01 Syllabus

Monday, August 26, 2024 3:48 PM

Welcome to Flow Vis!

Introduce yourself to people around you

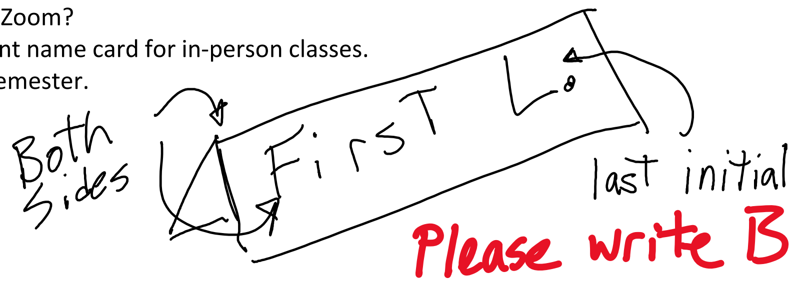
Today:
Syllabus

3 documents in handout package:

1. Syllabus
2. Initial Assignments
3. Schedule

All documents are available on http://flowvis.org>Course Info

Volunteer for Voice of Zoom?
Please make a table tent name card for in-person classes.
Use it every class, all semester.



Please write Big & Dark

We'll be using iClicker Reef/Cloud for polls now and then. Join code is https://join.iclicker.com/ZAXL, also in Initial Assignments.
We'll be using Slack. Workspace is FlowVis2024
If you have a camera, please bring it Weds so students who are shopping can try various models.

What is flow visualization? Let's start with an example:
https://www.danielwurtzel.com/

Prosaically:
Flow visualization = making the physics of gasses and liquids visible

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Version 8/23/2024

SYLLABUS

MCEN 4151/5151/ FILM 4200/ ARTF 5200/ ATLS 4151/5151

Flow Visualization: The Physics and Art of Fluid Flow

Fall 2024

Course Overview

Goals

Both science and art can be described as being fundamentally based in our perception of the world around us. In science, clear observations lead to understanding, particularly of physics, which is a prerequisite to successful engineering. In art, creating and influencing our own and others' perception of the work, whatever it may be, is the whole point. Art may also be defined as an execution of a vision; an instantiation of an idea, 'making it so'. In this course we will focus on making the physics of fluid flow more available to perception, specifically, in a word, *visible*. You may also find that your perception of fluid flow in everyday life has been sharpened. In the process we will be creating both art and science.

Flow visualization is particularly suited to the interface between art and science. Many fluid physicists are motivated not only by the important scientific and engineering goals of their work, but also by a visceral fascination with their subject. Few scientists or engineers admit as much, but the existence of several venues for display of fluid flow art belies purely dispassionate motivations. Foremost among these venues is the Gallery of Fluid Motion [1], a poster and video competition which is held in conjunction with the American Physical Society Division of Fluid Dynamics (APS-DFD) annual fall meeting. Gallery entries are judged "based upon criteria of scientific merit, originality, and artistry/aesthetic appeal." (Some winners were works from this course.) Additional examples include the seminal *Album of Fluid Motion* [2], which can be found on the bookshelf of nearly every fluid dynamics researcher. In each of these examples, the sheer beauty of fluid flow is revealed and acknowledged to some extent. Thus we hope to encourage engineering students to gain a deeper perception of fluid flow by capitalizing on this previously unacknowledged motivation, that is, for aesthetic and creative purposes. In the case of art and other non-engineering students, our goal is to introduce students to the simple beauty and fascination of fluid flow, as well as a bit of exposure to the discipline of documented experimentation.

Another goal of this course is to perhaps give you a chance to work with students from different disciplines. Art, engineering and interdisciplinary students have been trained with different approaches and values. In this course you will work with a range of colleagues, and discover your differences and similarities. Hopefully, you'll see value in the range of perspectives.

