School of Meteorology Course
Fall 2017
Computational Fluid Dynamics
METR 5344
Instructor: Prof. Ming Xue
1:00 pm - 2:15pm, Tuesday, Thursday, NWC 5930
Credit: 4 hours

General Information: This course teaches the background theories and numerical methods for solving fluid dynamics and related problems. It is the foundation of numerical modeling/simulation and numerical weather prediction.

Prerequisites: Math 3123 (Engineering Math II or equivalent); ENGR 3723 (Numerical Methods or equivalent); a course in fluid mechanics/dynamics (e.g., ENGR 3223, METR 3113 and/or 5113) or their equivalent; ability to program in Fortran and/or another programming language (e.g., C, matlab) but Fortran is strongly preferred; familiarity with the UNIX operating system.

Text: *Computational Fluid Mechanics and Heat Transfer* by R. H. Pletcher, J.C. Tannehill, D. A. Anderson, 3rd Edition, CPC Press, 753pp.
Reference Books: *Numerical Methods for Wave Equations in Geophysical Fluid Dynamics* by Dale R. Durran. *Computational Techniques for Fluid Dynamics* (1991 2nd Ed.) by C. A. J Fletcher.

Practical Issues of High-Performance Computing; computer architectures; code design and optimization; parallel and vector constructs; limiting factors and constraints on simulation studies; guidelines for writing maintainable code. Background of numerical weather prediction. (1.5 week)

Theory of Partial Differential Equations; classification; canonical forms; linear vs nonlinear problems; characteristics; well-posed problems (1 week)

Fundamentals of Finite Difference Methods consistency; stability; convergence and order of accuracy; methods for obtaining discretizations (2 weeks)

Classical Problems and Methods implicit and explicit methods for parabolic, hyperbolic, and elliptic problems; directional splitting; dissipation and dispersion errors; practical measures of convergence and accuracy. (5 weeks)

Basic Hydrodynamics Burgers equation and nonlinear steepening; filtering; the shallow water equations; grid staggering, nonlinear instability, conservation constraints. (2 weeks)

Boundary Conditions (BC) for Hyperbolic Problems/Systems - Options of BC, wave-permeable radiation conditions, well-posedness of BC; PE and vorticity/streamfunction formulations. (2 weeks)

Semi-Lagrangian and Spectral/Pseudo Spectral Methods philosophy and formulation; application to 1-D problems; FFT and spectrum transform method. (3 weeks)

Survey of Numerical Methods used in Mainstream Mesoscale Models/New techniques used in NWP Models (time permitting)

Course Grading:	3 In-class Exams	60%
	Homework Computer Problems	40%

Students will be required to write computer programs using high-level languages such as Fortran, C, Matlab, including running parallel programs that will use multiple processors. Students will have access to OSCER supercomputer Schooner (see www.oscer.ou.edu).

If you have any question, please contact me at 325-6037, *mxue@ou.edu* or see me in NWC 2502.

Any student in this course who has a disability that may prevent him or her from fully demonstrating their potential should contact the School of Meteorology (325-6561) immediately to arrange for appropriate accommodations that will ensure your full participation and facilitate your educational opportunity.

All students are expected to be familiar with and abide by the OU Academic Misconduct Code. Information on this code and other student policies is located at http://studentconduct.ou.edu.