF)
- Probability density function (PDF)
- Cumulative distribution function (CDF)

UNIT 5: Probability Distributions

5.1 Discrete Probability Distributions

- Binomial distribution
    - Assumptions, properties, mean and variance
    - Applications and numerical problems
- Poisson distribution
    - Conditions, properties, Poisson approximation to binomial
    - Applications

5.2 Continuous Probability Distributions

- Normal distribution
    - Properties and characteristics
    - Standard normal distribution
    - Applications and problems
- Exponential distribution
    - Definition and properties
    - Applications in reliability and life testing

5.3 Other Probability Distributions

- Uniform distribution
- Geometric distribution
- Brief introduction to Gamma and Weibull distributions

UNIT 6: Correlation and Regression Analysis

6.1 Correlation Analysis

- Concept and types of correlation
- Scatter diagram
- Karl Pearson’s coefficient of correlation
- Spearman’s rank correlation coefficient
- Interpretation and limitations

6.2 Regression Analysis

- Concept of regression
- Simple linear regression
- Regression equations and regression coefficients

- Properties of regression coefficients

6.3 Applications

- Prediction and forecasting
- Relationship analysis in economics, biology, and social sciences
- Numerical problems and case studies

UNIT 7: Fundamentals and Basic Queuing Models

7.1 Introduction to Queuing Theory

- Definition, origin, and historical development
- Scope and importance of queuing theory
- Role of queuing models in operations research and decision-making

7.2 Elements of a Queuing System

- Calling population: finite and infinite
- Arrival process and arrival patterns
- Service mechanism and service channels
- Queue discipline: FCFS, LCFS, priority, random service
- System capacity and queue length

7.3 Arrival and Service Processes

- Deterministic and stochastic arrivals
- Poisson arrival process: assumptions and properties
- Inter-arrival time distribution
- Service time distributions
- Single-server and multi-server systems

7.4 Kendall's Notation and Classification of Queues

- General queuing model notation (a/b/c):(d/e/f)
- Interpretation of each parameter
- Common queuing models and their assumptions

7.5 Performance Measures of Queuing Systems

- Average number of customers in the system (L)
- Average number of customers in the queue (Lq)
- Average waiting time in the system (W)
- Average waiting time in the queue (Wq)
- Little's Law and its significance

7.6 Single-Server Queuing Models

- Assumptions of single-server models
- M/M/1 model
- Steady-state conditions
- Derivation of performance measures
- Applications and numerical illustrations

UNIT 8: Advanced Queuing Models, Cost Analysis, and Applications

8.1 Multi-Server Queuing Models

- Assumptions of multi-server systems
- M/M/c model
- Probability of waiting
- Performance measures
- Comparison with single-server systems

8.2 Finite Capacity and Finite Population Models

- M/M/1/K model
- M/M/1/N model
- Practical significance and limitations

8.3 Priority Queuing Models

- Concept of priority in service systems
- Non-preemptive priority model
- Preemptive priority model
- Performance evaluation

8.4 Queues with Special Features

- Bulk arrival and bulk service models
- Single-phase and multi-phase service systems
- Queues in series and parallel

8.5 Cost Analysis in Queuing Systems

- Components of queuing cost
- Waiting cost and service cost
- Optimization of service facilities
- Economic decision-making using queuing models

UNIT 9: SEQUENCING MODELS

1. Introduction to Sequencing Models

- Meaning and concept of sequencing in operations research
- Need and importance of sequencing models in production planning
- Objectives of sequencing: minimization of total elapsed time, idle time, and makespan
- Applications of sequencing models in manufacturing and service systems

2. Basic Assumptions and Terminology

- Definition of jobs and machines
- Processing time and order of processing
- Idle time of machines and jobs
- Assumptions underlying sequencing problems

3. General Sequencing Problem

- Nature of sequencing problems
- Constraints involved in sequencing
- Criteria for optimal sequencing
- Role of sequencing in scheduling and workflow optimization

4. Processing *n* Jobs Through Two Machines

- Statement of the problem
- Johnson's rule for two-machine sequencing
- Algorithm and steps involved
- Construction of optimal sequence
- Determination of total elapsed time and idle time
- Numerical illustrations

