Course	GEOS 353: *Environmental Fluid Mechanics* (Fall, 2019)
Lecture days & times	Tuesdays and Thursdays from 12:30 to 1:45 PM
Instructor	Dr. Shane D. Mayor
Office hours	To be determined or by appointment. (Please e-mail first. If not in office, look in lab: PHSC 128.)
Office	PHSC 117
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Class webpage	http://physics.csuchico.edu/~sdmayor/teaching/GEOS353_F19/index.html
Required Book	None.
Great books	Smyth, W. D., ©2019, *All Things Flow: Fluid Mechanics for the Natural Sciences*, 167 pages. Available from the author's website.
	Cushman-Roisin, B., ©2014, *Environmental Fluid Mechanics*, John Wiley & Sons. Available from author's website
	Kundu et al., *Fluid Mechanics*, 6th Edition, ©2016, Academic Press, 921 pages.
	Furbish, D. J., ©1997, *Fluid Physics in Geology*, Oxford University Press, 476 pages.
	Schlichting H. & K. Gersten, ©2016, *Boundary Layer Theory*, 9th Edition, Springer, 805 pages.
	White, F., ©2006, *Viscous Fluid Flow*, 3rd Edition, McGraw Hill, 629 pages.
	Durst, F., ©2008, *Fluid Mechanics*, Springer, 723 pages.
	Katz, J., ©2010, *Introductory Fluid Mechanics*, Cambridge, 441 pages.
	Pozrikidis, C., ©2009, *Fluid Dynamics: Theory, Computation, and Numerical Simulation*, 2nd Edition, Springer, 773 pages.
	Versteeg, H. and W. Malalasekra, ©2007, *An Introduction to Computational Fluid Dynamics–The Finite Volume Method*, 2nd edition, Pearson, 520 pages.
	Hutter, K. and Y. Wang (editors), ©2016, *Fluid and Thermodynamics*, Vols. 1 & 2, Springer.
Related	Fleisch, D., ©2012, *A Student's Guide to Vectors and Tensors*, Cambridge University Press, 197 pages.

Course Overview

Fluids (gases and liquids) are ubiquitous and play critical roles in shaping the environment and transporting heat, momentum, pollutants, and constituents that support life, erode the solid earth, circulate the oceans, drive weather, and control climate. Moreover, the treatment of *geophysical* (or *environmental*) *fluids* must take into consideration important factors that are often ignored in typical engineering fluid mechanics, namely the unique and profound effects of fluid density stratification and rotation. The field of geophysical or environmental fluid mechanics is vast and this course is designed to be an entry point for students of the natural sciences to become fluent with the issues, terminology, and nomenclature so that they may have the tools needed to continue learning in their chosen specializations.

Tentative topics

We will begin by introducing some of the math concepts that are simply unavoidable when studying fluid mechanics, most importantly vectors and partial derivatives. We'll then discuss the nature of fluids including viscosity, flux-gradient relationships, pressure gradients, and shear stresses. We'll distinguish Lagrangian and Eulerian frameworks. We'll also talk extensively about buoyancy effects in fluids, density stratification, and the effects of the rotation of the Earth (the Coriolis force). With these concepts in hand, we will derive the Navier-Stokes equations that are foundational to understanding fluid motions, so that students can identify and compare the relative power of the forces that control various geophysical and environmental flows. We'll discuss the nature of turbulence and how it must be parameterized in models.

Assignments

Instead of focusing on problem solving, this course will emphasize becoming fluent with terminology, symbols, and the interpretation of terms in equations. Some homework or quiz or exam questions may involve evaluating the magnitudes of terms in equations (scale analysis), computing dimensionless numbers or fluxes, or sketching flow fields. Students may be asked to derive equations, but only after being shown in class or having done so in assignments.

In addition to attendance, quizzes, exams, and homeworks, course grades will probably be influenced by one or more special assignments. For example, students may be required to select an area of environmental science involving fluid mechanics that is of special interest to them, and prepare a written report and/or oral presentation.

Prerequisites

PHYS 202A or 204A and MATH 109 or MATH 120. Students should be comfortable with basic Newtonian mechanics (esp. Newton's second law, velocity, acceleration, etc.) and the concepts of a derivative and vectors.

Other

Typesetting in LaTeX may be required. Students should be prepared to learn how to use LaTeX to create beautiful equations and documents.

Course Grade

The course grade may be based on a number of homeworks, quizzes, exams, and assignments. Attendance will also be a factor.

Dropping

You may drop without obtaining permission until Friday, September 6. From September 7 – 20, you must obtain permission from the instructor to drop. After Friday, September 20, you will need a serious and compelling reason to drop and your request must be approved by the Department Chair and the College Dean.

GEOS 353, Fall 2019, List of meeting dates and **tentative** schedule.

1	Tues.	27	Aug.	Review syllabus. Math preliminaries: Vectors, slopes, derivatives, gradients.
2	Thurs.	29	Aug.	Nature of fluids, fluid continuum, fluid parcel, hydrostatics
3	Tues.	3	Sept.	Review Newton's 1st and 2nd laws. Body forces vs. surface forces
4	Thurs.	5	Sept.	Momentum flux in laminar flow, Cauchy stress tensor.
5	Tues.	10	Sept.	Surface forces: viscous stress, pressure gradient force
6	Thurs.	12	Sept.	Transport phenomena at molecular level (flux-gradient relationships), viscosity.
7	Tues.	17	Sept.	Index notation: Einstein's summation notation; dummy indices; free indices.
8	Thurs.	19	Sept.	
9	Tues.	24	Sept.	Kinematics of fluid flow.
10	Thurs.	26	Sept.	
11	Tues.	1	Oct.	Lagrangian and Eulerian descriptions of fluid flow. Local derivative and advection terms.
12	Thurs.	3	Oct.	
13	Tues.	8	Oct.	Gravity, centrifugal force, apparent gravity.
14	Thurs.	10	Oct.	
15	Tues.	15	Oct.	Effects of rotation: Coriolis. Cross-product.
16	Thurs.	17	Oct.	
17	Tues.	22	Oct.	Parameterization of small scale turbulence: Reynolds stresses.
18	Thurs.	24	Oct.	
19	Tues.	29	Oct.	Turbulence and boundary layers.
20	Thurs.	31	Oct.	
21	Tues.	5	Nov.	Transition to turbulence
22	Thurs.	7	Nov.	
23	Tues.	12	Nov.	Aspects of stratified rotating fluids
24	Thurs.	14	Nov.	
25	Tues.	19	Nov.	Dimensionless numbers: Richardson, Reynolds, Froude, etc., scale analysis
26	Thurs.	21	Nov.	
	Tues.	26	Nov.	Thanksgiving week. No classes.
	Thurs.	28	Nov.	Thanksgiving week. No classes.
27	Tues.	3	Dec.	
28	Thurs.	5	Dec.	
29	Tues.	10	Dec.	Review week. Instructor at AGU.
30	Thurs.	12	Dec.	Review week. Instructor at AGU.
				Week of Dec 16 is finals week.