

Flow Visualization Equipment and Facilities
09/11/18
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. Make a reservation with Daniel.Godrick@Colorado.edu to use the big facilities in the ITLL (flume, wind tunnel, sink space room, high speed camera). Some of our Flow Vis equipment will be first-come-first-served in the ITLL 1B level equipment bay (be sure to leave your contact info and a list of what you have). To check out the smaller equipment in the ITLL, see Kai Amey (ameyexc@Colorado.edu). His office is the checkout office on the 2B level of the ITLL. If he is not there, pick up the checkout phone on the south facing wall near the south stairs of either lab level; an equipment checkout person should be able to help you.

Shirley Chessman in the Idea Forge (east end of Fleming) has a huge assortment of free parts for DIY setups; glassware, plexi, pumps, plumbing, fans etc.. Kai Amey in ITLL has a stash of miscellaneous free stuff in the Project Depot room.

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.

* Means equipment is currently in Hertzberg's lab ECME 1B64

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 home use.	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
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 (<\$5) ² Fog generators	Jet flows, positive buoyancy convective flow	JH has nebulizers, humidifier
Color Schlieren, Large system for ECME 1B64 (JH lab) only. 1 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.

FLOW FACILITIES: LIQUIDS

Facility	Lighting	Visualization	Phenomena	Access
ITLL Flume	Strobe or 500 Watt work lights or North Star lights, or new LED floodlights (JH checkout)	Free surface or food coloring. Be sure to bleach water clean. Try poster paint dots for surface flows.	Free surface: weirs, hydraulic jump, inclined flow. Wakes: submerged objects, one can inject dye. Jets: coflow, reverse,	Sign up for flume time in ITLL. See daniel.godrick @Colorado.edu ITLL module engineer.

¹ Dry ice is solid carbon dioxide. Do not seal into a container, let it breathe. Handle with extreme care; it can freeze flesh and displace breathable air. Cover with hot water for best effect, otherwise a water ice shell will form.

² Medical nebulizers require a small compressed air source. Do not nebulize oils (i.e. canola) without use of a proper respirator or aerosol filter mask: oil coated lungs define pneumonia and asphyxiation.

			transverse. Boundary layers and surface flows.	North Star lights in Idea Forge
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 in ITLL (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
Hele-Shaw cell	Work light or bounced strobe	Food coloring of detergent, corn syrup, water, etc	Saffman-Taylor instability	*ITLL checkout In 1B Equipment Bay.
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)
Soap Film Tunnel; high humidity needed.	Diffuse sunlight is best.	Thin film effect	Jets, wakes, shear layers	JH lab. Could use a redesign.
Glitter Tanks 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	*In ITLL 1B Equipment Bay. 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		Built in	Various, including low- order	JH. An assortment of dynamic desk

lamp, drip timers, sparkly fluid in balls, etc.			turbulence, wakes, droplet motion	toys that have fluid motion.
Blackstock Rheoscopic Fluid cell	Has polarized light setup	Streaming birefringence	Cylinder wake	Prof. Hertzberg. Also have extra fluid available, but apparatus must be very clean; no salts.
Ferrofluid	Normal studio lighting	Move it with magnets	Magnetic field lines	*ITLL or Idea Forge? 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	Reflection and refraction of fluids	Worthington jets, crown splashes	Check out from JH only

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, stolen, or broken, there are no funds available for replacement or repair (no, CU has no insurance for this stuff).

Equipment	Location	Notes
Stage fog generator (cooled)	*JH	Fog is nontoxic water-based glycol solution. \$40/gal., don't waste. Can leave residue.
Stage fog generator, (small)	*ITLL 1B Equipment Bay or JH	
Zero Blaster ring generator and fog fluid	JH	
Ultrasonic humidifier	*ITLL 1B Equipment Bay	
4.5" schlieren system (2) Big schlieren (20" diameter,	JH	

