

Chapter 5

FINITE-DIFFERENCE METHODS

1. Boundary Value Problems for Ordinary Differential Equations

Some types of problems from fluid dynamics lead to boundary value problems for differential equations of the form

$$\frac{d^2y}{dx^2} + A(x)\frac{dy}{dx} + B(x)y = C(x), x \in [x_{\min}, x_{\max}], \quad (5.1)$$

$$y(x_{\min}) = y_m, \quad y(x_{\max}) = y_M.$$

The first step to approximately solve these problems by finite differences is to construct the grid

$$x_{\min} = x_0, \dots, x_j = jh, \dots, x_{N+1} = x_{\max}, j = 0, \dots, N + 1$$

with the step size $\Delta x = h = \frac{1}{N+1}$. The values of y evaluated at these points x_j will be denoted by y_j . We will evaluate also the derivatives of y at the same points x_j using the values of y at the neighboring grid points. From the Taylor expansion we have, for a small h ,

$$y_{j+m} \equiv y(x_j + mh) = y_j + mhy'_j + \frac{(mh)^2}{2!}y''_j + \frac{(mh)^3}{3!}y'''_j + \dots$$

Therefore,

$$y_{j-1} = y_j - hy'_j + \frac{h^2}{2}y''_j - \frac{h^3}{6}y'''_j + \dots,$$

$$y_{j+1} = y_j + hy'_j + \frac{h^2}{2}y''_j + \frac{h^3}{6}y'''_j + \dots$$

and, consequently,

$$y'_j = \frac{y_{j+1} - y_{j-1}}{2h} - \frac{h^2}{6}y'''_j + \dots$$

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Victor M. Corman



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Numerical Methods and Modeling for Chemical Engineers Mark E. Davis, 2013-01-01 Geared toward advanced undergraduates or graduate students of chemical engineering studying applied mathematics this text introduces the quantitative treatment of differential equations arising from modeling physical phenomena in chemical engineering Coverage includes topics such as ODE IVPs placing emphasis on numerical methods and modeling implemented in commercial mathematical software available in 1985 *Paper*, 1982 **Technical Book Review Index**, 1970 **Dissertation Abstracts International**, 2003 **Computational Fluid Dynamics** Michael B. Abbott, David R. Basco, 1989 *Construction of Integration Formulas for Initial Value Problems* P. J. van der Houwen, 1977 **Engineering**, 1957 **Automatic Control Theory & Applications**, 1978 *International Computer Bibliography* Stichting Studiecentrum voor Administratieve Automatisering, National Computing Centre Limited, 1968 **INIS Atomindex**, 1987 *Mesoscale Meteorological Modeling* Roger A. Pielke, 2013-10-08 This chapter provides a framework to assess the quantitative accuracy of numerical computational tools that are used to model advection subgrid scale fluxes the pressure gradient force and the Coriolis effect Exact solutions are presented for linear forms of these terms Nonlinear effects are also discussed including the concept of aliasing in which information is transferred between spatial scales Among the results it is shown that two grid increments are required to minimally resolve a modeled field with at least four increments in each spatial direction and probably more required to adequately resolve the modeled variables **10th IMACS World Congress, August 8-13, 1982: Numerical methods for scientific computation, Computers and computer arithmetics for scientific computation, Languages and codes for continuous systems**, 1982 **Highway Research Abstracts**, 1993 **IRE Transactions on Automatic Control**, 1956 **Water Power**, 1964 **Bulletin of the Institution of Engineers (India)**. Institution of Engineers (India), 1986 *Aeronautical Engineering Review*, 1957 **Archives of Acoustics Quarterly**, 2017 **Chemical Engineering Progress**, 2003 **Mathematical Reviews**, 2007

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Table of Contents Chapter 5 Finite Difference Methods York University

1. Understanding the eBook Chapter 5 Finite Difference Methods York University
 - The Rise of Digital Reading Chapter 5 Finite Difference Methods York University
 - Advantages of eBooks Over Traditional Books
2. Identifying Chapter 5 Finite Difference Methods York University
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Chapter 5 Finite Difference Methods York University
 - User-Friendly Interface
4. Exploring eBook Recommendations from Chapter 5 Finite Difference Methods York University
 - Personalized Recommendations
 - Chapter 5 Finite Difference Methods York University User Reviews and Ratings
 - Chapter 5 Finite Difference Methods York University and Bestseller Lists

5. Accessing Chapter 5 Finite Difference Methods York University Free and Paid eBooks
 - Chapter 5 Finite Difference Methods York University Public Domain eBooks
 - Chapter 5 Finite Difference Methods York University eBook Subscription Services
 - Chapter 5 Finite Difference Methods York University Budget-Friendly Options
6. Navigating Chapter 5 Finite Difference Methods York University eBook Formats
 - ePub, PDF, MOBI, and More
 - Chapter 5 Finite Difference Methods York University Compatibility with Devices
 - Chapter 5 Finite Difference Methods York University Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Chapter 5 Finite Difference Methods York University
 - Highlighting and Note-Taking Chapter 5 Finite Difference Methods York University
 - Interactive Elements Chapter 5 Finite Difference Methods York University
8. Staying Engaged with Chapter 5 Finite Difference Methods York University
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Chapter 5 Finite Difference Methods York University
9. Balancing eBooks and Physical Books Chapter 5 Finite Difference Methods York University
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Chapter 5 Finite Difference Methods York University
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Chapter 5 Finite Difference Methods York University
 - Setting Reading Goals Chapter 5 Finite Difference Methods York University
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Chapter 5 Finite Difference Methods York University
 - Fact-Checking eBook Content of Chapter 5 Finite Difference Methods York University
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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