Flow Visualization Equipment and Facilities
09/13/23
MCEN 4151-5151/ ATLS 4151/ Film 4200/Arts 5200
Flow Visualization: The Physics and Art of Fluid Flow

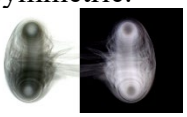
Here is a list of flow facilities; equipment for checkout is listed below. Unless otherwise specified, most of this stuff is in my lab, and I will check it out to you. MWF afternoons are the best time to catch me.

ITLL equipment:

The Consumables Closet, ITLL 151 near the Ball Machine (north end of upper level), has all kinds of free stuff to make small fluids apparatuses from. Check with ITLL Launchpoint (south end of upper level) if you don't see what you want.

Idea Forge: 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 (needs a little work).	Try projector for light sheet, or strobe	Stage fog	Vortex rings, symmetric and asymmetric.  Brynne Sutton, Emrys Hall, Thomas King, Bethany Rotherham FV2003	JH Lab
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	JH Lab

Medical nebulizer, ultrasonic humidifier	Strobe for volume vis	Dry ice vapor[1] humidifiers, steaming pots, medical nebulizers (<$5) [2] Fog generators	Jet flows, positive buoyancy convective flow Ultrasonic atomizer (same	JH has nebulizers, humidifier, fog machines

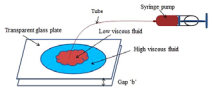
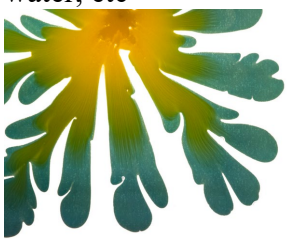
[1] Dry ice is solid carbon dioxide. Do not seal into a container, let it breathe. Handle with extreme care; it can freeze flesh and displace breathable air. Cover with hot water for best effect, otherwise a water ice shell will form.

[2] Do not nebulize oils (i.e. canola) without use of a proper respirator or aerosol filter mask: oil coated lungs define pneumonia and asphyxiation.

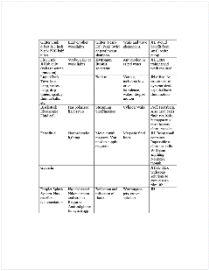
			as humidifier) flow	
2 small (4 inch diameter) schlieren systems for home checkout. See Guidebook.	Single LED headlight works well.	Schlieren: Light bent by η gradients Could do stereo with 2 small systems	Convective flows from warm/hot objects: hands, candles, hair dryers (turbulent jet). You may need time to make your own color stops. Can be used in water too.	 Colleen Stroud FV 2004
Reuben's Tube	Flame	Flame length represents pressure.	Standing wave resonance in a pipe, excited by a loudspeaker on the end.	Maybe? These come and go.

FLOW FACILITIES: LIQUIDS

Facility	Lighting	Visualization	Phenomena	Access
Flume  Tanner Ladtkow, Tim Read FV 2006  Melissa Talmage, Nigel Gorbold, Lok Kin lee, Christopher McCray, Taylor Simonson FV2006	LED panel	Surface flow or food dye injection. Must change water after	Open channel flow, 8 ft long x 6inch wide x 1 ft deep. Flow around obstacles	ITLL. Reservation and maybe short training required. Ask at Launch-point
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 lab. Requires setup.

Large Fish Tank. 50 gal. (50 gal)	Strobe or work lights	Food coloring. Be sure to bleach water clean afterwards	Short jets, vortex rings, boundary layers	Can set up in ITLL
Several small (10 gal) Fish Tanks, larger fish tank, pumps available too. For checkout.	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.	
Hele-Shaw cell  Singh, Akhileshwar, Yogesh Singh, and Krishna Murari Pandey. "Viscous Fingering Instabilities in Radial Hele-Shaw Cell: A Review." Materials Today: Proceedings, 10th International Conference of Materials Processing and Characterization, 26 (January 1, 2020): 760–62. https://doi.org/10.1016/j.matpr.2020.01.022.	Work light or bounced strobe	Food coloring of detergent, corn syrup, water, etc  https://www.flowvis.org/2015/06/01/blue-milk-and-then-yellow-milk-were-injected-into-clear-detergent-in-a-hele-shaw-cell-to-create-the-saffman-taylor-fingering-instability/	Saffman-Taylor instability	

