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

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

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

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

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,

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

Therefore,

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

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

and, consequently,

$$y'_j = \frac{y_{j+1} - y_j}{h} - \frac{h}{2}y''_j + \cdots .$$

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Minjie Lin

Chapter 5 Finite Difference Methods York University:

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 *Mathematical Reviews* ,2007 **Computational Electrodynamics** Allen Taflove,Susan C. Hagness,2005 This extensively revised and expanded third edition of the Artech House bestseller Computational Electrodynamics The Finite Difference Time Domain Method offers you the most up to date and definitive resource on this critical method for solving Maxwell s equations There has been considerable advancement in FDTD computational technology over the past few years and this new edition brings you the very latest details with four new invited chapters on advanced techniques for PSTD unconditional stability provably stable FDTD FETD hybrids and hardware acceleration Moreover you find many completely new sections throughout the book including major updates on convolutional PML ABCs dispersive nonlinear classical gain and quantum gain materials and micro nano and bio photonics *Finite Element and Finite Difference Methods in Electromagnetic Scattering* Michael A. Morgan,1990 The Shortest Path Method for Seismic Ray Tracing in Complicated Media Tijmen Jan Moser,1992 **SIAM Journal on Applied Mathematics** ,1962 Contains research articles on mathematical methods and their applications in the physical engineering biological and medical sciences Conference Publication ,1988 **The Design and Application of Parallel Digital Processors, 11-15 April 1988** ,1988 *Nonlinear Dynamics of Production Systems* Günter Radons,Reimund Neugebauer,2004 This reference work provides a comprehensive insight into the recent developments of applications of Nonlinear Dynamics in the field of production systems Applications range from manufacturing and process engineering to selected topics in mechanical engineering automation technology and plant management This compilation of contributions shows how methods of Nonlinear Dynamics can be used to solve problems arising in traditional or non conventional manufacturing techniques such as turning high speed milling laser welding jet cutting or electrochemical processing Recent progress in optimizing the dynamics of production lines and complete production systems is also covered The book addresses both experts in Nonlinear Dynamics who want to apply their methods to real world problems and practitioners who seek solutions for their engineering problems **Journal of flight sciences and space research** ,1993 Reviews in Partial Differential Equations, 1980-86, as Printed in Mathematical Reviews ,1988 *A M. Kir. Ferencz Jozsef-Tudomanyegyetem tudomanyos ko zlemenyei. Mathematikai tudomanyok* József Attila Tudományegyetem,1979 *Transactions of the ASAE.* American Society of Agricultural Engineers,1993 *Journal of Heat Transfer* ,1987 Publishes research on energy transfer in equipment and applied thermodynamic processes in all fields of mechanical engineering and related industries Topic areas include

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