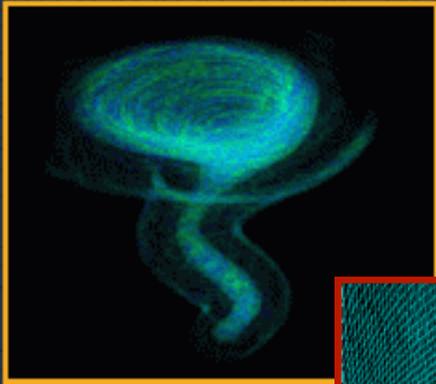
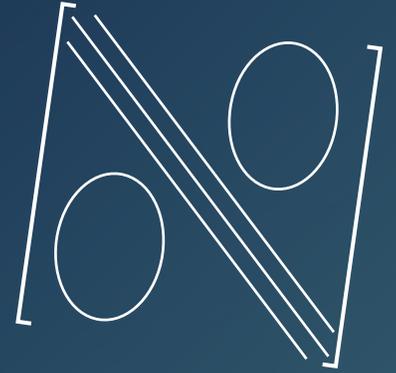


GRADUATE CERTIFICATE IN COMPUTATIONAL FLUID DYNAMICS

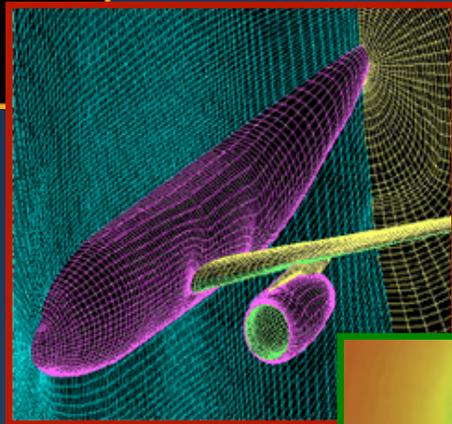


$$\Delta p = \frac{1}{k} \nabla \cdot \mathbf{U}$$



$$Q_t + \nabla \cdot \mathcal{F}(Q) = 0$$

$$\nabla \cdot \mathbf{U} = 0$$

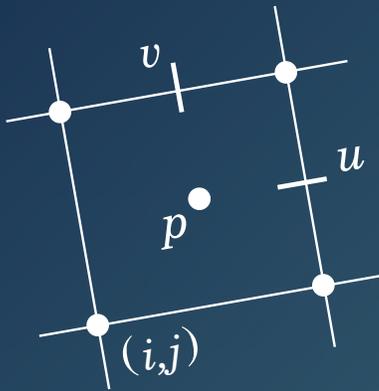


$$\tau_{xy} = \frac{1}{2} \mu (u_y + v_x)$$

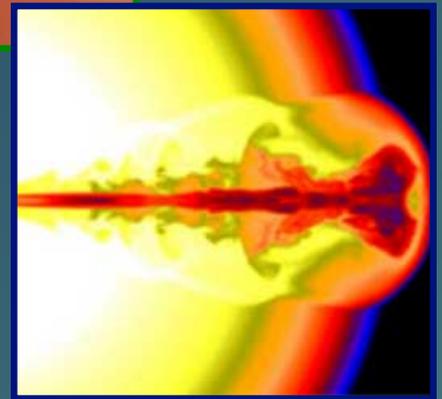
$$u^{n+1} = u^n + \delta u$$



$$u(\mathbf{x}, t) = \sum_{k=-\infty}^{\infty} a_k(t) \phi_k(\mathbf{x})$$



$$\mathbf{U}_t + \mathbf{U} \cdot \nabla \mathbf{U} = -\nabla P + \nu \Delta \mathbf{U} + \mathbf{F}_B$$



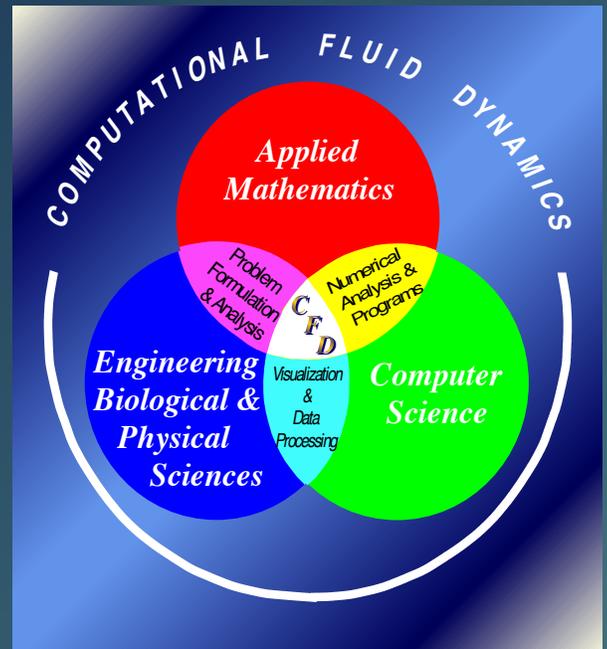
$$\mathbf{A} \mathbf{u}^{n+1} + \mathbf{B} \mathbf{u}^n = \mathbf{S}^n$$