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 office. 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 extra fluid available, but apparatus must be very clean; no salts.
Ferrofluid  Ferrofluid Climbs http://vimeo.com/55136676 David Oakley, Peter Davis, Kerylyn Lay, Jakob Anderegg, Brayden Hass. 2012 Ferrofluid Flies Up http://vimeo.com/55075720 Brayden Hass, Jakob Anderegg, Peter Davis, Kerylyn Lay, David Oakley 2012	Normal studio lighting	Move it with magnets. You need to supply magnets.	Magnetic field lines show the 'normal field instability'	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 excellent documentation	Has dedicated Nikon camera and strobes. Requires Android phone for synch app	Reflection and refraction of fluids	Worthington jets, crown splashes	JH  http://www.flowvis.org/2016/09/11/worthington-jet-of-first-drop-

				collides-with-second-drop/

Small Equipment Checkout

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	Buy at Lowe's or Target in late September , $30 Is basically a vape system but no human required.
City models, famous downtowns ~ 1 ft^2. 1:5000	JH	Use with water or air. Supply your own Godzillas.
Ultrasonic humidifier	JH	
Glass sheets, tempered	JH	28" x 10 to 17 inch. 3 sheets
	CAMERAS and LENSES	
Vision Research Phantom VR Micro C110 **High** speed video.	ITLL. High ticket item, but free to you. Requires checkout.	Instruction manual
- Sony HXR-NX80 (240 fps?) - Phantom C110 - Lumix DC-GH5 - Nikon – D3400 - JVC GC-PX100BU	Cameras live in ITLL Electronics fab lab, ECCE 167, west end of skybridge, in Jonah's office.	ITLP-gg-EngineeringSupport@colorado.edu For availability and checkout.
Olympus I-Speed high speed video system	ME Idea Forge.	Training required. Up to 30,000 fps, but is low resolution, and low sensitivity; needs lots of light.
Canon Eos T3i DSLR with kit lens, 2 batteries		JH
Time lapse trigger for Canon		

Canon extension tubes (for cheap lenses, no electronic pass thru)	JH	
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 58 mm dia, +2,+3 in 72 mm dia.	JH	
Stereo cameras (film) and slide bar	JH	
FLIR Infrared thermal imaging camera. For iPhones only	**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 V860IIN 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	Produces a lot of heat as well as light.

Small LED worklight pair	JH	
North Star video lights (2), cooled	Idea Forge	
	MISC	
Gretag-Macbeth/X-Rite Eye-1 Spectrophotometer	See Prof. Hertzberg	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.
Small white table-top tent, ~2 ft^3	Idea Forge	Provides diffuse white light and control of reflections
black velvet	JH	Small pieces
Assorted tripods	JH	
LP Turntable	JH	For study of rotating flows

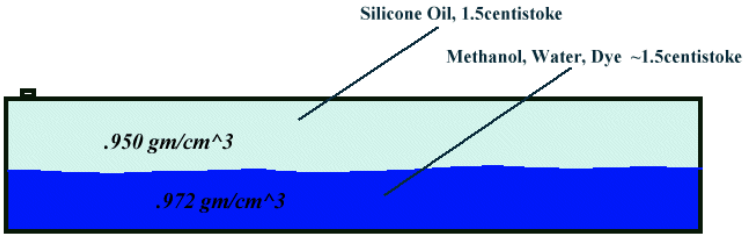
ATOC Equipment

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

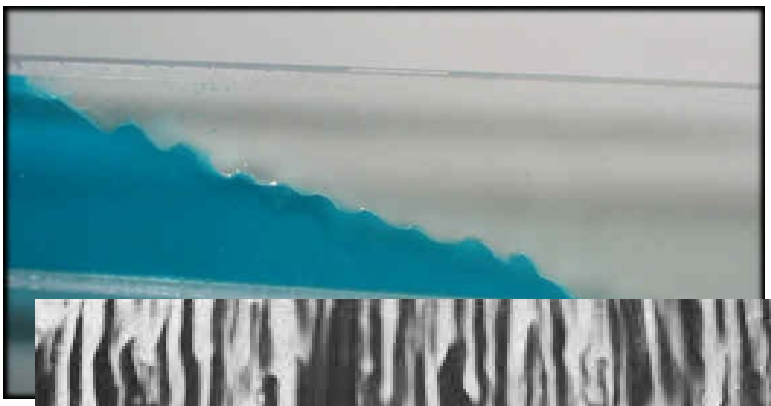
Scott has a wide range of equipment available, and he is happy to work with groups in his lab. He is busy, so scheduling in advance is required.

