as $(1-x^2)^{-1/2}$ as x approaches ± 1. Comparisons are made with the errors associated with derivatives of functions approximated by Fourier series, in which case it is reported that the errors only grow linearly with N and are evenly distributed throughout the domain. A method for reducing the error is discussed.

A NUMERICAL METHOD FOR SOLVING SYSTEMS OF LINEAR ORDINARY DIFFERENTIAL EQUATIONS WITH RAPIDLY OSCILLATING SOLUTIONS. Ira B. Bernstein and Leigh Brookshaw, *Department of Applied Physics, Yale University, Yale Station, New Haven, Connecticut 06520-2159, U.S.A.*; Peter A. Fox, *Center for Solar and Space Research, Yale University, P.O. Box 6666, New Haven, Connecticut 06522-6666, U.S.A.*

A numerical method is presented which allows the accurate and efficient solution of systems of linear equations of the form $dz_i(x)/dx = \sum_{j=1}^{N} A_{ij}(x)\, z_j(x)$ $i = 1, 2, ..., N$, when the solutions vary rapidly compared with the $A_{ij}(x)$. The method consists of numerically developing a set of basis solutions characterized by new dependent variables which are slowly varying. These solutions can be accurately computed with an overhead that is substantially independent of the smallness of the scale length characterizing the solutions. Examples are given.

DENSITY-SCALING: A NEW MONTE CARLO TECHNIQUE IN STATISTICAL MECHANICS. J. P. Valleau, *Chemical Physics Theory Group, Lash Miller Laboratories, University of Toronto, Toronto, Ontario, CANADA M5S 1A1.*

We demonstrate the feasibility of using "umbrella sampling" to do Monte Carlo Markov-sampling runs each covering a substantial range of density: "density-scaling Monte Carlo," or DSMC. One can obtain in this way not only the usual canonical averages but also the relative free energy as a function of density. To test this it has been applied to systems for which there are some previous reliable results: the hard-sphere system and the restricted primitive model of 1:1 and 2:2 electrolytes. The method proves to be startlingly powerful in that very extensive results can be obtained with very few DSMC runs. An important further motivation is the prospect of using the technique to study phase transition regions.

A COMPUTATIONAL MODEL OF THE COCHLEA USING THE IMMERSED BOUNDARY METHOD. Richard P. Beyer, Jr., *Department of Applied Mathematics, University of Washington, Seattle, Washington 98125, U.S.A.*

In this work we describe a two-dimensional computational model of the cochlea (inner ear). The cochlea model is solved by modifying and extending Peskin's immersed boundary method, originally applied to solving a model of the heart (*J. Comput. Phys.* **25** (1977), 220). This method solves the time-dependent incompressible Navier–Stokes equations in the presence of immersed boundaries. The fluid equations are specified on a fixed Eulerian grid while the immersed boundaries are specified on a moving Lagrangian grid. The immersed boundaries exert forces locally on the fluid. These local forces are seen by the fluid as external forces that are added to the other forces, pressure and viscous, acting on the fluid. The modifications and extension of Peskin's method involve both the fluid solver and the calculation and transfer of immersed-boundary forces to the fluid. For the fluid, the Navier–Stokes equations are solved on a doubly periodic rectangular grid in a second-order accurate manner using a projection method developed by Bell, Colella, and Glaz (*Lawrence Livermore National Laboratory Report* UCRL-98225, 1988). The extension of the immersed-boundary forces from the moving grid to the fixed fluid grid and the restriction of the fluid velocities from the fixed fluid grid to the moving grid have been modified to be second-order accurate. The calculation of the immersed-boundary forces can be done either explicitly or implicitly or a combination of both. The cochlea is modelled as two fluid chambers

separated by a flexible partition whose stiffness varies exponentially along its length. The stapes is represented by a moving piston and the bony outer walls are allowed to be either straight or tapered. A travelling wave propagates along the flexible partition under the influence of the moving piston, and the dependence of this wave on partition stiffness is studied. Also included are studies of transient signal analysis and comparisons of model results to experimental data and asymptotic results.

A Consistently Formulated Quick Scheme for Fast and Stable Convergence Using Finite-Volume Iterative Calculation Procedures. T. Hayase, J. A. C. Humphrey, and R. Greif, *Department of Mechanical Engineering, University of California at Berkeley, Berkeley, California 94720, U.S.A.*

Previous applications of QUICK for the discretization of convective transport terms in finite-volume calculation procedures have failed to employ a rigorous and systematic approach for consistently deriving this finite difference scheme. Instead, earlier formulations have been established numerically, by trial and error. The new formulation for QUICK presented here is obtained by requiring that it satisfy four rules that guarantee physically realistic numerical solutions having overall balance. Careful testing performed for the wall-driven square enclosure flow configuration shows that the consistently derived version of QUICK is more stable and converges faster than any of the formulations previously employed. This testing includes the relative evaluation of boundary conditions approximated by second- and third-order finite-difference schemes as well as calculations performed at higher Reynolds numbers than previously reported.

Triangle Based Adaptive Stencils for the Solution of Hyperbolic Conservation Laws. Louis J. Durlofsky, *Chevron Oil Field Research Company, P.O. Box 446, La Habra, California 90633-0446, U.S.A.*; Bjorn Engquist and Stanley Osher, *Department of Mathematics, University of California at Los Angeles, Los Angeles, California 90024, U.S.A.*

A triangle-based adaptive difference stencil for the numerical approximation of hyperbolic conservation laws in two space dimensions is constructed. The novelty of the resulting scheme lies in the nature of the preprocessing of the cell-averaged data, which is accomplished via a nearest neighbor linear interpolation followed by a slope limiting procedure. Two such limiting procedures are suggested. The resulting method is considerably more simple than other triangle-based non-oscillatory approximations which, like this scheme, approximate the flux up to second-order accuracy. Numerical results for constant and variable coefficient linear advection, as well as for nonlinear flux functions (Burgers' equation and the Buckley–Leverett equation), are presented. The observed order of convergence, after local averaging, is from 1.7 to 2.0 in L_1.

A Computer Method for Simulation of Cardiovascular Flow Fields: Validation of Approach. C. Cockerham Vesier and A. P. Yoganathan, *Cardiovascular Fluid Mechanics Laboratory, School of Chemical Engineering, Georgia Institute of Technology, Atlanta, Georgia 30332-0100, U.S.A.*

An existing pressure correction method to model unsteady flow with arbitrarily moving boundaries has been adapted to simulate three-dimensional blood flow in compliant vessels. This noniterative method, which is first-order time accurate, solves the three-dimensional unsteady Navier–Stokes equations with arbitrarily moving boundaries for the no slip boundary condition. It is capable of realistically modeling blood flow in the heart, since it allows the simulation of both passive tissue (e.g., heart valves) and active tissue (e.g., heart muscle fibers). The boundaries, which represent cardiovascular tissue, are displaced by the fluid motion. When they are moved, the boundaries have the ability to exert a force which opposes fluid motion. The force the boundary exerts is assumed to be proportional to strain. The results of simulating 3D pulsatile flow through a flexible tube are presented, as well as a comparison to Womersley's analytic approximate solution for axisymmetric pulsatile flow in a flexible tube.