

Today:

Team member Expectations	Bring to class:
Facilities and Equipment	Zeroblasters
	Small fog machine
	Ultrasonic humidifier
	Desk toys

Admin stuff:

- Please sit with your team, so you can discuss possibilities as they come up today
- Team First project plan and selfies due this Friday, 9/13. Short statement of what you are planning to do. Each person, online in Canvas.
- Team First image due Monday Sept 23. Same upload and posting requirements as Get Wet.
- Example Reports: Read the guidelines. Good reports: 2012 team First Ryan Kelley, Nicholas Travers
- Chem Stores: on campus source for glassware, chemicals, lab supplies (cash OK):
<https://www.colorado.edu/chembio/resources/research-facilities/chemstores-chemstores-east>
-
- Optics cleaning tips: <http://www.newport.com/How-to-Clean-Optics/141176/1033/content.aspx> for lab optics
- <https://www.adorama.com/alc/fag-how-to-clean-camera-lenses> for camera lenses
 - Cleaning fluids: OK to buy a commercial variety, or try distilled water first, then isopropyl (rubbing) alcohol, then ethyl alcohol (lab grade), then acetone as a last resort.

Team Expectations

Expectations For Teams Flow Visualization

Reasons for putting you on teams:

1. So that you can attempt to image more complex flow phenomena. If the work of developing a setup is spread out among you, then you can try a challenging experiment.
2. So that you can attempt more challenging imaging techniques. The teams were chosen to spread out photographic and fluids expertise and equipment amongst the teams.
3. To have partners to bounce ideas off of. This makes ideas multiply.
4. To get informal feedback on your work.
5. To interact with students from different backgrounds.

Thus, working on a team is STRONGLY EXPECTED, but not strictly required for the team assignments. You are not required to work only with your team, but you are expected to make significant effort to be available to help them with their images and ideas. You do not all have to use the same equipment. Do plan to spend at least an hour or two to help **each** of your teammates, and recognize that you can plan on having 4 to 8 person-hours at your disposal for your project. Plan multiple meetings. If you find you are not available for specific sessions, figure out how to make it up to your team.

I hope you will take advantage of the benefits of working in teams and of the opportunity to broaden your network. Strong recommendation: don't work only with your friends. Bad for you professionally.

Following from this, here are the expectations for the deliverables on the team assignments:

Each student is expected to turn in a unique image or video that they had primary artistic and scientific responsibility for. You must give credit appropriately in your report, by explicitly naming the teammates that contributed, and what they did.

Each image/vid must be accompanied by a report. If several images come out of the same setup, you can copy descriptions of the apparatus, and the basic physics. If appropriate, give credit to report section authors. Be sure to describe the details relevant to your particular image.

Equipment and Facilities

Flow Visualization Equipment and Facilities 09/10/19

MCEN 4151-5151/ ATLS 4151/ Film 4200/Arts 5200
Flow Visualization: The Physics and Art of Fluid Flow

Here is a list of flow facilities; equipment for checkout is listed below.

Both ITLL and Idea Forge have space for temporary setups. For official access, everybody must take a short free orientation tour (once in your life) to learn what is available. Idea Forge tours are MTR @ 4pm, lower east entrance (Fleming building). ITLL tours M-F 5-15, lobby, bring Buffcard.

ITLL equipment:

If you need technical help, the entire ITLL engineering team can be reached at ITLL-EngineeringSupport@colorado.edu

- o Need to reserve the flume, have Prof. H send us an email!
- o We all receive these emails and whoever is most aligned and/or available will chime in with a response!
- Most of the equipment for checkout (high-speed camera included) can be found in the Project Depot (ITLL 1B60), where Brianne Willett and Mo Woods are located. The Project Depot has lots of free materials (Plexiglas, wood, metal, fasteners and plumbing fittings) for your use.
- If your students need electrical assistance, they can visit Tim May in the Electronics Center (ECCE 167) or Lauren Darling in the Electronics Fabrication Center (ECCE 168)
- The ITLL Launch Point is typically staffed with an Engineering Support Student who can assist you and your class with general questions; 3D printing, laser cutting, and so on.

Idea Forge: Shirley Chessman in the Idea Forge (east end of Fleming) also has a huge assortment of free parts for DIY setups; glassware, plexi, pumps, plumbing, fans etc..