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

2) Two layer tank with two immiscible fluids



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



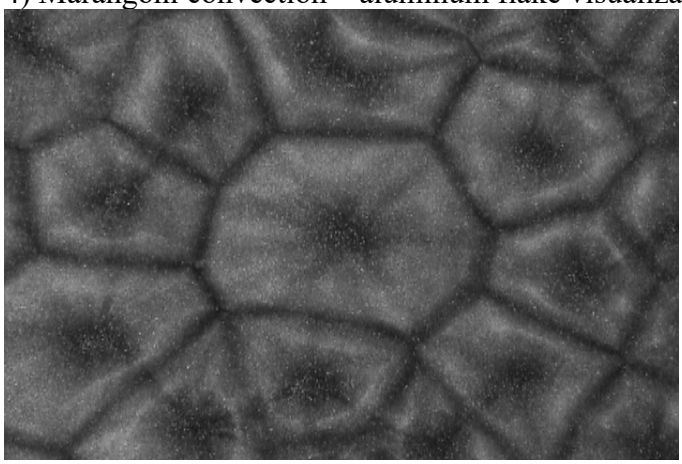
Example of a gravity current with two layer tank

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

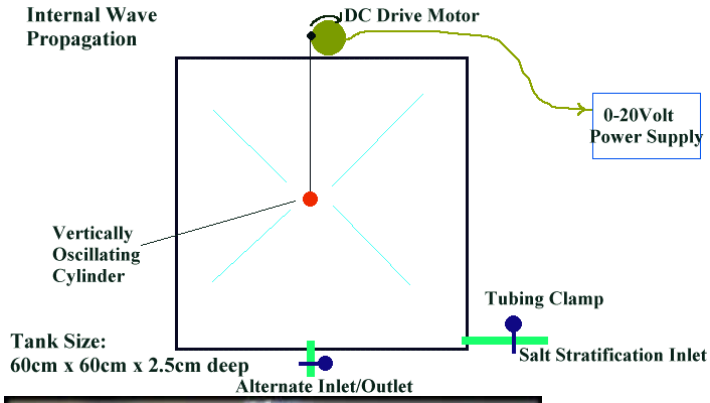
3) Double diffusive convection "Salt fingers"

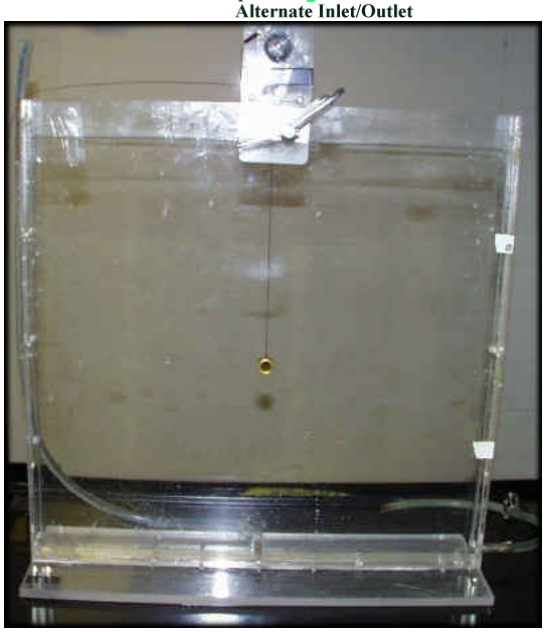
Salinity and temperature diffusion rate differences result in vertical mixing within a statically stable fluid.

