

NUMERICAL METHODS *with* EXCEL

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PREFACE

Numerical methods provide approximation solutions when exact solutions are not available. Calculation in numerical methods is time consuming as it involves repetitive procedure and thus, a scientific calculator alone is not adequate. *Numerical Methods with Microsoft Excel®* offers spreadsheet skills for engineering students with little knowledge of programming. It does not include macros which require writing program codes. As Microsoft Excel® is readily available to almost all notebooks, students can access Excel® anywhere without any hassle. The nature of the Excel® program makes numerical method problems easy to be implemented, experiment and applied due to the availability of rows and columns, relative row, relative column, fix row, fix column and the graphing abilities. The simple command and immediate result display in Excel make numerical methods easy to understand compared to the conventional programming. Furthermore, the features of the spreadsheet provide an easy, fast and accurate solution. As a result, it helps to motivate students to learn numerical methods which they now can do the calculations without having to use scientific calculators.

The main objectives of this book are

- to teach engineering students who take Numerical Methods at an undergraduate and postgraduate levels, covering from fundamentals to advance topics of numerical methods.
- to prepare students with spreadsheet skills which can assist them in their future area of specialization.

The aim of this book is to make it as comprehensive as possible for students. We present solutions for each example given in the chapters. A step-by-step Excel commands are given after the numerical examples. In addition to that, the related built-in functions in the Excel spreadsheet are also given for direct solution. We end each chapter with exercises to strengthen students' problem solving skills. We encourage students to do these exercises to better understand each topic.

This book consists of eleven chapters. We provide an introduction to Microsoft Excel® for those who are unfamiliar with spreadsheet in the first chapter. This is a self-study section. Students may read through this chapter and at the same time, do the examples provided.

Chapter 2 discusses the implementation of non-linear equations by using Bisection, Newton-Raphson, Secant and fixed-point iteration methods. Solutions of the multiple roots and system of non-linear equation are also

included. We show the usage of two Excel built-in functions; *Goal Seek* to solve non-linear equations and *solver* to solve systems of non-linear equations.

Chapter 3 focuses on the methods to solve systems of linear equations. Two methods, which are direct and iterative methods, are presented. In direct method, the forward substitution and the backward substitution methods are discussed. It is followed by the discussion on Gauss elimination method, matrix inversion method, Cramer's rule and triangular factorization. For the iterative method, Jacobi and Gauss-Seidel methods are covered.

Chapter 4 is about interpolation. Lagrange interpolation and Newton's divided difference methods will estimate the corresponding value of y for an intermediate value of x which is not in the data set. Likewise, the inverse of both methods will approximate the value of x for a certain value of y which is in the range of the list. Multivariate approximation based on Lagrange interpolation is also included.

Chapter 5 covers numerical differentiation which include equally and unequally spaced data. It also introduces Richardson's extrapolation approach that increases the accuracy of a numerical differentiation.

Chapter 6 contains trapezoidal rule, Simpson's $\frac{1}{3}$ rule, Simpson's $\frac{3}{8}$ rule to solve numerical integration. It also introduces Romberg's integration that increases the accuracy of a numerical integration. Numerical approximation for solving multiple integrations is also shown.

Chapter 7 discusses eigenvalues and eigenvectors problems. Power method is used for finding the most dominant eigenvalue and its corresponding eigenvector, whereas inverse power and shifted power methods are used to find the smallest eigenvalue and its corresponding eigenvector.

Chapter 8 deals with Ordinary Differential Equations (ODEs). We showed the implementation of numerical solution of initial-value problem (IVP) of ODEs by Euler, second-order Taylor's series, Midpoint, Heun, the fourth-order Runge-Kutta (RK4) and fourth-order Adams Predictor-Corrector methods with the aid of the Excel spreadsheet. Solutions of systems of ODEs by the RK4 method and boundary value problem (BVP) of the ODEs with the aid of the Excel spreadsheet are also include.