Learning Objectives

1) Increase your perception of fluid physics in the real world
2) Employ aesthetics (art) as a valid and useful motivation for exploring fluid physics
3) Demonstrate the ability to communicate both aesthetics and fluid physics to a wide audience
4) Critique your peers using supportive but substantive techniques
5) Master basic skills of scientific and artistic imaging
6) Design, carry out and analyze flow visualization experiments

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[1]. https://gfm.aps.org/ .
[2]. Van Dyke ed. *An Album of Fluid Motion*. Parabolic Press, 1982.

Course Format

The course will consist of lectures on photography, optics, visualization techniques and fluid physics, critique sessions, and a guest lecture or two. We will focus on the production and critique of student images: there will be six assignments consisting of an image or video, and an accompanying report, plus live and written peer critiques. Two of the assignments will be to image atmospheric clouds. For the four lab scale experiments you'll do the first one on your own, and then I'll assign you to a small team for the remaining three assignments. You'll still be responsible for your own image and report, but working with the team will let you take on more complex experiments and share equipment. Remote students will have to work on their own, but will have a team to talk to. There will be some flow vis and photographic equipment available for check-out. You'll be expected to try various techniques throughout the semester including at least one video, but what and when are up to you. A final showing will be presented in Fiske Planetarium during our final exam slot, and will be open to the public; invite your friends and family.

There are no formal lab sessions; instead, you are expected to treat assignments as homework. Plan to play with flow vis every couple of days for short periods; this will allow you to iterate to get the best results, and frequently bring joy and wonder into your life. Leaving assignments to the last minute often results in sadness and regret.

Students are required to attend all critique sessions, which will be on Zoom during the regular class meeting time. Lectures will be hybrid: both in-person and remote via Zoom. Lectures will also be recorded for asynchronous viewing, but the lectures are interactive, and students are expected, but not required to attend normal lectures.

We will use CU Clickers now and then for informal polls and activities in class. Please come prepared.

Course Content

This course will reveal the techniques of making laboratory and everyday fluid flow physics visible for both scientific and aesthetic purposes. You'll create images using photographic and video techniques, and document your work in written reports, posted on the class website, focusing on "why does it look like that?". Questions such as "what makes an image scientific? What makes an image art?" will be explored, but this is largely a technical course. You'll also gain technical expertise in a range of flow visualization and photographic techniques drawn from the following list. Quantitative applications and analysis will be considered where appropriate.

Partial lists:

Possible fluid media:

- liquid dye or particles in water
- smoke or fog in air
- water in air; sprays, clouds, free surface waves
- temperature or concentration gradients in air and water
- many combinations of everyday fluids such as milk, vegetable oil, alcohol, shampoo, etc. **Caution, do not combine anything with a bleach product.**

Fluid phenomena:

Atmospheric clouds and optical phenomena
Vortex dominated flows, including rings
Buoyancy induced flows
Surface tension driven flows
Multiphase flows (fountains, bubbles, sprays)
Laminar or turbulent flow
Wakes, Jets, and Shear layers
Immiscible effects
Combusting flows. **See posted safety guidelines for working with flames.**
Ultrasonic driven flows (fountain/fog generators)

Visualization techniques:

Marker techniques including dyes, light emitting fluids and particles
Laser sheet visualization
Refractive index techniques such as Schlieren and shadowgraphy
Oil flow techniques (wind tunnel applications)

Imaging techniques:

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Photography (digital or film, stereo or mono) Post processing of above.
Video/movies (analog, digital or film)

Safety Considerations: If you want to work with combustion, you must follow the combustion guidelines posted on the website. When working with household materials, you are pretty safe if you stick to personal hygiene (i.e. soaps and shampoos) and food products. If you are working with cleaning or medical products, or lab chemicals, you must discuss them with me first, and you may be required to submit a safety proposal.

Assignments, Assessment and Grading

"Big" assignments will consist of images or videos paired with written technical reports, and must be submitted digitally via the Flowvis.org blog site **AND** Canvas (Videos must also be posted to Vimeo or Youtube). Everybody is expected to provide written reports and self-assessments with their images, but expectations for the level of science discussed varies with your background. The required image and report formats are detailed in other documents which will be posted on the Flow Vis website. You will also be expected to critique other students' work.

