Computational Fluid Dynamics (Vol. 2)

Editor	Wolfgang Kollmann
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Price	$55.00
Reviewer	Clarence E. Lee

Computational Fluid Dynamics, Vol. 2, contains a collection of notes on the lecture series held at the von Karmen Institute, March 19-23, 1979.

H. Hollanders and H. Vivand, Office National d'Études et de Recherches Aérospatials Châttilon-sur-Bagneux, France, lectured on the "Numerical Treatment of Compressible High Reynolds Number Flow." The global approach (wherein no distinction is made between the viscous layer and the inviscid flow region) is discussed and reviewed in considerable theoretical detail. After formulating the Navier-Stokes equations, including general properties and boundary conditions, the time-averaged versions are developed for turbulent compressible flow using mass-averaged dependent variables. The basic Cebeci-Smith-Masinokis two-layer model and formulations independent of boundary layer approximations are reviewed. The transport-equation-based turbulence modelings of Rubesin (one equation) and Jones-Launder (two equations) are presented. Numerical finite difference techniques are surveyed in general for viscous-inviscid interaction problems. The MacCormack classical splitting up and the newer hybrid schemes are reviewed. The three time level Beam-Warning implicit schemes, including boundary treatment, are discussed. Extensions to curvilinear meshes are developed after a discussion of the transformation of the Navier-Stokes equations. The finite volume method of Deiwart in plane flow and an extension of the finite difference unsplit MacCormack scheme are outlined. The formulation and implementation of several artificial viscosity treatments (MacCormack, Richtmeyer-Morton, and Barnwell) are reviewed. Finally questions of speed, accuracy, matrix inversion, matching procedures, and numerical convergence are addressed.

E. Krause, Aerodynamisches Institut der Rheinish-Westfaelischen Technischen Hochschule Aachen, Aachen, Federal Republic of Germany, summarized the recent dissertations of N. S. Liu and F. Bartels in "The Computation of Three-Dimensional Viscous Flows." The basic ideas for solving low Reynolds number biofluiddynamics problems with moving boundaries are outlined for curved pipes and bifurcations. Using the Navier-Stokes curvilinear moving coordinate equations, the convective and dissipative momentum flux terms are expressed using the divergence of a second rank tensor. The standard conservation formulation using the Gauss theorem is used to construct spatial difference equations. The momentum and continuity equations are iterated each time step to assure self-consistency, and the total pressure and velocity are computed iteratively using Newton-Raphson until the flow is source free (Div $v = 0$). Mixed-boundary conditions compatible with the continuity equation are used for the specification of the outflow condition from a finite computational domain so that the pressure boundary conditions are eliminated. A stability analysis result for the time step restrictions is given for the curvilinear coordinate solution of this nonlinear problem. In part II, Taylor-Goertler vortices are studied computationally in spherical gaps with $Re < 2000$ and compared to experiment. A self-consistent discretized procedure is employed to solve the problem in the stream function vorticity formulation. Explicit and implicit methods were utilized. If the flow is nonturbulent, the vortex formulation is predicted accurately provided that mesh conditions from an error analysis are satisfied in terms of the spatial and time resolutions.

J. L. Lions, College de France and Iria-Laboria, Paris, lectured on "Some Aspects of the Approximation of Free Surface Problems." The theoretical solutions of free surface problems are addressed in the framework of Variational Inequalities. Approximate solutions are studied when the solutions are regular and the free boundary is smooth. The obstacle problem and Bingham fluid flow models are examined. The homographic penalty method is outlined and an iterative solution algorithm proved. Using a standard penalty method, an error estimate for the obstacle problem is proved. The formulation of stationary Bingham flows is discussed and, using incompressibility as a constraint, error bounds on the solution are estimated. Finally, the elliptic operator modeling of composite materials with periodic structure is considered and the free surface behavior examined. A number of open and unsolved questions are noted.

E. Turkel, New York University, Courant Institute of Mathematical Sciences, lectured on recent studies in "Numerical Methods for Large-Scale Time-Dependent Partial Differential Equations." The properties of the Leapfrog, Lax-Wendroff, and Implicit methods are outlined for the scalar diffusion equation, $u_t + Au_{xx} = 0$. Boundary layer coarse grid difficulties and solutions are examined for the steady-state Burgers equation. Higher order pseudospectral method formulations, advantages, and disadvantages are reviewed for $u_t + f_x = 0$ with emphasis on methods that are second order in time and various boundary treatment techniques. Several techniques are compared for the smooth solutions to the one-dimensional steady-state nozzle flow problem. Implicit methods and stability criteria for hyperbolic systems are discussed and justified for phenomena with different times scales when only the steady-state solutions are desired. Disadvantages of some of the standard techniques and possible remedies are examined. The importance of a correct boundary treatment is emphasized in order for the methods to avoid phase errors. Moving boundary and adaptive grid problems are outlined. The SMITE elastic-plastic code solution technique is summarized. Radiation boundary conditions at an artificial boundary (to simulate an infinite region) are examined specifically for the two-dimensional cylindrical linearized Euler equations and compared to the Sommerfeld condition treatment. Applications, numerical difficulties, and properly representing the problem physics are discussed for shocks, artificial viscosity, intrinsic time step limitations and splitting techniques, boundary layers, shallow water waves, chemical processes, and plasma physics problems.