8' focal length, need 24' dark space)		
	CAMERAS and LENSES	
Vision Research VR Micro C110 High speed video.	After 2/14 in class demo	Check out from ITLL 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	See Prof. Hertzberg	
Canon extension tubes (for cheap lenses, no electronic pass thru)	JH	
Canon zoom lens: EF 75-300 mm	See Prof. Hertzberg	Autofocus, but no image stabilization.
Nikon extension tubes	See Prof. Hertzberg	
Nikon 24 mm wide angle lens	See Prof. Hertzberg	
Nikon 50 mm lens	See Prof. Hertzberg	
Nikon macro lens 102 mm	See Prof. Hertzberg	Manual only
Closeup Lenses: +1, 2 4 in 58 mm dia, +2,+3 in 72 mm dia.	JH	
Stereo cameras (film)	See Prof. Hertzberg	
	LIGHTING	
Sunpak Auto 383 Flash (strobe) unit & 25' pc cable	See Prof. Hertzberg	
Nd-YAG pulsed laser, green light	See Prof Hertzberg	Serious safety training required
CW 1 watt green LED lasers	See Prof Hertzberg	Serious safety training required
Party strobe	JH	
500 W work lights, several sets	ITLL, JH	
Fluorescent shop lights: 3 foot X 2 tubes	JH	
LED worklight pair, on tripod	JH	
North Star video lights (2), cooled	Idea Forge	

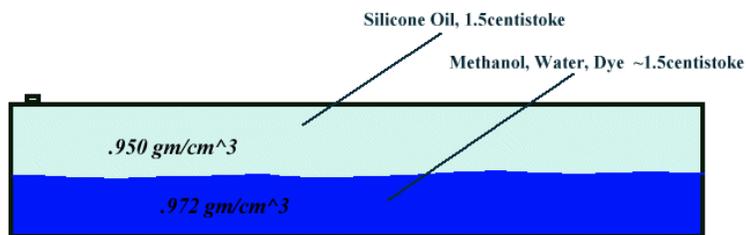
	MISC	
Gretag-Macbeth/X-Rite Eye-1 Spectrophotometer	See Prof. Hertzberg; on loan to Prof. Bruns	For color calibration of monitors, cameras, printers and projectors.
Large black backdrop (8 foot square),	Idea Forge	
Small white table-top tent, ~2 ft ³	Idea Forge	Provides diffuse white light and control of reflections
black velvet	JH	
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

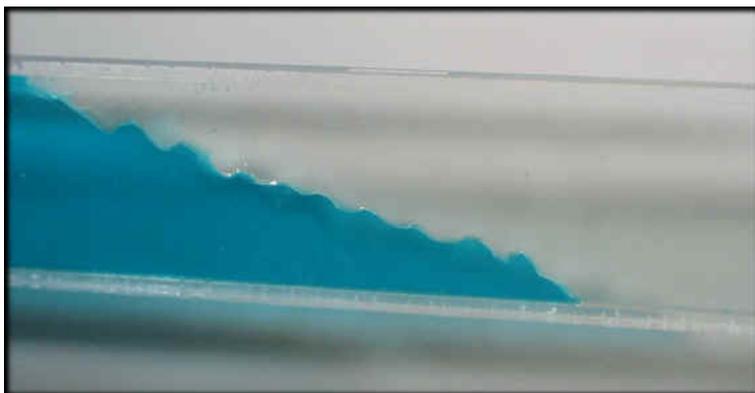
Scott Kittelman <alan.kittelman@colorado.edu>
 Department of Atmospheric and Oceanic Sciences
 CB-311
 303-492-4248 (lab phone number)

Scott has a wide range of equipment available, but he is only able to help one or two Flow Vis groups this semester, so contact me if you want to use this equipment.

