

1. Record Nr.	UNINA9910787623703321
Autore	Sengupta Tapan Kumar <1955->
Titolo	High accuracy computing methods : fluid flows and wave phenomena / / Tapan K. Sengupta [[electronic resource]]
Pubbl/distr/stampa	Cambridge : , : Cambridge University Press, , 2013
ISBN	1-107-06965-3 1-107-05783-3 1-107-05456-7 1-107-05907-0 1-107-05561-X 1-139-15182-7
Descrizione fisica	1 online resource (xix, 569 pages) : digital, PDF file(s)
Classificazione	COM000000
Disciplina	532/.050285
Soggetti	Fluid dynamics - Data processing Wave mechanics - Data processing Spectrum analysis - Data processing
Lingua di pubblicazione	Inglese
Formato	Materiale a stampa
Livello bibliografico	Monografia
Note generali	Title from publisher's bibliographic system (viewed on 05 Oct 2015).
Nota di bibliografia	Includes bibliographical references and index.
Nota di contenuto	Machine generated contents note: ch. 1 Basic Ideas of Scientific Computing -- 1.1.Overview on Scientific Computing -- 1.2.Major Milestones in Electronic Computing -- 1.3.Supercomputing and High Performance Computing -- 1.3.1.Parallel and cluster computing -- 1.3.2.Algorithmic issues of HPC -- 1.4.Computational Fluid Mechanics -- 1.5.Role of Computational Fluid Mechanics -- ch. 2 Governing Equations in Fluid Mechanics -- 2.1.Introduction -- 2.2.Basic Equations of Fluid Mechanics -- 2.2.1.Finite control volume -- 2.2.2.Infinitesimal fluid element -- 2.2.3.Substantive derivative -- 2.3.Equation of Continuity -- 2.4.Momentum Conservation Equation -- 2.5.Energy Conservation Equation -- 2.6.Alternate Forms of Energy Equation -- 2.7.The Energy Equation in Conservation Form -- 2.8.Notes on Governing Equations -- 2.9.Strong Conservation and Weak Conservation Forms -- 2.10.Boundary and Initial Conditions (Auxiliary Conditions) -- 2.11.Equations of Motion in Non-Inertial Frame -- 2.12.Equations of Motion in Terms of Derived Variables -- 2.13.Vorticity-