Chapter 9 is about Partial Differential Equations. Numerical solution of Parabolic (Heat equation), Hyperbolic (Wave equation) and Elliptic equation (Laplace and Poisson equations) by Excel spreadsheet are discussed. In solving heat equation implicitly, wave equation implicitly and elliptic equation, we

make use of Excel spreadsheet built-in function that involves *iterative calculation* as it is faster and easier compared to solve it manually by forming system of linear equations and then solve the linear system.

Chapter 10 takes the readers to linear programming. The basic approach, which involves graphs, provides an easy way to obtain the optimal solution of linear programming problems. The power of the simplex methods, both for maximization and minimization problems, are discussed. The irregular types in linear programming problems are given. In addition, the application of the *spreadsheet solver* is explained in detail so that the optimal solution of linear programming problems can be easily obtained.

Chapter 11 provides the statistical inference on the hypothesis testing and the regression models. It starts from the discussion on the hypothesis testing and followed by the simple linear regression models. We extend the model to the multiple regression models. Each formulated coefficient is examined with a hypothesis testing to verify the model that has been constructed. The *data analysis tool*, particularly for examining the regression model in the spreadsheet is also discussed.

Although this book has gone through the process of editing and revision, we believe it may still contain some technical errors. Therefore, we appreciate if you can give us your feedback, comments or suggestions for its continuous improvement.

We believe this book is beneficial to lecturers and students in teaching and learning numerical methods. Lastly but not least, we hope this book will provide a different way on how students perceive Numerical Methods and find this subject more interesting.

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TABLE OF CONTENTS

Chapter 1	An Introduction to Microsoft Excel	1
1.0	Introduction	1
1.1	Getting Started	1
1.1.1	Copy and Paste	1
1.1.2	Enter, Drag and Move	4
1.1.3	Rank and Sort	4
1.1.4	Fixed Columns and Rows	5
1.2	Calculations in Spreadsheet	6
1.2.1	Basic Operations	7
1.2.2	Logarithm and Exponential	8
1.2.3	Sine and Cosine	9
1.3	Exploring Data in Spreadsheet	10
1.4	Functions Evaluation with Spreadsheet	11
1.4.1	Typing A Function	11
1.4.2	Evaluation of A Single-Variable Function	12
1.4.3	Evaluation of A Two-Variable Function	13
1.4.4	Built-In Functions	13
1.5	Operations on Vectors and Matrices	14
1.5.1	Defining A Vector	15
1.5.2	Matrices Calculations	16
1.6	Graphing With Spreadsheet	17
1.6.1	Interactive Graphing For Polynomial Functions	21
1.6.2	Interactive Graphing For Trigonometry Functions	23
Chapter 2	Non-Linear Equations	25
2.0	Introduction	25
2.1	Intermediate Value Theorem	25
2.2	Bisection Method	26
2.3	Secant Method	27
2.4	Newton's Method	29
2.5	Fixed Point Iteration Method	30
2.6	Solving Non-Linear Equation By Excel Package	32
2.7	Multiple Roots	33
2.8	System of Non-linear Equations	35
2.8.1	Newton's Method	35
2.8.2	Fixed-Point Iteration Method	39
2.8.3	Solving System of Non-Linear Equation By Excel Package	41
	Summary	43
	Exercises 2	44
Chapter 3	System of Linear Equations	55
3.0	Introduction	55
3.1	Direct Methods	56
3.1.1	Forward Substitution Method	56
3.1.2	Backward Substitution Method	57
3.1.3	Gauss Elimination Method	59
3.1.4	Matrix Inversion Method	60
3.1.5	Cramer's Rule	61