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



Approx: 125cm long. Layer Depths ~7.5 cm each



Example of a gravity current with two layer tank

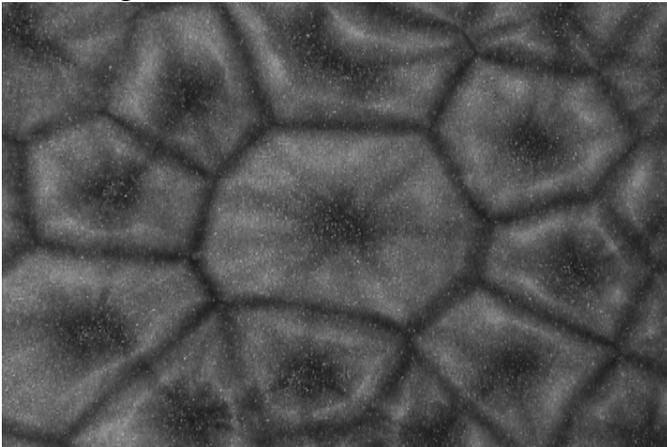
Kelvin-Helmholz instability in a 6' clear acrylic tank –two or three layer – dye visualization

3) Double diffusive convection “Salt fingers”

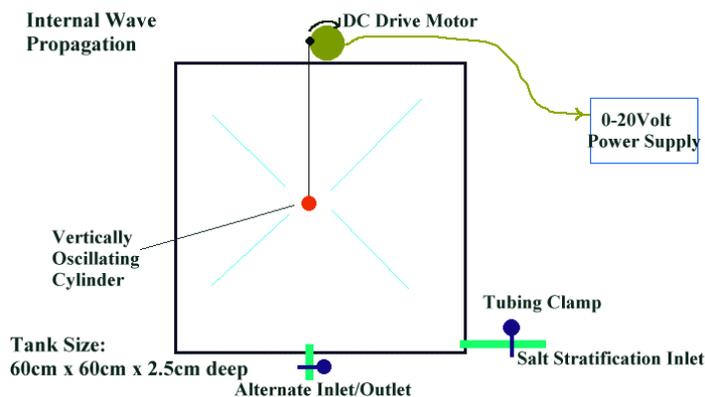


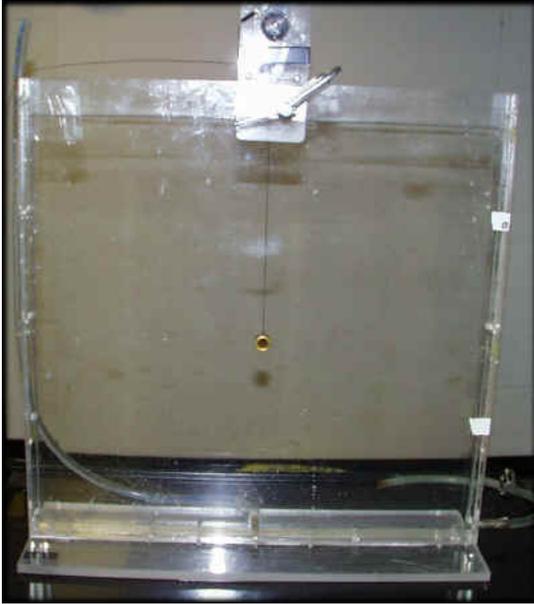
Salinity and temperature diffusion rate differences result in vertical mixing within a statically stable fluid.

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

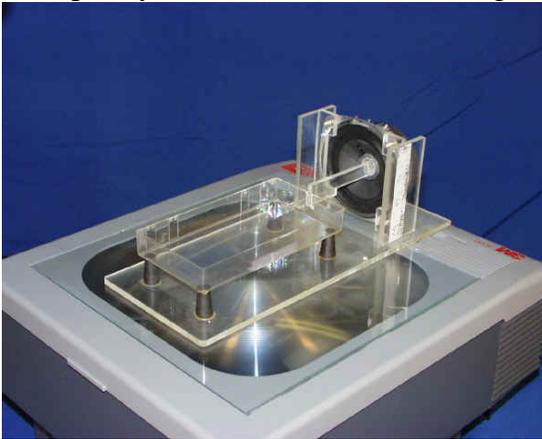


5) Internal gravity waves in a continuously stratified fluid- shadowgraph or Schlieren visualization