FLOW FACILITIES: AIR

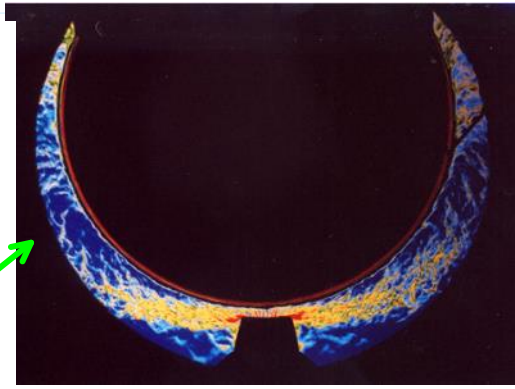
Facility	Lighting	Visualization	Phenomena	Access
Vortex ring generators; zeroblaster, or timed generator. Use in the ITLL sink space or Area 51 in Idea Forge (can be made dark), or checkout for	Try projector for light sheet, or strobe	Stage fog	Vortex rings, symmetric and asymmetric	*Check out fog generators and timed vortex generator from ITLL; in 1B equipment bay. Check out zero blasters and projector from JH

Surprisingly difficult to capture.



Brynne Sutton, Emrys Hall,
Thomas King, Bethany
Rotherham FV2003

home use Laser sheet/fog Desk toy	Built in rotating mirror and green laser pointer	Built-in stage fog generator	Turbulent jet cross section and room air turbulence/mixing	*
Misc air flows	Strobe for volume vis	Dry ice vapor ¹ humidifiers, steaming pots, medical nebulizers (<\$) ² Fog generators	Jet flows, positive buoyancy convective flow	JH has nebulizers, humidifier, fog machines
Color Schlieren Large system for ECME IB64 (JH lab) only. 2 small systems for home checkout.	EG&G strobe, provided. Maybe works. Bright single LED headlight works well too.	Schlieren: Light bent by η gradients Could do stereo with 2 small systems	Convective flows from warm/hot objects: hands, candles, hair dryers (turbulent jet). You may need time to make your own color stops. Can be used in water too.	See Prof. Hertzberg, last two projects only.
Reuben's Tube	Flame	Flame length represents pressure.	Standing wave resonance in a pipe, excited by a loudspeaker on the end.	Greg Potts, Idea forge. You'll need to provide a regulated propane supply, and follow combustion guidelines.



Colleen Stroud FV 2004

<https://vimeo.com/74130357>
By Susie Sie

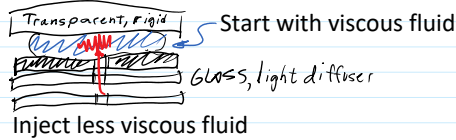


Tanner Ladtkow, Tim Read
FV 2006



Melissa Talmage,
Nigel Gorbald, Lok
Kin lee, Christopher
McCray, Taylor
Simonson FV2006

Hele-Shaw cell
Taylor-Saffman
instability

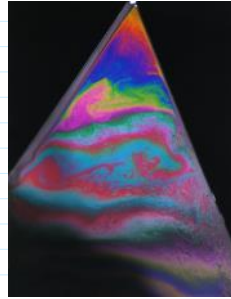


<http://www.flowvis.org/category/flow-categories/saffman-taylor-instability/>

FLOW FACILITIES: LIQUIDS

Facility	Lighting	Visualization	Phenomena	Access
ITLL Flume	Strobe or 500 Watt work lights or North Star lights (Idea Forge), or new LED floodlights (JH checkout)	Free surface or food coloring. Be sure to bleach water clean or change water. Try poster paint dots for surface flows.	Free surface: weirs, hydraulic jump, inclined flow. Wakes: submerged objects, one can inject dye. Jets: coflow, reverse, transverse. Boundary layers and surface flows.	YOU MUST sign up for flume time; do not use without permission: ITLLP-gg-EngineeringSupport@colorado.edu
Small water tunnel for checkout; 3' long, 2' deep	Includes water pump for circulation	Bubbles Dye, rheoscopic fluid, paint, anything safe for drains	Designed for object wakes	JH
Large Fish Tank. (50 gal)	Strobe or work lights	Food coloring. Be sure to bleach water clean afterwards	Short jets, vortex rings, boundary layers	*Check with JH first. ITLL signup/checkout
Small (10 gal) Fish Tanks, larger fish tank, pumps available too.	Strobe, laser sheets	Food coloring, alumina powder, cornstarch particles; anything you are willing to put down your own drain.	Short jets, vortex rings, boundary layers. Steady vertical vortex (from stirring machine). Small ring generators available.	*ITLL or JH checkout (take home 2 days)
Hele-Shaw cell	Work light or bounced strobe	Food coloring of detergent, corn syrup, water, etc	Saffman-Taylor instability	JH
Soap Film Tunnel, high humidity needed.	Diffuse sunlight is best.	Thin film effect	Jets, wakes, shear layers	JH lab. Could use a redesign.