Vector Potential Formulation -- 2.14. Pressure Poisson Equation -- 2.15. Comparison of Different Formulations -- 2.16. Other Forms of Navier-Stokes Equation -- ch. 3 Classification of Quasi-Linear Partial Differential Equations -- 3.1. Introduction -- 3.2. Classification of Partial Differential Equations -- 3.3. Relationship of Numerical Solution Procedure and Equation Type -- 3.4. Nature of Well-Posed Problems -- 3.5. Non-Dimensional Form of Equations -- ch. 4 Waves and Space-Time Dependence in Computing -- 4.1. Introduction -- 4.2. The Wave Equation -- 4.2.1. Plane waves -- 4.2.2. Three-dimensional axisymmetric wave -- 4.2.3. Doppler shift -- 4.2.4. Surface gravity waves -- 4.3. Deep and Shallow Water Waves -- 4.4. Group Velocity and Energy Flux -- 4.4.1. Physical and computational implications of group velocity -- 4.4.2. Wave-packets and their propagation -- 4.4.3. Waves over layer of constant depth -- 4.4.4. Waves over layer of variable depth $H(x)$ -- 4.4.5. Wave refraction in shallow waters -- 4.4.6. Finite amplitude waves of unchanging form in dispersive medium -- 4.5. Internal Waves at Fluid Interface: Rayleigh-Taylor Problem -- 4.5.1. Internal and surface waves in finite over an infinite deep layer of fluid -- 4.5.2. Barotropic or surface mode -- 4.5.3. Baroclinic or internal mode -- 4.5.4. Rotating shallow water equation and wave dynamics -- 4.6. Shallow Water Equation (SWE) -- 4.6.1. Various frequency regimes of SWE -- 4.7. Additional Issues of Computing: Space-Time Resolution of Flows -- 4.7.1. Spatial scales in turbulent flows -- 4.8. Two- and Three-Dimensional DNS -- 4.9. Temporal Scales in Turbulent Flows -- 4.10. Computing Time-Averaged and Unsteady Flows -- ch. 5 Spatial and Temporal Discretizations of Partial Differential Equations -- 5.1. Introduction -- 5.2. Discretization of Differential Operators -- 5.2.1. Functional representation by the Taylor series -- 5.2.2. Polynomial representation of function -- 5.3. Discretization in Non-Uniform Grids -- 5.4. Higher Order Representation of Derivatives Using Operators -- 5.5. Higher Order Upwind Differences -- 5.5.1. Symmetric stencil for higher derivatives -- 5.6. Numerical Errors -- 5.7. Time Integration -- 5.7.1. Single-step methods -- 5.7.2. Single-step multi-stage methods -- 5.7.3. Runge-Kutta methods -- 5.7.4. Multi-step time integration schemes -- ch. 6 Solution Methods for Parabolic Partial Differential Equations -- 6.1. Introduction -- 6.2. Theoretical Analysis of the Heat Equation -- 6.3. A Classical Algorithm for Solution of the Heat Equation -- 6.4. Spectral Analysis of Numerical Methods -- 6.4.1. A higher order method or Milne's method -- 6.5. Treating Derivative Boundary Condition -- 6.6. Stability, Accuracy and Consistency of Numerical Methods -- 6.6.1. Richardson's method -- 6.6.2. Du Fort -- Frankel method -- 6.7. Implicit Methods -- 6.8. Spectral Stability Analysis of Implicit Methods -- Appendix I -- ch. 7 Solution Methods for Elliptic Partial Differential Equations -- 7.1. Introduction -- 7.2. Jacobi or Richardson Iteration -- 7.3. Interpretation of Classical Iterations -- 7.4. Different Point and Line Iterative Methods -- 7.4.1. Gauss-Seidel point iterative method -- 7.4.2. Line Jacobi method -- 7.4.3. Explanation of line iteration methods -- 7.5. Analysis of Iterative Methods -- 7.6. Convergence Theorem for Stationary Linear Iteration -- 7.7. Relaxation Methods -- 7.8. Efficiency of Iterative Methods and Rate of Convergence -- 7.8.1. Method of acceleration due to Lyusternik -- 7.9. Alternate Direction Implicit (ADI) Method -- 7.9.1. Analysis of ADI method -- 7.9.2. Choice of acceleration parameters -- 7.9.3. Estimates of maximum and minimum eigenvalues -- 7.9.4. Explanatory notes on ADI and other variant methods -- 7.10. Method of Fractional Steps -- 7.11. Multi-Grid Methods -- 7.11.1. Two-Grid method -- 7.11.2. Multi-Grid method -- 7.11.3. Other classifications of multi-grid method -- ch. 8 Solution of Hyperbolic PDEs: Signal and Error Propagation -- 8.1.