Detailed *grading* of your work will not be done, although it will be checked for completeness and quality, and you will be expected to revise and resubmit your reports in response to critique. Instead, you will be motivated to achieve excellence by the actual meaning, context and quality of your work. Qualitative feedback will be provided publicly during class critique sessions, by your peers, and me or another fluids expert. Your reports will be constructively critiqued by your peers. In addition, your work will be publicly archived on the high-visibility Flow Visualization site (just Google 'flow visualization'). Employers in years to come may view this work when they Google your name. If you are dissatisfied with your work, you can revise, improve and update your posts without limit for one year.

Your grade for this course will be largely determined by your meeting the stated expectations for turning in all work and participation in critiques, and to a lesser extent by attendance at guest lectures, completing surveys, returning borrowed equipment, etc. In rare cases, substandard work such as poorly executed images and reports that grievously fail spell and grammar checks or display an inappropriately low level of science or inaccurate physics have resulted in lowered course grades. Again, getting an 'A' in this course is not as meaningful as producing quality work that you will be proud of.

You can miss the in-person lectures without penalty or notification; recordings of the lectures will be available within a day or two. Nag me if I forget to post them.

If you must miss a required attendance date such as a critique, you will be expected to review the critiqued work and add comments to the associated posts. See your pod's Google spreadsheet to see what you missed. Then notify the TA for makeup credit. If you are assigned as a Pod or Critique Facilitator and you have to miss, it's your responsibility to get somebody in your pod to substitute for you. Notify your pod and the TA in that case.

If you miss the required 'Meet Your Team' class period, it's your responsibility to contact your team and get to know them – exchange contact info, and help decide on team activities.

Prerequisites

There are no formal prerequisites, but engineering students are expected to have completed a course in fluid mechanics, and fine arts and CTD students are expected to have some competence in photography and/or video. This course counts as a technical elective towards engineering degrees in the College of Engineering and Applied Science, and may be petitioned as studio or production credit towards photography and video degrees in the College of Arts and Sciences or as an upper division science credit towards any A&S degree.

If you are missing both a fluids background and imaging experience, you must have a self-directed willingness to engage with the material. In all cases, what you get out of this course depends on what you put in.

Contact Information

Instructor: Prof. Jean Hertzberg
Email: Hertzberg@colorado.edu
Office: ECME 220, 303-492-5092
Cell: 303-817-0967. You can text me, but please no contact between midnight and 10 AM.
Personal Webpage: http:JeanBizHertzberg.com
Personal photography site: BizHertzberg.com
Office hours: Right after each class, or by appointment on Zoom. Late afternoon/ early evenings are best.

TA: Anjali Shadija AnjaliSanjaykumar.Shadija@colorado.edu. 425-589-9259.
Slack workspace: FlowVis2024
See Canvas for the Zoom link.

Course Website

http://flowvis.org, or just Google 'flow visualization' or 'flow vis'. Our site is #1 in much of the world! This site has all sorts of useful content and is the permanent site where your work will be posted. **All course information will be posted there**, and you will be issued a login with author privileges. We will use Canvas (https://cuboulder.instructure.com/) only for submission of your archival work and to keep track of your grades.

Textbooks

I'm almost done writing the textbook. It is an Open Educational Resource, so it's free online. You can find it on the Flowvis.org website in the right column and at https://www.flowvis.org/Flow%20Vis%20Guide/introduction-to-the-guidebook/ . In addition, you are expected to research background information online and in the archival technical literature. Some research papers are collected for you in a Zotero.org group library: Fluid Physics for Flow Vis. Make yourself a Zotero login (free) and request to join the group. More instructions are on the Course Info page on Flowvis.org.