http://www.youtube.com/watch?v=iGySs9bJbwU&feature=youtu_gdata_player



Katina Butler, Kerstin Lieff, Adrien Robert, Chris Wilke, FV 2004 team1

Ferrofluid Climbs

<http://vimeo.com/55136676>

David Oakley, Peter Davis, Kerylyn Lay, Jakob Anderegg, Brayden Hass. 2012

Pasted from <<https://vimeo.com/home/mvvideos/page?/sort:date/format:video->>

Ferrofluid Flies Up

<http://vimeo.com/55075720>

Brayden Hass, Jakob Anderegg, Peter Davis, Kerylyn Lay, David Oakley 2012

Pasted from <<https://vimeo.com/home/mvvideos/page?/sort:date/format:video->>

Add watercolors:

<http://fabianoefner.com/?portfolio=millefiori>



<http://www.flowvis.org/2016/09/11/worthington-jet-of-first-drop-collides-with-second-drop/>



<https://www.youtube.com/watch?v=rmbHhZ0NMEfo>
Kline's Flow Visualization NCFM vid

Glitter Tank 6 foot X 3 inch black PVC half tubes	LED or other worklights	Glitter (Pearl-Ex), Pearl Swirl or pearlescent shampoo	Wake and wave phenomena	JH. Would benefit from small recirc pump.
Fish Tank JH lab only (voltage source limitation)	Strobe, LED or work lights	Hydrogen Bubble apparatus	Any motion in salted water	JH. Extra training and work required
Liquid Desk Toys: lava lamp, vortex lamp, drip timers, sparkly fluid in balls, etc.		Built in	Various, including low-order turbulence, wakes, droplet motion	JH. An assortment of dynamic desk toys that have fluid motion.
Blackstock Rheoscopic Fluid cell	Has polarized light setup	Streaming birefringence	Cylinder wake	Prof. Hertzberg. Also have wake fluid available, but apparatus must be very clean, no salts.
Ferrofluid	Normal studio lighting	Move it with magnets. You need to supply magnets.	Magnetic field lines	JH. Bring small container. Impossible to clean up spills. Will stain anything. Nontoxic, though.
Glycerin				JH lab. Mix with soap solutions to extend soap film life
Droplet Splash System	Has dedicated Nikon camera and strobes. Requires Android phone for synch app	Reflection and refraction of fluids	Worthington jets, crown splashes	JH

Small Equipment Checkout

Please note that this equipment may be either expensive, rare, or both. Students checking out equipment are expected to take responsibility for the equipment. If equipment is lost,

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Equipment	Location	Notes
Stage fog generator (cooled)	JH	Fog is nontoxic water-based glycol solution. Can leave residue, and may trigger smoke alarms in high concentrations.
Stage fog generator, (small)	JH	
Zero Blaster ring generator and fog fluid	JH	
Ultrasonic humidifier	JH	
CAMERAS and LENSES		
Vision Research VR Micro C110 High speed video.	\$S Check out from ITLL Project Depo.	Must be used in ITLL with tech supervision. Mo.Woods@colorado.edu.
Olympus I-Speed high speed video system	ME Idea Forge. See Shirley Chessman	Training required. Up to 30,000 fps, but is low resolution, and low sensitivity; needs lots of light.
Canon EOS Rebel XT 8 Mpx, no movie mode	JH	Extended checkout available.
Canon extension tubes (for cheap lenses, no electronic pass thru)	JH	
Canon zoom lens: EF 75-300 mm	JH	Autofocus, but no image stabilization.
Nikon extension tubes	JH	
Nikon 24 mm wide angle lens	JH	
Nikon 50 mm lens	JH	
Nikon macro lens 102 mm	JH	Manual only
Closeup Lenses: +1, 2, 4 in	JH	