$$\omega = \nabla \times \mathbf{U}$$

$$\|u\|_{L^2} = \left(\int_{\Omega} |u|^2 dx \right)^{1/2}$$

Purpose. The Graduate Certificate in Computational Fluid Dynamics (CFD) is available, in principle, to all graduate students in Engineering and the Mathematical, Physical and Biological Sciences at the University of Kentucky. It will be a minimum of 12 credit hours in length and represents a collaborative effort between the Department of Mechanical Engineering and various other departments within the College of Engineering (particularly Civil and Computer Science) and the College of Arts and Sciences (especially the Mathematics Department) at UK.

Background. Computational fluid dynamics is by now a generally recognized subdiscipline of fluid dynamics, complementing (and now often supplanting) use of theory and experimentation in the analysis of fluid behavior from sub-micro scales to intergalactic cosmological distances. CFD is highly interdisciplinary, as hinted by the accompanying figure, and due to this it can be approached for study from a number of different directions; correspondingly, its potential applications are essentially unlimited. Examples that are currently of very high interest include biological flows (e.g., air in respiratory systems and blood in circulatory systems of animals), flows in porous media (e.g., remediation of contaminated ground water, extraction of oil from marginal deposits), and combusting flows (e.g., for higher energy conversion efficiencies and less pollutant production). Thus, competency in the use of CFD is becoming critical to the advance of science and technology in the 21st Century, and it has become an essential engineering tool in industrial environments ranging from aerospace and automotive to food preparation and pharmaceutical.



It is of interest to further note that wide use of the term “computational fluid dynamics” actually began following publication of a book written at the University of Kentucky by a visiting researcher in Mechanical Engineering, P. Roache, in 1971, and which now is considered a classic reference. Yet, to this day, UK has no formal program in this very important field. This proposed Graduate Certificate represents an attempt to at least minimally address this shortcoming.

Director. The Director of the Graduate Certificate in CFD will be Professor J. M. McDonough of the Department of Mechanical Engineering, who also holds a secon-

dary appointment in the Department of Mathematics. Dr. McDonough has performed analyses via CFD since the mid 1970s, initially in an industrial setting, and has been teaching CFD and related courses since 1980—first at UCLA and then, beginning in 1990, at UK. He is well prepared to make decisions regarding qualifications of applicants for the CFD Graduate Certificate and to advise them on appropriate courses of study.

Associates. Associates will be drawn from numerous departments reflecting the interdisciplinary nature of this endeavor. At a minimum, the list of Associates will be comprised of: Prof. Tate Tsang (Chemical and Materials Engineering), Prof. Scott Yost (Civil Engineering), Prof. Peter Hislop, Prof. Zhongwei Shen and Prof. Qiang Ye (Mathematics), Prof. Vince Capece and Prof. Alexandre Martin (Mechanical Engineering), and Prof. Isaac Shlosman (Physics and Astronomy). While this list of associates must not be viewed as permanent, it should be clear that the ability to present a broad spectrum of interdisciplinary CFD-related courses is easily attainable.

Admission Requirements. Admission to eligibility for a Graduate Certificate in CFD follows the same minimum requirements as apply for admission to the Graduate School of UK. In particular, any student currently enrolled, or accepted, in the Graduate School as a graduate student, or in post-baccalaureate or university scholar status, can be considered for admission.

Graduate Certificate Requirements (General). As required by the Graduate School, a student must maintain a minimum GPA of 3.0 in the set of courses required for completion of the Graduate Certificate. In addition, a grade of C will be permitted only in fewer than one half of the total credit hours a student wishes to apply toward the certificate, and no more than one half of the certificate credits may be satisfied with 4XXG and/or 500-level courses.

Course Requirements. Course work applied to satisfy the minimum 12 credit-hour requirement will be selected from three categories: *i*) basic mathematics/numerical analysis, *ii*) specific CFD and CFD related courses and *iii*) independent studies and “Topics” courses in closely related fields. A minimum of one course must be selected from category *i*), and a minimum of two courses must come from the second category. One course will be permitted from category *iii*) but is not required. Lists of courses in each of these categories are contained in the following table.