The following texts are recommended. All are available online from Amazon.com or other booksellers. I own most of these, and you can borrow them from me. Many are also available in the Engineering and/or MathPhysics Libraries on campus. Additional texts are referenced on the course website and in the lecture notes. **Several cost less than a pizza, and will serve you well both this semester and in years to come**:

The Cloudspotter's Guide by Gavin Pretor-Pinney. Perigee/Penguin Publishers. 2006. ISBN 978-0-399-53345-7. $16 paperback, $13 on Kindle. A non-mathematical but accurate description of cloud physics and identification. Readable and useful for engineers and art students alike. An official publication of the Cloud Appreciation Society. **HIGHLY recommended.**

Flow Visualization Techniques and Examples, 2nd Edition, A.J. Smits and T.T. Lim. Imperial College Press, London, 2000. ISBN 1-86094-193-1. Available from World Scientific Publishing, http://www.wspc.com/books/engineering/p167.html. $98 hardcover, $30 on Kindle, but it's an excellent reference text. **Highly recommended for graduate students in fluids**.

An Album of Fluid Motion by Milton Van Dyke. Parabolic Press, Stanford CA, 1982. ISBN 0-915760-02-9. Classic images in black and white. Everybody who does fluid mechanics owns a copy. I have three. Out of print now but used copies available for < $100. http://courses.washington.edu/me431/handouts/Album-Fluid-Motion-Van-Dyke.pdf

A Gallery of Fluid Motion by M. Saminy, K.S. Breuer, L.G. Leal, P.H. Steen. Cambridge University Press, 2003. ISBN 0 521 53500 X. $35. This is a collection of winners of the flow vis competition at the annual APS meeting. One of this course's images won in 2003, and another in 2006.

Handbook of Flow Visualization, Wen-Jei Yang, 2nd edition. Taylor and Francis, NY, NY 2001. ISBN 1-56032-417-1.$500, but free download from CU library! https://www-taylorfrancis-com.colorado.idm.oclc.org/books/edit/10.1201/9780203752876/handbook-flow-visualization-wen-jei-yang , also in Zotero. Detailed information on a wide range of topics.

Schlieren and Shadowgraph Techniques by G.S. Settles. Springer Verlag, 2001. ISBN 3- 540-66155-7. $170.The gold standard reference for these techniques, with practical suggestions for both small and very large systems.

Flow Visualization, Wolfgang Merzkirch, 2nd edition. Academic Press, Orlando, FL, 1987. ISBN0-12-491351-2 ($67 on Kindle, $73 paperback). Classic flow vis reference. Quite technical, not a lot of examples.

M-F 5:15 pm ITLL
100 level

Cameras and Software

Students are expected to provide their own imaging device (in lieu of a textbook). A digital camera of 10 Mpx or more is recommended. The camera should provide the option of **manual focusing** and exposure control: shutter speed, **aperture**, and ISO. Cell phone cameras are OK for cloud images but not for the other assignments; you can't control aperture on any of them and focusing properly is difficult. One of many examples of a useful camera is the Canon Eos Rebel T3i. This is an older camera, available $100 - 200 used.

There are a variety of free image processing programs. I'll be demonstrating Darktable, an open source program that can edit raw files. Gimp is also a fine open source photo editing program. For video editing any program you are comfortable with is OK; Minitool Moviemaker (free but limited to short vids) is easy to get started with, as is iMovie for Macs. DaVinci Resolve is what I use; personal copies are free, and it's very powerful but has a steep learning curve. Final Cut for Macs and Adobe Premier for PCs are not free, but are comparable in power to Resolve.

Darktable and Davinci Resolve are available on the computers in the ITLL. You'll need a fast computer like that to run Resolve.

Publications

This course has attracted a great deal of interest from the fluid dynamics and engineering education and art/science communities. Student images from previous course offerings have been presented at conferences (garnering several awards), published in professional journals and on the web with the instructors as co-authors, and selected for traveling and permanent public display. **Thus, students will be asked to submit high resolution digital files of their work and release a non-exclusive copyright to the instructor.** No prints or hard copies will be required. Students who supply contact information will be kept informed of all future publications of their work. All images and reports produced for the course will be published on the course website. **Videos may only use music to which rights have been acquired.** A list of volunteer musicians will be provided if you'd like to collaborate with a musician on original music for your video. Acquiring rights to other music via stock libraries is easy and inexpensive. You will be expected to **provide documentation of your music rights**.