The lecture material is presented in a straightforward and clear manner. The reference cutoff dates are roughly late 1978 to early 1979. All the numerical treatments are specialized to finite difference representations. It is interesting to note that although almost all the numerical schemes described are based on conservation laws, no direct mention seems to be made about the level at which balance is satisfied by the computer calculations.

The basic techniques treated are timely, are closely related to several fluid dynamic applications to nuclear engineering problems, and should certainly be of general interest to many American Nuclear Society members.

Clarence E. Lee is a professor in the Department of Nuclear Engineering at Texas A&M University. He is currently doing research on analytical and numerical methods in diffusion and transport theory, charged particle transport, high temperature gas-cooled reactors (prismatic and pebble bed), fission product migration, and fast reactor accident analysis.

Nuclear Energy (2nd ed.)

Author	Raymond L. Murray
Publisher	Pergamon Press, Inc., Elmsford, New York (1980)
Pages	317
Price	$15.00
Reviewer	Jerome G. Morse

The author has succeeded in bringing together in concise form the broader aspects of nuclear energy as a useful introductory text. It is correctly subtitled "An Introduction to the Concepts, Systems, and Applications of Nuclear Processes." Constructed in three sections, the flow is as follows: Part I treats Basic Concepts; II, Nuclear Systems; and III, Nuclear Energy and Man. Each of the 27 chapters concludes with its own brief summary, followed by a useful selection of challenging problems to enable testing the comprehension of the information presented. Answers are also provided.

The first section carries the reader through the fundamentals of nuclear energy in a well-organized, "no frills" manner. As a review of the subject, the treatment is excellent; for the new student, however, its effectiveness would be enhanced considerably by increasing the number of illustrative examples. Next is the section covering concepts and some application, and it reflects well the author's long experience in nuclear engineering. He shows a good balance between theory and hardware at this intended entry level. The section deals with particle accelerators, isotope separators, radiation detectors, fission, fusion, and breeder systems, and energy conversion methods.

In the last and largest section, Murray addresses the critical issues now facing nuclear energy, from an unemotional technical perspective. Included are the health, safety, and environmental concerns related to reactor operation and waste disposal. He is to be commended for his balanced views on timely subject matter not normally treated in texts of this type.

The book reads well; its coverage is direct and unambiguous, and is amply illustrated and referenced adequately. Its audience may comprise two major groups. As a college text, it should serve very well, and it should be equally effective as a reference/review volume for those engaged in the nuclear field.

Jerome G. Morse is adjunct associate professor of physics at the Colorado School of Mines, where he teaches graduate level courses in nuclear methods in mineral exploration and production, and radiation and its control in uranium mining and milling. Morse is also president of Morse Associates, Inc., a consulting firm addressing radiation-related environmental issues. He is a fellow of the American Nuclear Society, and co-editor in chief of Elsevier's new International Journal of Uranium.

Introduction to Metallurgical Thermodynamics (2nd ed.)

Author	David R. Gaskell
Publisher	Hemisphere Publishing Corporation, New York (1973)
Pages	611
Price	$29.95
Reviewer	Craig Shumaker

Gaskell's second edition of *Introduction to Metallurgical Thermodynamics* is not a real improvement over the first edition. The text's strengths are in the latter chapters where solutions, condensed phase reactions, and graphical representation of thermodynamic data are discussed. The early chapters suffer for a number of problems:

1. The first law material (Chap. 2) deals only with gases. No discussion of the application of the first law to condensed phases is made, such as tensile and compressive loading of metals.

2. Section 2.10 (Numerical Examples) has proven difficult for students to follow.

3. The International Union of Pure and Applied Chemistry has recommended that work be defined as positive when done on a system. Therefore, the first law is

$$\Delta E = q + w \ .$$

Gaskell has not adapted this convention in the second edition.

4. Section 3.5 (An Illustration of Irreversible and Reversible Processes) is extremely hard to follow *and* explain to students. A simpler explanation would be better.

5. The discussion of the carnot cycle in Chap. 3 is confusing because of notation and erroneous signs. Specifically, the text shows that the work obtained w is equal to $q_1 - q_2$ where it should be

$$-w_{\text{net}} = q_2 + q_1 \ .$$

The subscript "net" clarifies the work, the minus sign on w_{net} is from the positive convention for work, and the