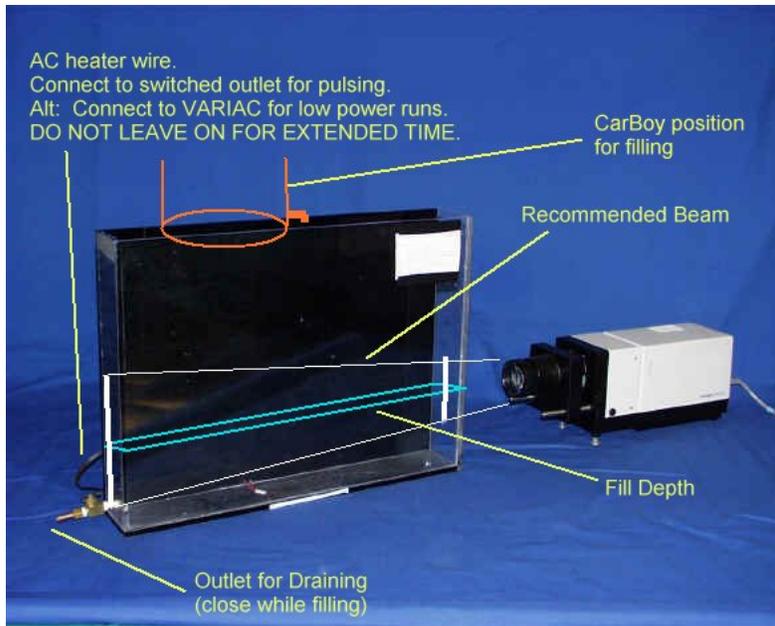




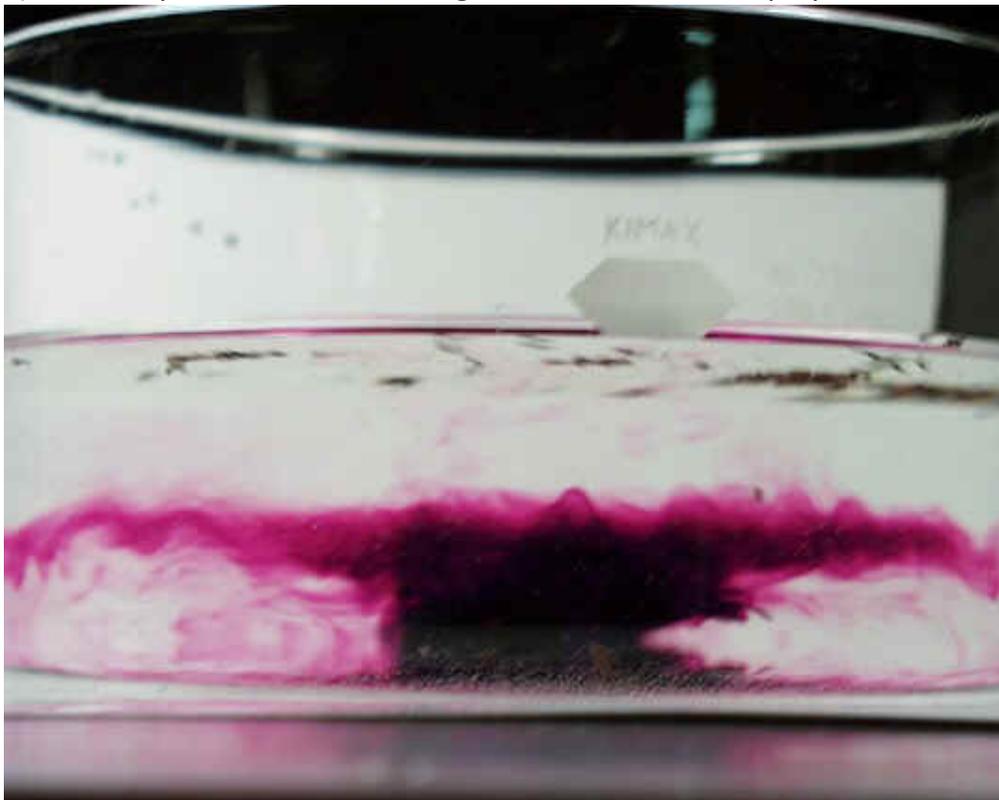
6) Capillary waves - visualization using a view graph projector.



- 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.