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



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

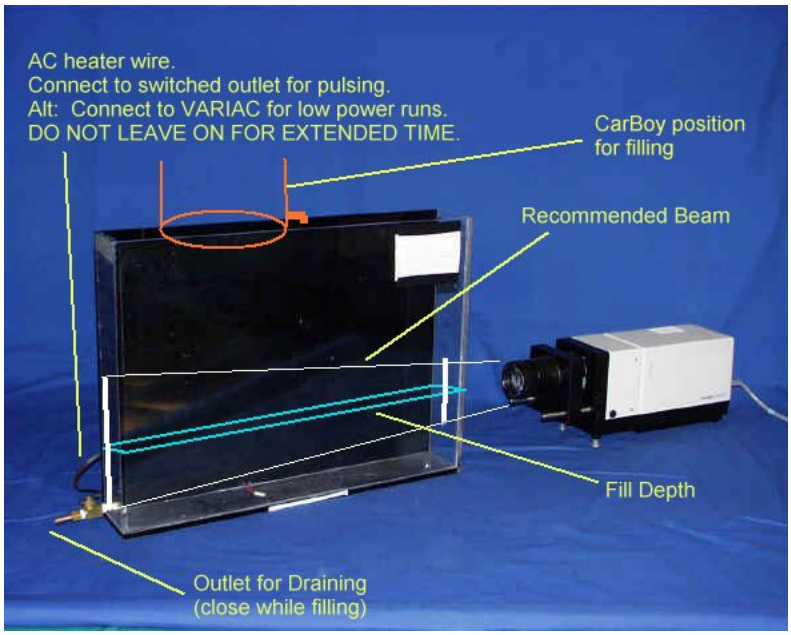




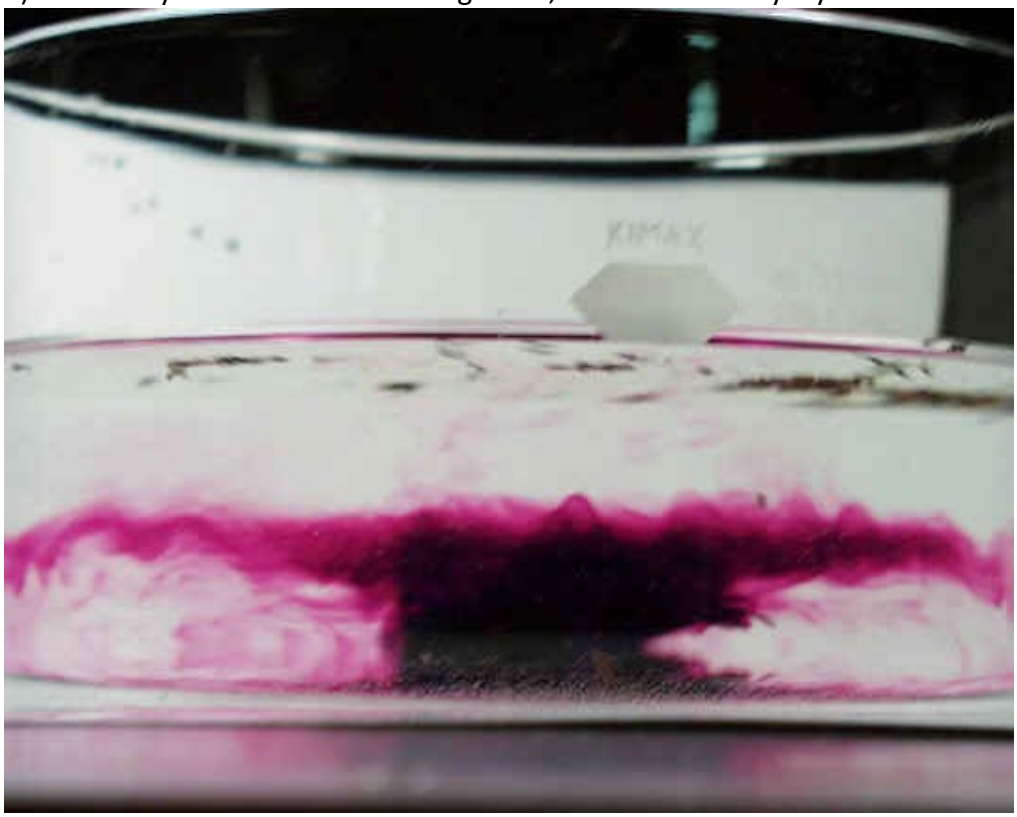
6) Capillary waves - visualization using a view graph projector.

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.