At the end of the semester, you will be offered the opportunity to donate proceeds from the sale of your work. The proceeds will be used to benefit this course.

Professionalism Expectations

A primary objective of the Mechanical Engineering Department is to prepare each of our students for careers in the engineering profession. As professionals, engineers must meet high standards of technical competence and ethical behavior. According to the Accreditation Board of Engineering and Technology (ABET) code of ethics, engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

1. Using their knowledge and skill for the enhancement of human welfare;
2. Being honest and impartial, and serving with fidelity the public, their employers and clients;
3. Striving to increase the competence and prestige of the engineering profession.

The Department of Mechanical Engineering (ME) believes that it is essential for each of you to learn the professional behavior that will prepare you for your career after college. Therefore, in each mechanical engineering course you will be required to practice the professional behavior that will be expected by your future employers. This syllabus clearly outlines the ME policy regarding academic integrity and academic climate. These policies will be upheld in each of your courses throughout the mechanical engineering curriculum. However, we also expect that this culture of professionalism will pervade all of your University of Colorado experiences.

Academic Integrity

You will be asked to complete individual homework assignments in this course. Though you may work in groups to discuss and solve problems, it is expected that you will abide by the University of Colorado at Boulder honor code at all times. Therefore, you may not plagiarize images, videos or reports or allow another student to plagiarize your work. Examples of plagiarism include copying from Internet sites, copying from previous student work, and copying directly from classmates. However, in your reports **for this course** you can (and should!) use direct quotes and paraphrased information and examples from the Internet and other published sources ***as long as you properly cite the source.*** If you have any doubt about how to cite, or whether you are using sanctioned materials, please ask. Citation techniques will be covered in lecture. Plagiarism detection will be enabled in Canvas, and you will be able to check the overlap of your reports with others.

You can use ChatGTP to help you write your reports *as long as you cite it in your references.* Beware! You will need to carefully check its facts; it often makes stuff up.

Academic Climate

Diversity, Equity and Inclusion

I fully support the ME Department's commitment to DEI. In addition, I personally commit to making you welcome in this class, especially if you are not sure you belong.

In Class Expectations:

It is our expectation that each of you will be respectful to your fellow classmates and instructors at all times. In an effort to create a professional atmosphere within the classroom, it is requested that you:

- Arrive to class on time
- Mute your cell phone
- Limit use of your phone and tablet to class purposes
- If you must leave early do so without disrupting others
- Display professional courtesy and respect in all interactions related to this class

Compliance with these expectations will assist us with the creation of a learning community and a high quality educational experience. The University of Colorado Classroom behavior policy will compliment the outlined classroom expectations. The University of Colorado Classroom Behavior policy is stated below.

Discrimination and Harassment:

Discriminatory and harassing behavior will not be tolerated in the Department of Mechanical Engineering. A safe and inclusive environment will be created and maintained by the students and instructing faculty member. Students with concerns about discrimination or harassment actions should immediately contact the instructor, the Department Chair or their academic advisor, or contact the Office of Discrimination and Harassment (below).

Examples that may be considered harassment:

A teaching assistant or instructor asking a student for a date.
Displaying sexually explicit material in an academic setting (including laptop wallpaper).
Persisting in asking a classmate for a date after being turned down.
Using degrading terminology in referring to others, including peers.

Professional Expectations Bottom Line

We're not trying to be fussy. Following these guidelines provides a safe, respectful, fair and efficient environment for everybody. Plus you get to practice these skills in a low-risk context.

Additional University policies governing COVID-19 Policies, Accommodation for Disabilities, Classroom Behavior, Honor Code, Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation and Religious Holidays can be found here. See Page 3 for specific course policies on absences.

You will receive a Docusign form via email to acknowledge that you have read this Syllabus and agree to these policies, and another for the copyright/use agreement.