Introduction -- 8.2. Classical Methods of Solving Hyperbolic Equations -- 8.2.1. Explicit methods -- 8.3. Implicit Methods -- 8.4. General Characteristics of Various Methods for Linear Problems -- 8.5. Non-linear Hyperbolic Problems -- 8.6. Error Dynamics: Beyond von Neumann Analysis -- 8.6.1. Dispersion error and its quantification -- 8.7. Role of Group Velocity and Focussing -- 8.7.1. Focussing phenomenon -- ch. 9 Curvilinear Coordinate and Grid Generation -- 9.1. Introduction -- 9.2. Generalized Curvilinear Scheme -- 9.3. Reciprocal or Dual Base Vectors -- 9.4. Geometric Interpretation of Metrics -- 9.5. Orthogonal Grid System -- 9.6. Generalized Coordinate Transformation -- 9.7. Equations for the Metrics -- 9.8. Navier-Stokes Equation in the Transformed Plane -- 9.9. Linearization of Fluxes -- 9.10. Thin Layer Navier-Stokes Equation -- 9.11. Grid Generation -- 9.12. Types of Grid -- 9.13. Grid Generation Methods -- 9.14. Algebraic Grid Generation Method -- 9.14.1. One-dimensional stretching functions -- 9.15. Grid Generation by Solving Partial Differential Equations -- 9.16. Elliptic Grid Generators -- 9.17. Hyperbolic Grid Generation Method -- 9.18. Orthogonal Grid Generation for Navier-Stokes Computations -- 9.19. Coordinate Transformations and Governing Equations in Orthogonal System -- 9.19.1. Gradient operator -- 9.19.2. Divergence operator -- 9.19.3. The Laplacian operator -- 9.19.4. The curl operator -- 9.19.5. The line integral -- 9.19.6. The surface integral -- 9.19.7. The volume integral -- 9.20. The Gradient and Laplacian of Scalar Function -- 9.21. Vector Operators of a Vector Function -- 9.22. Plane Polar Coordinates -- 9.23. Navier-Stokes Equation in Orthogonal Formulation -- 9.24. Improved Orthogonal Grid Generation Method for Cambered Airfoils -- 9.24.1. Orthogonal grid generation for GA(W)-1 airfoil -- 9.24.2. Orthogonal grid generation for an airfoil with roughness element -- 9.24.3. Solutions of Navier-Stokes equation for flow past SHM-1 airfoil -- 9.24.4. Compressible flow past NACA 0012 airfoil -- 9.25. Governing Euler Equation, Auxiliary Conditions, Numerical Methods and Results -- 9.26. Flow Field Calculation Using Overset or Chimera Grid Technique -- ch. 10 Spectral Analysis of Numerical Schemes and Aliasing Error -- 10.1. Introduction -- 10.2. Spatial Discretization of First Derivatives -- 10.2.1. Second order central differencing (CD2) scheme -- 10.3. Discrete Computing and Nyquist Criterion -- 10.4. Spectral Accuracy of Differentiation -- 10.5. Spectral Analysis of Fourth Order Central Difference Scheme -- 10.6. Role of Upwinding -- 10.6.1. First order upwind scheme (UD1) -- 10.6.2. Third order upwind scheme (UD3) -- 10.7. Numerical Stability and Concept of Feedback -- 10.8. Spectral Stability Analysis -- 10.9. High Accuracy Schemes for Spatial Derivatives -- 10.10. Temporal Discretization Schemes -- 10.10.1. Euler time integration scheme -- 10.10.2. Four-stage Runge-Kutta (RK4) method -- 10.11. Multi-Time Level Discretization Schemes -- 10.11.1. Mid-point leapfrog scheme -- 10.11.2. Second order Adams-Bashforth scheme -- 10.12. Aliasing Error -- 10.12.1. Why aliasing error is important? -- 10.12.2. Estimation of aliased component -- 10.13. Numerical Estimates of Aliasing Error -- 10.14. Controlling Aliasing Error -- 10.14.1. Aliasing removal by zero padding -- 10.14.2. Aliasing removal by phase shifts and grid-staggering -- ch. 11 Higher Accuracy Methods -- 11.1. Introduction -- 11.2. The General Compact Schemes -- 11.2.1. Approximating first derivatives by central scheme -- 11.3. Method for Solving Periodic Tridiagonal Matrix Equation -- 11.4. An Example of a Sixth Order Scheme -- 11.5. Order of Approximation versus Resolution -- 11.6. Optimization Problem Associated with Discrete Evaluation of First Derivatives -- 11.7. An Optimized Compact Scheme For First Derivative by Grid Search Method -- 11.8. Upwind

Compact Schemes -- 11.9.Compact Schemes with Improved Numerical Properties -- 11.9.1.OUCS1 scheme -- 11.9.2.OUCS2 scheme -- 11.9.3.OUCS3 scheme -- 11.9.4.OUCS4 scheme -- 11.10. Approximating Second Derivatives -- 11.11.Optimization Problem for Evaluation of the Second Derivatives -- 11.12.Solution of One-Dimensional Convection Equation -- 11.13.Symmetrized Compact Difference Schemes -- 11.13.1.High accuracy symmetrized compact scheme -- 11.13.2.Solving bidirectional wave equation -- 11.13.3. Transitional channel flow -- 11.13.3.1.Establishment of equilibrium flow -- 11.13.3.2.Receptivity of channel flow to convecting single viscous vortex -- 11.13.4.Transitional channel flow created by vortex street -- 11.14.Combined Compact Difference (CCD) Schemes -- 11.14.1.A new combined compact difference (NCCD) scheme -- 11.14.2.Solving the Stommel Ocean Model problem -- 11.14.3. Operational aspects of the CCD schemes -- 11.14.4.Calibrating NCCD method to solve Navier-Stokes equation for 2D lid-driven cavity problem -- 11.15.Diffusion Discretization and Dealiasing Properties of Compact Schemes -- 11.15.1.Dynamics and aliasing in square LDC problem --

Sommario/riassunto

This book presents topics in a single source format using unified spectral theory of computing. With developments of DNS and LES, practitioners are rediscovering waves as important in fluid flows, and capturing these numerically is central to high accuracy computing. Analysis of waves and its use in numerical methods in propagating energy at the right velocity (dispersion effects) and with right amplitude (dissipation) are essential. Most industrial codes using Reynolds-averaged Navier-Stokes equations with turbulence models cannot conceive of capturing waves. The new themes covered in this book are:

- Correct error propagation analysis
- Practical compact schemes and global analysis tool
- Aliasing error and its alleviation
- Spurious upstream propagating q-waves
- Explanation of the Gibbs phenomenon
- New 1D and 2D filters for LES/DNS without SGS modelling
- Anisotropic skewed wave propagation
- Development and analysis of dispersion relation preservation (DRP) schemes
- Flow instabilities and wave propagation phenomena