1 W Green LED Lasers

58 mm dia, +2,+3 in 72 mm dia		
Stereo cameras (film) and slide bar	JH	
LIGHTING		
Dimmable Bi-color 660 LED Video Light (continuous) with Barndoor and 6.5 feet Light Stand,	ITLL has one, JH has two	
Godox VING V860IEN TTL Li-Ion Flash with X1T-C TTL Trigger Kit for Nikon	JH	Good for remote and multiple triggers
Godox VING V860IIC TTL Li-Ion Flash with X1T-C TTL Trigger Kit for Canon Cameras	JH	Good for remote and multiple triggers
Yongnuo YN560-IV Speedlite Flash with Manual and Slave Control"	JH	Can be triggered by flash on your camera
Umbrella reflectors	JH	2 on stands, one short/table mount. Comes with weak CFL lights
24" (60cm) 5-in-1 Disc Light Reflector with Bag -	JH	Translucent, Silver, Gold, White and Black
Sunpak Auto 383 Flash (strobe) unit & 25' pc cable	JH	
CW 1 watt blue LED laser	JH	Serious safety training required
Party strobe	JH	
500 W work lights, several sets	ITLL, JH	
Small LED worklight pair	JH	
North Star video lights (2), cooled	Idea Forge	
MISC		
Gretag-Macbeth X-Rite Eye-1 Spectrophotometer	See Prof. Hertzberg, on loan to Prof. Bruns	For color calibration of monitors, cameras, printers and projectors.
Large black backdrop (8 foot square), integral stand	Idea Forge	Lots of fun to fold back up.
7 foot backdrop stand, with white and black backdrops	JH	Easy set up and take down. Not great quality black.
Small white table-top tent,	Idea Forge	Provides diffuse white light


~2 ft ²		and control of reflections
black velvet	JH	Small pieces
Assorted tripods	JH	
Velbon Macro Slider	JH	Attaches between tripod and camera. Donated by FV alum Nick Travers.
		
LP Turntable	JH	For study of rotating flows

ATOC Equipment

Scott Kittelman <alan.kittelman@colorado.edu>
Department of Atmospheric and Oceanic Sciences
CB-311
303-492-4248 (lab phone number)

Scott has a wide range of equipment available, and he is happy to work with groups in his lab. He is busy, so scheduling in advance is required.

1) Karman vortices – Kalliroscope visualization in a large circular tank

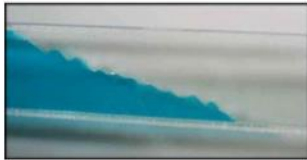
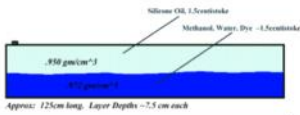
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- 1) Karman vortices – Kalliroscope visualization in a large circular tank
- 2) Two layer tank with two immiscible fluids



Example of a gravity current with two layer tank

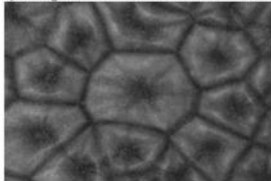
Kelvin-Helmholz instability in a 6' clear acrylic tank –two or three layer – dye visualization

- 3) Double diffusive convection “Salt fingers”

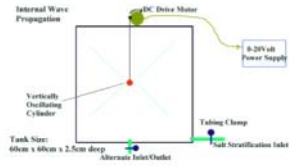


Salinity and temperature diffusion rate differences result in vertical mixing within a statically stable fluid.

- 4) Marangoni convection – aluminum flake visualization, timelapse video best



- 5) Internal gravity waves in a continuously stratified fluid- shadowgraph or Schlieren visualization



- 6) Capillary waves - visualization using a view graph projector.

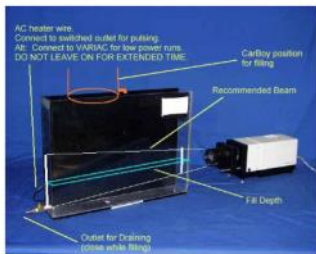




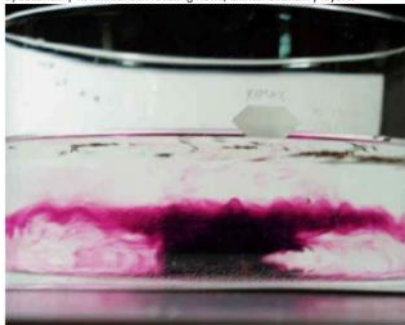
6) Capillary waves - visualization using a view graph projector.



7) Surface gravity waves with a shallow water ripple shadowgraph imagery. Can visualize wave: interference reflection refraction dispersion group and phase velocity plane and circular waves Doppler effect
8) Thermal convection - aluminum flake visualization of convection over a heating pad in a 6" layer of silicone oil



9) Secondary circulations in rotating flows, Ekman boundary layers.



Side view image of dye erupting vertically up out of the bottom Ekman boundary layer.