
MATLAB Essentials: Symbolic and Numeric Problem-Solving in Engineering

1. Title

MATLAB Essentials: Symbolic and Numeric Problem-Solving in Engineering — Lester W. Schmerr, Jr., Springer, 1st Edition, 2025. The verified publisher TOC contains seven substantive chapters, followed by two appendices.

2. Target Audience

This course is intended for engineering students, practicing engineers, researchers, and learners in scientific fields who need to use MATLAB as an interactive engineering problem-solving environment. It is suitable for learners who have a basic mathematical background and want to develop practical proficiency with MATLAB's numerical and symbolic capabilities, including vectors, matrices, linear equations, ordinary differential equations, nonlinear problems, and engineering visualization. The source specifically identifies engineering students, practicing engineers, and researchers as its intended audience.

3. Course Outcomes

- Understand the MATLAB environment, Command Window, workspace, functions, commands, and fundamental computational operations.
- Apply MATLAB vector and matrix operations to engineering problems.
- Create numerical and symbolic solutions for linear, differential, and nonlinear equations.
- Analyze engineering vector and matrix problems using MATLAB.
- Implement numerical solutions of ordinary differential equations using MATLAB.
- Optimize nonlinear engineering problem-solving workflows using appropriate MATLAB capabilities.
- Design effective two-dimensional and three-dimensional engineering plots.
- Evaluate numerical solution accuracy and control errors in computational results.
- Troubleshoot MATLAB calculations, variables, functions, scripts, and computational workflows.
- Prepare reusable MATLAB scripts, functions, function handles, and workspace data.

4. Course Objectives

- Establish a structured progression from fundamental MATLAB interaction to engineering problem-solving.
- Develop proficiency with MATLAB's numerical and symbolic capabilities.

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- Build practical competence in vectors, matrices, linear equations, differential equations, and nonlinear equations.
 - Develop engineering-oriented computational workflows using MATLAB.
 - Reinforce learning through the engineering examples and exercises contained in the source text.
 - Develop visualization skills for two-dimensional, three-dimensional, and symbolic plots.
 - Introduce reusable MATLAB scripts, functions, function handles, and workspace-management techniques.

5. Course Outline

The course comprises 32 hours of theory and labs and is divided into 7 different chapters. Each chapter will be followed by hands-on lab exercises to reinforce learning and gauge understanding of the topics covered. The source book contains seven substantive chapters, with Appendix A: MATLAB Resources and Appendix B: Supplemental Material provided as supporting material.

6. Table of Contents (TOC)

Chapter 1 – Introduction

- Overview
 - MATLAB Toolboxes
 - About this Chapter
- MATLAB Essentials
 - Getting Started
 - The MATLAB Desktop, Command Window, and REPL
 - Editor and Command Window
 - Current Folder Window
 - Workspace Window
 - Using the Keyboard, Clearing the Command Window, and Canceling Execution
 - Simple Calculations and Suppressing Output
 - Clearing Variables and Managing the Workspace
 - Floating Point Arithmetic and the Display of Numbers
 - The Variables Nan, Eps, and Inf
 - Mathematical Operations and Constants/Variables
 - Adding Comments and Continuing Input Lines
 - Complex Variables and Arithmetic
 - MATLAB Functions
 - Scalars, Vectors, and Arrays

- Colon Notation
- Use of the Linspace Function
- Direct Vector Generation
- Matrix Generation
- Element-by-Element Operations and Functions
- Operator Precedence
- Strings, Characters, and Cell Vectors
- Plotting Essentials
- Command/Function Duality
- Anonymous Functions in the Command Window
- Relational Operations and Logical Operators
- Getting Help
- Symbolic Variables, Operations, and Plotting
 - Defining Symbolic Variables
 - Defining Symbolic Functions
 - Substitution
 - Differentiation
 - Integration
 - Double Integrals
 - Symbolic Plotting
 - Piecewise Symbolic Functions
- Directory and File Management
- Control Statements
 - For Loops
 - If, Else, Elseif Statements
- Scripts, Functions, and Handles
 - Writing Scripts
 - Writing Functions
 - Function Handles
- Saving and Loading Workspace Data
- Diary of Command Window Interactions
- About this Book

Chapter 2 – Vectors and Vector Operations

- Vectors in MATLAB
 - Row and Column Vectors and the Vector Transpose
 - Vector Operations

- Accessing/Removing Vector Components and Determining the Size of a Vector
- Using Logical Values to Index Vector Components
- Symbolic Vectors
- Three-Dimensional and Two-Dimensional Vectors in Engineering
 - Cartesian Unit Vectors
 - The Dot Product
 - Direction Cosines
 - The Vector Cross Product

Chapter 3 – Matrices and Matrix Operations

- Matrices (Arrays) in MATLAB
 - Defining Matrices and Accessing Them
 - Special Matrices
 - Symbolic Matrices
 - Eliminating Rows or Columns
 - Matrix Addition, Subtraction, and Multiplication by a Constant
 - Multiplication of Matrices
 - Matrix Functions
 - Size of a Matrix
 - Transpose of a Matrix
 - Determinant of a Matrix
 - Inverse of a Matrix
 - Adjoint of a Matrix
 - Eigenvalues and Eigenvectors
- Some Matrices in Engineering
 - The Direction Cosine Matrix
 - Eigenvalue Problems

Chapter 4 – Linear Equations

- Systems of Linear Equations—Numerical Solutions
- Systems of Linear Equations—Symbolic Solutions
 - Symbolic Solutions and the Solve Function
 - Symbolic Solutions of Static Equilibrium Problems
- Overdetermined and Underdetermined Systems
 - Overdetermined Systems
 - Underdetermined Systems
 - Data Fitting and Statically Indeterminate Structures

Chapter 5 – Ordinary Differential Equations

- Equations of Motion
 - A MATLAB Differential Equation Solver
 - Controlling Errors in the Numerical Solution
- Symbolic Solutions
- Use of Symbolic Algebra for Numerical Solutions
- Animations and Movies
 - MATLAB Animations
 - The Spring-Pendulum
 - MATLAB Movies

Chapter 6 – Nonlinear Problems

- Numerical Solutions of Nonlinear Equations
 - A Nonlinear Equation in One Unknown
 - Nonlinear Equations with Multiple Unknowns
- Numerical Solutions of Nonlinear Equations with Symbolic Functions
- Symbolic Formation and Solution of Nonlinear Equations
- Remarks on Optimization

Chapter 7 – Advanced Plotting

- Two-Dimensional Plots
 - Controlling Plot Axes
 - Line Styles, Markers, Colors, and Other Line Properties
 - Plot Box, Grid, and Tick Marks
 - Text Symbols, Formatting, and Special Characters
 - Multiple Plots and Plots with Two Y-Axes
 - Subplots
 - Specialized Plots
- Three-Dimensional Plots
 - Line Plots in 3-D
 - Plotting Functions of Two Variables
 - RGB Colormaps
 - Specialized Plots
 - Symbolic Plotting
 - Parametric Line Plots
 - Mesh Plots

· Surf Plots