5. Processing *n* Jobs Through Three Machines

- Assumptions and conditions
- Reduction of three-machine problem to two-machine problem
- Application of Johnson's rule
- Solution procedure with examples
- Interpretation of results

6. Processing Two Jobs Through *m* Machines

- Problem formulation

- Construction of processing time table
- Sequencing procedure
- Computation of total elapsed time
- Numerical examples

7. Processing *n* Jobs Through *m* Machines

- Nature and complexity of the general sequencing problem
- Limitations of Johnson's rule
- Heuristic approaches to $n \times m$ sequencing problems
- Practical considerations and approximations

UNIT10: Introduction to R and Basic Programming Concepts

1. Introduction to R Software

- What is R?
- History and development of R
- Features and advantages of R
- Applications of R in statistics, data science, research, and industry
- Comparison of R with other statistical software (SPSS, SAS, Python – brief)

2. R Environment and Installation

- Installing R and RStudio
- Components of R environment
- R console, script editor, workspace, and help system
- Working directory and file management

3. Basic Programming Concepts in R

- R as a calculator

- Arithmetic, logical, and relational operators
- Assignment operators
- Comments and script writing

4. Data Types and Objects in R

- Basic data types: numeric, integer, character, logical
- Special values: NA, NULL, NaN, Inf
- Data objects: vectors, matrices, arrays
- Factors and their importance

5. Data Structures in R

- Lists
- Data frames
- Creating, accessing, and modifying data structures
- Type conversion and coercion

6. Basic Input–Output Operations

- Reading data from keyboard
- Importing data from CSV, Excel, and text files
- Viewing and exporting data

UNIT11: Data Handling, Functions, and Basic Statistical Analysis in R

1. Data Manipulation in R

- Subsetting data
- Sorting and ordering data
- Handling missing values
- Basic data transformation

2. Control Structures in R

- Conditional statements: if, if–else
- Looping structures: for, while, repeat
- Vectorized operations

3. Functions in R

- Built-in functions
- User-defined functions
- Function arguments and return values
- Apply family of functions (apply, lapply, sapply – introduction)

4. Basic Statistical Analysis Using R

- Descriptive statistics: mean, median, mode, variance, standard deviation
- Frequency tables and summary statistics
- Correlation and covariance

5. Data Visualization in R

- Introduction to graphical capabilities of R
- Bar charts, histograms, boxplots
- Scatter plots and line graphs
- Customizing plots

6. Introduction to R Packages

- What are packages?
- Installing and loading packages
- Introduction to commonly used packages (tidyverse, ggplot2 – overview)

UNIT 12 : SOFTWARE TOOLS – SPSS

1. Introduction to SPSS

- Meaning and full form of SPSS (Statistical Package for the Social Sciences)
- Historical development of SPSS
- Importance of SPSS in statistical data analysis
- Areas of application: social sciences, management, health sciences, education, and research
- Advantages and limitations of SPSS

2. Basics of SPSS Environment

- Installation and launching of SPSS
- SPSS interface and main components
    - Data View
    - Variable View
    - Output Viewer
- Menu system and toolbars
- Types of files used in SPSS

3. Data Entry and Data Management in SPSS

- Defining variables in Variable View
- Types of variables and measurement scales
- Coding of data
- Data entry methods
- Importing data from Excel, CSV, and text files
- Editing, sorting, and filtering data
- Handling missing values

4. Descriptive Statistics Using SPSS

- Concept and role of descriptive statistics
- Frequency distributions
- Measures of central tendency: mean, median, mode
- Measures of dispersion: range, variance, standard deviation
- Graphical presentation: bar charts, histograms, pie charts, boxplots
- Interpretation of descriptive output

5. Data Analysis and Reporting in SPSS

- Running statistical procedures
- Understanding SPSS output tables and charts
- Exporting results to Word, Excel, and PDF
- Best practices for reporting results

6. Applications and Limitations of SPSS

- Use of SPSS in academic research
- Applications in surveys and experimental studies
- Limitations of SPSS
- Comparison with other statistical software (brief overview)