Courses shown above the dashed line of the table are to be viewed as core courses of the CFD Graduate Certificate curriculum, and most students, especially those from Mechanical Engineering, would be expected to construct their course sequence mainly

<i>Math/Numerical Analysis</i>	<i>CFD/CFD Related</i>	<i>Related Indep. Studies</i>
MA/CS/EGR 537 MA 625 ME 690	ME 691 ME 692	ME 599 ME 699 ME 780
MA 471G or MA 575 MA 481G MA 483G or MA 533 MA 622 MA 633	ME 530 ME 531 ME 626 ME 631 ME 634	Analogous courses from other departments

from these with the help of their graduate advisor and the CFD Certificate Director. On the other hand, because of the interdisciplinary nature of CFD, students from outside of Engineering may wish to apply a somewhat different curriculum toward satisfying certificate requirements. For example, a student from Mathematics might find it worthwhile to take ME 531, a basic fluid dynamics course emphasizing analysis of viscous incompressible flows before taking ME 691, the corresponding incompressible CFD course. Similarly, a student from astrophysics might benefit by taking ME 530 (gas dynamics) before enrolling in the basic compressible CFD course ME 692. Finally, we note that the purpose of the independent study and topics courses is to address two main issues. First, there are recognized deficiencies in our current CFD curriculum. Specific examples of this are lack of courses in which so-called “grid generation” is taught (although a minimal amount of this is covered in ME 690), and similarly no course in which use of commercial CFD codes, as widely employed world wide in industry, is specifically taught. But at present, we believe these subjects can be handled in independent studies and topics courses.

Award of Certificate. When a student enrolled in the UK Graduate School has successfully completed the last required course of their CFD Graduate Certificate curriculum and has satisfied the above-stated GPA requirements, the Director shall send a signed Graduate Certificate Completion Form to the Dean of the Graduate School verifying that the student has fulfilled all requirements for the certificate and requesting award thereof, and he will officially notify the University Registrar of award of the certificate for posting to the student’s permanent transcript.

Application and coursework proposal forms follow and can be downloaded and completed by students interested in pursuing studies toward a CFD Graduate Certificate.



UNIVERSITY OF KENTUCKY

The Graduate School
Computational Fluid Dynamics Certificate
Application for Admission

Name Student ID

Home Address Home (or local) Phone

Date

Office Address Office Phone

E-mail Address (that you check regularly)

List all undergraduate and graduate degrees you have earned or are in the process of earning:

Table with 5 columns: Institution, Degree, Major, Date, GPA

Complete the appropriate portion:

(1) I am pursuing the Certificate in Computational Fluid Dynamics in conjunction with a graduate degree:

Academic Unit Graduate Advisor

Prospective Degree Anticipated Date of Completion

(2) I already hold a terminal degree and am pursuing only the Certificate in Computational Fluid Dynamics:

Name of Institution Degree Date Granted

Specify the term in which you expect to begin work toward the Certificate:

Year Fall Semester Spring Semester Summer

Anticipated date of completion of Certificate requirements:

Briefly describe (1) your reason for interest in the Graduate Certificate in Computational Fluid Dynamics, and (2) your career goals in relation to CFD with respect to the type of institution (academic, government, industrial) in which you are currently most interested in working upon completion of your certificate and/or terminal degree:

I certify that the statements in this application are correct and complete.

Signature

Date

For advisors of graduate student applicants:

I certify that I support the applicant's participation in the Computational Fluid Dynamics Certificate curriculum.

Signature, Graduate Advisor

Date

Return completed form to:

Dr. J. M. McDonough, *Departments of Mechanical Engineering and Mathematics*

267 RGAN Bldg.

Lexington, KY 40506-0503

E-mail: jmmcd@uky.edu



The Graduate School

Computational Fluid Dynamics Certificate

Course Work Proposal

Name _____ Student ID _____

Graduate Program (if applicable) _____

Graduate Advisor (if applicable) _____

Date of Application _____

Proposed Course Work

List Course Number, Name, and Credit Hours:

(Minimum 12 credit hours; must include MA/EGR 537 and ME 691 or ME 692.)

Course Number	Course Name	Credit Hours

CFD/Fluid Dynamics/Numerical Analysis/PDE Courses Already Completed

Course Number	Course Name	Semester Completed

Return completed form to:

Dr. J. M. McDonough, *Departments of Mechanical Engineering and Mathematics*
267 RGAN Bldg.
Lexington, KY 40506-0503
E-mail: jmmcd@uky.edu