AME 530b: Dynamics of Incompressible Fluids (3.0 Units)
Spring 2017
12:30-1.50pm Monday and Wednesday

Instructor: Prof. Mitul Luhar (luhar@usc.edu)
Office Hours: Wednesday, 2.00pm–3.15pm, OHE 400C; or by appointment

Overview:
This course follows on from the material covered in AME 530a, focusing on higher Reynolds number flows of engineering and scientific interest. We will cover topics such as vorticity dynamics, boundary layer theory, transition to turbulence, and turbulent shear flows. Note that turbulence will be covered at an intermediate level, balancing the mathematical rigor required for complete statistical and spectral descriptions with empirical relations and closures useful for engineering. Assessment will be based on 5 homework assignments and 1 take-home final, all of which will involve challenging research-level problems.

Textbook and Other Resources:
There is no required text for this class. All of the lecture material will be available electronically to the students. However, the following books will be useful as additional references:

- *A First Course in Turbulence* by H. Tennekes and J. L. Lumley, MIT Press
- *Fluid Mechanics* by P. Kundu, I. Cohen, and D. Dowling, Academic Press
- *Boundary-Layer Theory* by H. Schlichting and K. Gersten, Springer
- *An Introduction to Fluid Dynamics* by G. K. Batchelor, Cambridge University Press
- *Turbulent Flows* by S. B. Pope, Cambridge University Press

Finally, there is a series of 39 videos developed by the National Committee for Fluid Mechanics Films (NCFMF) that I highly recommend for anyone interested in Fluid Dynamics: http://web.mit.edu/hml/ncfmf.html

Topics Covered:
1. Basics
   a. Tensor Notation
   b. Dimensional Analysis and Scaling
2. The Navier-Stokes Equations
   a. Convective Derivative
   b. Velocity Gradient and Stress Tensors
   c. Energetics
3. Vorticity Dynamics
   a. Vorticity and Angular Momentum
   b. Classical 'Inviscid' Models
   c. Viscous Effects

4. Boundary Layers and Related Topics
    a. Steady Boundary Layers
    b. Unsteady Boundary Layers and Perturbation Analyses
5. Turbulence
    a. Origins of Turbulence in Shear Flows
    b. Length and Velocity scales
    c. Reynolds Averaging and the Closure Problem
    d. Energetics and Vorticity Dynamics
    e. Spectral Description
6. Simplified Models for Turbulent Shear Flows
    a. Boundary-Free Flows (Jets, Wakes, Mixing Layers, Plumes)
    b. Wall-bounded Flows (Pipes, Channels, Boundary Layers)

Assessment:
Homework: 60% (5 total)
Final Exam: 40% (take-home)

There will be five homework assignments, and you will generally get two weeks per assignment. You are allowed to discuss homework problems with each other, but your solutions must be your own. Homework assignments that are late will be penalized 25% for each day after the due date. The final exam will be a take-home open-book exam that will involve solving research-level problems. Please notify the instructor <u>ahead of time</u> if you are unable to meet a homework or examination deadline.

Desire2Lean (D2L):
D2L is the USC Viterbi course management platform, and we will use it extensively. All lecture notes and videos will be made available online through this website. The D2L system will also be set up with a discussion forum for the homework assignments (see Supplementary Materials). Students are encouraged to use this for peer-to-peer discussions, and the instructor will chime in as necessary. Please familiarize yourself with the D2L system:
https://courses.uscden.net/d2l/home

Academic Conduct:
Plagiarism - presenting someone else's ideas as your own, either verbatim or recast in your own words - is a serious academic offense with serious consequences. Other forms of academic dishonesty are equally unacceptable. All USC students are responsible for reading and following the Student Conduct Code, which appears in the Scampus (http://scampus.usc.edu/).

Support Systems:
A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute (http://dornsife.usc.edu/ali), which sponsors courses and workshops specifically for international graduate students. The

Office of Disability Services and Programs (http://dsp.usc.edu/) provides certification for students with disabilities and helps arrange the relevant accommodations.

If an officially declared emergency makes travel to campus infeasible, USC Emergency Information (http://emergency.usc.edu/) will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity (http://equity.usc.edu/) or to the Department of Public Safety (http://adminopsnet.usc.edu/department/department-public-safety). This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can initiate the report on behalf of another person. The Center for Women and Men provides 24/7 confidential support (http://engemannshc.usc.edu/cwm/), and the sexual assault resource center webpage describes reporting options and other resources (https://sarc.usc.edu/).