3.1.6	Triangular Factorization	63
3.2	Iterative Methods	65
3.2.1	Jacobi Method	66
3.2.2	Gauss-Seidel Method	67
	Summary	69
	Exercises 3	69
Chapter 4	Interpolations	73
4.0	Introduction	73
4.1	Lagrange Interpolation	73
4.2	Newton's Divided Difference	76
4.3	Inverse Interpolation	77
4.3.1	Lagrange Inverse Interpolation	77
4.3.2	Newton's Divided Difference Inverse Interpolation	78
4.4	Multivariate Approximation	80
	Summary	83
	Exercises 4	84
Chapter 5	Numerical Differentiation	91
5.0	Introduction	91
5.1	Difference Formula	91
5.2	Numerical Differentiation with Unequally Spaced Data	96
5.3	Ricardson Extrapolation	98
	Summary	100
	Exercises 5	101
Chapter 6	Integration Differentiation	107
6.0	Introduction	107
6.1	Trapezoidal Rule	107
6.2	Simpson's $\frac{1}{3}$ Rule	109
6.3	Simpson's $\frac{3}{8}$ Rule	111
6.4	Numerical Integration with Unequally Spaced Data	113
6.5	Romberg Integration	115
6.6	Numerical Multiple Integration	117
	Summary	119
	Exercises 6	120
Chapter 7	Eigenvalue Problems	125
7.0	Introduction	125
7.1	Power Method	125
7.2	Inverse Power Method	127
7.3	Shifted Power Method	128
	Summary	130
	Exercises 7	130
Chapter 8	Ordinary-Differential Equations (ODEs)	133
8.0	Introduction	133

8.1	Initial-Value Problem (IVP)	133
8.1.1	Euler's Method	134
8.1.2	Taylor's Method	134
8.1.3	Midpoint (Improved Euler's) Method	135
8.1.4	Heun's Method (Modified Euler's Method)	137
8.1.5	Fourth-Order Runge-Kutta Method (RK4)	138
8.1.6	Fourth-Order Adams Predictor-Corrector Method	140
8.2	System of First-Order Differential Equations	142
8.3	Boundary-Value Problem (BVP) of Second-Order Differential Equation	144
8.3.1	Shooting Method	145
8.3.2	BVP: Finite-Difference Method	147
	Summary	149
	Exercise 8	151
Chapter 9	Partial Differential Equations	183
9.0	Introduction	183
9.1	Parabolic Equation: Heat Equation	184
9.1.1	Explicit Method	185
9.1.2	Implicit Method	187
9.1.3	Derivative Boundary Conditions For Heat Equation	191
9.2	Hyperbolic Equation: Wave Equation	193
9.2.1	Explicit Method	194
9.2.2	Implicit Method	197
9.3	Elliptic Equation	205
9.3.1	Laplace Equation With Dirichlet Boundary Conditions	205
9.3.2	Laplace Equation With Derivative Boundary Conditions	208
9.3.3	Poisson Equation With Dirichlet Boundary Conditions	214
9.3.4	Poisson Equation With Derivative Boundary Conditions	216
	Summary	220
	Exercise 9	221
Chapter 10	Linear Programming	235
10.0	Introduction	235
10.1	Graphical Approach	236
10.2	Simplex Method for Maximization Problems	238
10.3	Simplex Methods for Minimization Problems	243
10.3.1	The M Method	244
10.3.2	Two-Phase Method	249
10.4	Dual Simplex Method	255
10.5	Duality	259
10.6	Irregular Types of Linear Programming Problems	262
10.6.1	Infeasibility	262
10.6.2	Unboundedness	262
10.6.3	Alternative Optimal Solutions	264
10.6.4	Degeneracy	265
10.6.5	Special Cases for Dual Problem	267
10.7	Using Solver	267
	Summary	272
	Exercises 10	272

Chapter 11	Hypothesis Testing and Regression Models	277
11.0	Introduction	277
11.1	Hypothesis Testing	277
11.2	The Linear Regression	279
11.2.1	Simple Linear Regression Equation	281
11.2.2	The Multiple Linear Regression	287
11.3	Using Data Analysis Tools in Spreadsheet	293
	Summary	296
	Exercises 11	297