Physics 4931B – Physical Fluid Dynamics
Winter 2009

Instructor: Dr. John de Bruyn

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Office Hours: MWF 9:00-10:00 (usually), or make an appointment, or take your chances and drop in anytime.

Lecture Times: MWF 12:30-1:30
Room: PAB 215

Text: Elementary Fluid Dynamics by D. J. Acheson (Oxford University Press, Oxford, 1990).

Some other recommended books: (not required, but useful as references)

Fluid Mechanics by P. K. Kundu and I. M. Cohen (Academic Press, Burlington, MA, 2008). A modern and comprehensive text.

Physical Fluid Dynamics by D. J. Tritton (Clarendon, Oxford, 1988). A nice book with less math and more physical insight than most texts.

Fluid Mechanics by L. D. Landau and E. M. Lifschitz (Butterworth-Heinemann, Oxford, 1987). A classic, but not an easy read.

Course homepage: Course information, resources, assignments, deadlines, and other important information will be posted on the WebCT page for this course. You can access this page at http://webct.uwo.ca or https://owl.uwo.ca/webct/logon/419308621051 Use your UWO username and password to log in. Please check this page regularly.

There is also a web page for the course which contains some basic information about the course. You can access it at http://www.physics.uwo.ca/~debruyn/phys4931/phys4931.html

Course Outline: This course is an introduction to fluid dynamics. I will assume that you are familiar with vector calculus (div, grad, curl, the divergence theorem, etc.), that you are comfortable with ordinary differential equations (separation of variables, etc.), and that you understand Newton's Laws. Additional mathematical tools, possibly including PDEs, tensors, and complex analysis, will be introduced as needed. The course will focus on developing a physical understanding of fluid dynamical phenomena, as well as on how to solve problems mathematically.

My plan is to use two class hours per week for traditional lectures, and the third hour for problem solving, discussions, and "special events" such as lab tours and guest speakers. We'll see how this works out in practice!

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I expect the outline of this course to evolve over the term, depending on the interests of the class and the rate at which we find ourselves flowing through the material. Roughly speaking, the topics I hope to cover include:

1) phenomenological introduction to fluid dynamics
2) kinematics and conservation laws
3) ideal fluids, the Euler equations, irrotational flow
4) the Navier-Stokes equations
5) viscous flow
    a) Stokes flow, drag
    b) lubrication theory and thin film flow
6) waves
    a) surface waves
    b) internal gravity waves
    c) nonlinear waves: solitons, shocks
7) instabilities
    a) linear stability analysis
    b) Kelvin-Helmholts instability
    c) Rayleigh-Bénard convection
    d) Other instabilities depending on time and interest
8) other topics as time permits: airfoil theory, turbulence, boundary layers, non-Newtonian fluids, granular flows, astrophysical flows, biophysical flows … so many fluids, so little time!

Evaluation Scheme

- Assignments (4) 30%
- Term project 10%
- Presentation 5%
- Class Participation 5%
- Midterm test 15%
- Final Exam 35%

Assignments will involve a combination of analytical and numerical calculations. Some experience with Matlab, Maple, or another high-level mathematical programming language might be helpful but is not required.

The term project will involve an essay on a topic which you may choose in consultation with the instructor. Alternative forms of project (experiments, for example) will be considered – again, consult with the instructor. The presentation will take the form of a 20-minute lecture to the class on the subject of your project.

The class participation grade will be based on your active participation in class discussions and other activities.

The midterm will be held in the normal class timeslot on a date to be decided. The final exam will be a two-hour written exam covering all material treated in the course.

Late assignments or projects will be docked marks.

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Course Policies

- Religious holidays: A student who, due to unavoidable conflicts with religious holidays which (a) require an absence from the University or (b) prohibit or require certain activities (*i.e.*, activities that would make it impossible for the student to satisfy the academic requirements scheduled on the day(s) involved), is unable to write examinations and term tests on a Sabbath or Holy Day in a particular term shall give notice of this fact in writing to his or her Dean as early as possible but not later than November 15th for mid-year examinations and March 1st for final examinations, *i.e.*, approximately two weeks after the posting of the mid-year and final examination schedule respectively. In the case of mid-term tests, such notification is to be given in writing to the instructor within 48 hours of the announcement of the date of the mid-term test. The instructor(s) in the case of mid-term tests and the dean in the case of mid-year and spring final examinations will arrange for special examination(s) to be written at another time. In the case of mid-year and spring final examinations, the accommodation must occur no later than one month after the end of the examination period involved. It is mandatory that students seeking accommodations under this policy give notification before the deadlines, and that the Faculty accommodate these requests. The list of approved dates is given in http://www.uwo.ca/equity/docs/mfcalendar.htm.

- Academic misconduct:
  - Cheating: University policy states that cheating is a scholastic offence which can result in an academic penalty (which may include expulsion from the program). If you are caught cheating, there will be no second warning. Complete information on the University policies on academic offenses can be found at http://www.uwo.ca/equity/docs/mfcalendar.htm.
  - Plagiarism: Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing (such as footnotes or citations). Plagiarism is a major academic offence. For more details, see http://www.uwo.ca/univsec/handbook/appeals/scholoff.pdf.
  - Plagiarism or cheating will not be tolerated. Penalties will vary depending on the seriousness of the offence. They can range from a grade of zero on an assignment or essay, to failure of a course, to expulsion from the University.
  - If you have any questions at all on this issue please consult with your instructor