

Skill Enhancement Paper

SEC-2: Computer Algebra Systems and Related Software

Total Marks: 100 (Theory: 38, Internal Assessment: 12, and Practical: 50)

Workload: 2 Lectures, 4 Practicals (per week) **Credits:** 4 (2+2)

Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) **Examination:** 2 Hrs.

Course Objectives: This course aims at familiarizing students with the usage of computer algebra systems (/Mathematica/MATLAB/Maxima/Maple) and the statistical software **R**. The basic emphasis is on plotting and working with matrices using CAS. Data entry and summary commands will be studied in **R**. Graphical representation of data shall also be explored.

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

- i) Use of computer algebra systems (Mathematica/MATLAB/Maxima/Maple etc.) as a calculator, for plotting functions and animations
- ii) Use of CAS for various applications of matrices such as solving system of equations and finding eigenvalues and eigenvectors.
- iii) Understand the use of the statistical software **R** as calculator and learn to read and get data into **R**.
- iv) Learn the use of **R** in summary calculation, pictorial representation of data and exploring relationship between data.
- v) Analyze, test, and interpret technical arguments on the basis of geometry.

Unit 1: Introduction to CAS and Applications

Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Plotting functions of two variables using Plot3D and ContourPlot, Plotting parametric curves surfaces, Customizing plots, Animating plots, Producing tables of values, working with piecewise defined functions, Combining graphics.

Unit 2: Working with Matrices

Simple programming in a CAS, Working with matrices, Performing Gauss elimination, operations (transpose, determinant, inverse), Minors and cofactors, Working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue, eigenvector and diagonalization.

Unit 3: R - The Statistical Programming Language

R as a calculator, Explore data and relationships in **R**. Reading and getting data into **R**: Combine and scan commands, Types and structure of data items with their properties, Manipulating vectors, Data frames, Matrices and lists, Viewing objects within objects, Constructing data objects and conversions.

Unit 4: Data Analysis with R

Summary commands: Summary statistics for vectors, Data frames, Matrices and lists, Summary tables, Stem and leaf plot, Histograms, Plotting in **R**: Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts and bar charts, Copy and save graphics to other applications.

References:

1. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*. CRC Press, Taylor & Francis Group, LLC.
2. Torrence, Bruce F., & Torrence, Eve A. (2009). *The Student's Introduction to Mathematica[®]: A Handbook for Precalculus, Calculus, and Linear Algebra* (2nd ed.). Cambridge University Press.
3. Gardener, M. (2012). *Beginning R: The Statistical Programming Language*, Wiley.

Additional Reading:

- i. Verzani, John (2014). *Using R for Introductory Statistics* (2nd ed.). CRC Press, Taylor & Francis Group.

Note: Theoretical and Practical demonstration should be carried out only in **one** of the CAS: Mathematica/MATLAB/Maxima/Scilab or any other.

Practical / Lab work to be performed in Computer Lab.

[1] Chapter 12 (Exercises 1 to 4 and 8 to 12), Chapter 14 (Exercises 1 to 3)

[2] Chapter 3 [Exercises 3.2(1 and 2), 3.3(1, 2 and 4), 3.4(1 and 2), 3.5(1 to 4), 3.6(2 and 3)].

[2] Chapter 6 (Exercises 6.2 and 6.3) and Chapter 7 [Exercises 7.1(1), 7.2, 7.3(2), 7.4(1) and 7.6].

Note: Relevant exercises of [3] Chapters 2 to 5 and 7 (The practical may be done on the database to be downloaded from <http://data.gov.in/>).

Teaching Plan (Theory of SEC-1: Computer Algebra Systems and Related Software):

Weeks 1 to 3: Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Producing tables of values, Working with piecewise defined functions, Combining graphics. Simple programming in a CAS.

[1] Chapter 12 (Sections 12.1 to 12.5).

[2] Chapter 1, and Chapter 3 (Sections 3.1 to 3.6 and 3.8).

Weeks 4 and 5: Plotting functions of two variables using Plot3D and contour plot, Plotting parametric curves surfaces, Customizing plots, Animating plots.

[2] Chapter 6 (Sections 6.2 and 6.3).

Weeks 6 to 8: Working with matrices, Performing Gauss elimination, Operations (Transpose, Determinant, Inverse), Minors and cofactors, Working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue, Eigenvector and diagonalization.

[2] Chapter 7 (Sections 7.1 to 7.8).

Weeks 9 to 11: R as a calculator, Explore data and relationships in R. Reading and getting data into R: Combine and scan commands, Types and structure of data items with their properties. Manipulating vectors, Data frames, Matrices and lists. Viewing objects within objects. Constructing data objects and conversions.

[1] Chapter 14 (Sections 14.1 to 14.4).

[3] Chapter 2, and Chapter 3.

Weeks 12 to 14: Summary commands: Summary statistics for vectors, Data frames, Matrices and lists. Summary tables. Stem and leaf plot, histograms. Plotting in R: Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts and Bar charts. Copy and save graphics to other applications.

[1] Chapter 14 (Section 14.7).

[3] Chapter 5 (up to Page 157), and Chapter 7.

Facilitating the Achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Use of computer algebra systems (Mathematica/MATLAB/Maxima/Maple etc.) as a calculator, for plotting functions and animations	(i) Each topic to be explained with illustrations using CAS or R .	<ul style="list-style-type: none"> • Presentations and class discussions. • Assignments and class tests. • Mid-term examinations. • End-term examinations.
2.	Use of CAS for various applications of matrices such as solving system of equations and finding eigenvalues and eigenvectors.	(ii) Students to be given homework/ assignments.	
3.	Understand the use of the statistical software R as calculator and learn to read and get data into R .	(iii) Students to be encouraged to do look for new applications.	
4.	Learn the use of R in summary calculation, pictorial representation of data and exploring relationship between data. Analyze, test, and interpret technical arguments on the basis of geometry.		

Keywords: Plot3D, ContourPlot, Calculator, Summary commands, Histograms.