MATH 4xx: Fluid Mechanics
Spring 2007

Class Hours: MWF 11:00-12:00, WEIR 133
Prerequisites: MATH 231 (Calculus and Analytic Geometry III),
MATH 336 (Introduction to Partial Differential Equations)

Instructor:	Ranis Ibragimov
Office:	WEIR 242
Phone	(505) 835-5493
E-mail:	iranis@nmt.edu
Office Hours:	MWF 14:00-15:30 (or by appointment)

Literature:

[1] Fluid Mechanics, *J.H. Spurk, Springer (1997),* ISBN 3-540-61651-9
[2] Theoretical Hydrodynamics, *L.M. Milne-Thomson, Dover Publications, INC (1974),* ISBN 0-486-68970-0

1. Description of the subject

Fluid flow is governed by a complicated nonlinear system of partial differential equations. In many situations of interest the flow spans a huge range of length scales, with the nonlinearity of the governing equations resulting in the transfer of energy from one length scale to another. Because of this complexity, the field of fluid mechanics has been the birth place of many important fields in mathematics. It has stimulated much work in areas such as partial differential equations, asymptotics and perturbation theory, computational methods, nonlinear waves, including solitons, instability theory, chaos, and stochastic processes. Despite these developments, turbulence in fluids remains one of the major unsolved problems in classical physics.

Indeed, within the field of fluid mechanics there is something for students of all interests. For example, one of the forthcoming graduate courses, Environmental and Geophysical Fluid Dynamics, is primarily concerned with fluid flow in rivers, lakes, oceans and the atmosphere. Such flows dominate our physical existence. Geophysical Fluid Dynamics (GFD) is traditionally the study of naturally occurring large scale fluid motions in the oceans and in the atmosphere which are affected by the Earth's rotation, but also includes extraterrestrial atmospheres and the interior of the gas giants such as Jupiter. Examples of large scale motions are the Gulf Stream in the North Atlantic Ocean and atmospheric blocking events, one of which was responsible for the great heat wave in Europe in 2003. Over the past 30 years attention has been increasingly focused on the impact of large scale fluid flows on the environment, highlighted by fundamental issues such as global warming and long-term climate change. Smaller scale motions, such as turbulence and mixing caused by internal waves, and surface water waves have a direct impact on bio-geochemical processes in oceans and lakes and on hence on human activity. Due to their ubiquitous nature, these motions are also of fundamental importance to the large scale circulation in both the oceans and atmosphere.

2. *Aim of the Programme*

This one course cannot cover all of the topics but it aims to give the student a firm background from which they can then study other fluid dynamical systems of interest to them. Two graduate courses that I plan to offer that require a strong knowledge of fluid dynamics are Nonlinear Waves and Geophysical Fluid Dynamics.

3. *About the course*

This course is a basic introduction to the subject of fluid mechanics and is intended for undergraduate and beginning graduate students of science and engineering. MATH 4xx specializes the Navier-Stokes equations to many different scenarios in order to understand fluid dynamics. There is a strong emphasis on the physical phenomena as well as the mathematical techniques required. In particular, throughout the course the convenience of tensor algebra has been exploited freely. My previous experience is that many students feel uncomfortable with tensor notation in the beginning, especially with the permutation symbol ε_{ijk} . After a while, however, they like it. From the other hand, particular effort has been made to make the course clear and accurate and at the same time easy enough for students. The Topics covered in MATH 4xx are as follows

1) Review of the derivation of the equations of motion.
2) Potential or Irrotational Flow: special emphasis on flow around an aerofoil.
3) Surface Gravity Waves: study the behaviour of waves at the surface of a tank or the ocean.
4) Laminar Flow: study different exact solutions to the Navier-Stokes equations.
5) Boundary Layer Flow: viscosity is negligible within the interior of the fluid but becomes very important near solid boundaries.
6) Turbulence: study Reynolds averaging to obtain the modified equations of motion.

RANIS N. IBRAGIMOV

DEPARTMENT OF MATHEMATICS, NEW MEXICO TECH

SOCORRO, NM, 87801

E-mail: iranis@nmt.edu