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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