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TITLE: **CFDLIB: A Library of Computer Codes for Problems in Computational Fluid Dynamics**

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CFDLIB: A Library of Computer Codes for Problems in Computational Fluid Dynamics

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ABSTRACT

CFDLIB is the Los Alamos *LIBrary* of computer codes capable of solving a wide range of Computational Fluid Dynamics (*CFD*) problems in two– and three–space dimensions. The codes are related to one another by virtue of a set of common features. These include the use of Finite–Volume computational schemes in which all state variables are cell–centered; a multiblock data structure that enables highly efficient processing on modern supercomputers; and an Arbitrary Lagrangian–Eulerian (*ALE*) split computational cycle. All flow speed regimes are accessible in the library, ranging from fully incompressible to hypersonic; and code volumes exist that enable multifluid and multiphase computations with an arbitrary number of fluid fields, each with their own set of conservation equations.

The design of each code volume in the library is modular, making the development of codes for specialized applications exceptionally fast. For example, a $k - \epsilon$ model for the Reynolds stress, developed for one code volume, is easily inserted into another because of the common data structure among the codes.

CFDLIB is a research code library. This means that the code volumes are developed with the sophisticated user in mind; the experienced computist can quickly set up and solve a large variety of problems with little instruction from code manuals and internal documentation. This makes *CFDLIB* most useful for the computational physicist interested in exploring highly specialized effects in fluid dynamics. Nevertheless, the less experienced user can make significant progress, by focusing on the single code volume that is most closely related to their specific problem of interest.

Los Alamos Hydrocode Library CFDLIB

Common Features

- Multiblock data structure enables highly efficient processing on modern supercomputers, with complex geometries.
- Finite–Volume numerical schemes with fully cell–centered state variables.
- A companion version has been developed using a unstructured–grid format. This is motivated by the need to grid complex internal geometries, as well as by the interest in improved performance on distributed memory processors.
- All codes are UNIX portable, including workstations, vector processors, and parallel computers using PVM and MPI communication protocol.
- Interface to PLOT3D formatted mesh files.
- Interface to TecPlot via formatted output files.
- Split Lagrangian–Eulerian *ALE* formulation.
- Sesame equation of state interface.
- Adaptive meshing capability.
- Fully vectorized, and parallelized, solver for symmetric–positive–definite linear systems.

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Code Volumes

- CCMAC: 2D and 3D solver for incompressible, variable density, single–field flow, with thermal transport.

- CCICE: 2D and 3D solver for compressible, single–field flow at any flow speed.

- MFMAC: 2D and 3D solver for incompressible, multiphase flow, using the so–called continuum equations with mass–, momentum– and energy–exchange terms for interaction among fields.

- MFICE: 2D and 3D solver for compressible, multiphase flow, using the so–called continuum equations with mass–, momentum– and energy–exchange terms for interaction among fields.

- CGMHD: 2D solver for the composite–gas, magnetohydrodynamics equations. This adds the Lorentz force to the CCICE code, with explicit time integration of the magnetic acceleration. This means that a time increment must be used that respects the courant stability criterion based on the Alfven speed.

- FLIP–MP: All code volumes have a new lagrangian capability, using a variant of the FLIP method. This allows, for example, selection of either a Eulerian or Lagrangian frame of reference, field–by–field, in a multifield calculation. This has been enabled for Fluid–Structure–Interaction problems.

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