

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 ITLP-gg-EngineeringSupport@colorado.edu

- Need to reserve the flume, have Prof. H send us an email!
- 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

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

FLOW FACILITIES: LIQUIDS

Facility	Lighting	Visualization	Phenomena	Access
ITLL Flume	Strobe or 500	Free surface or	Free surface:	YOU MUST

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.

	Watt work lights or North Star lights (Idea Forge), or new LED floodlights (JH checkout)	food coloring. Be sure to bleach water clean or change water. Try poster paint dots for surface flows.	weirs, hydraulic jump, inclined flow. Wakes: submerged objects, one can inject dye. Jets: coflow, reverse, transverse. Boundary layers and surface flows.	sign up for flume time; do not use without permission: ITLP-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.


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 extra 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, 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. 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.	\$\$ 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	

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 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	
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. Brunns	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 ³		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

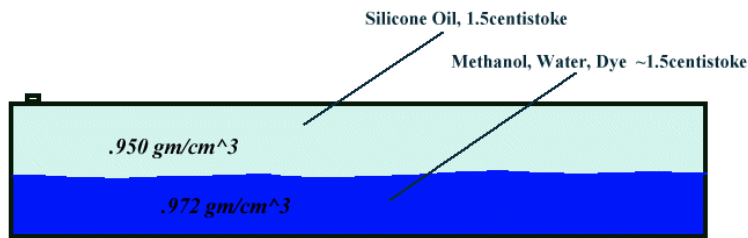
ATOC Equipment

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

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

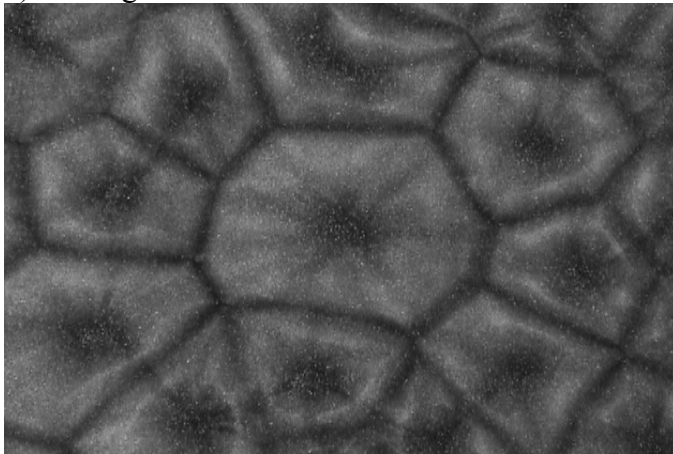
Kelvin-Helmholz instability in a 6' clear acrylic tank –two or three layer – dye visualization

3) Double diffusive convection “Salt fingers”

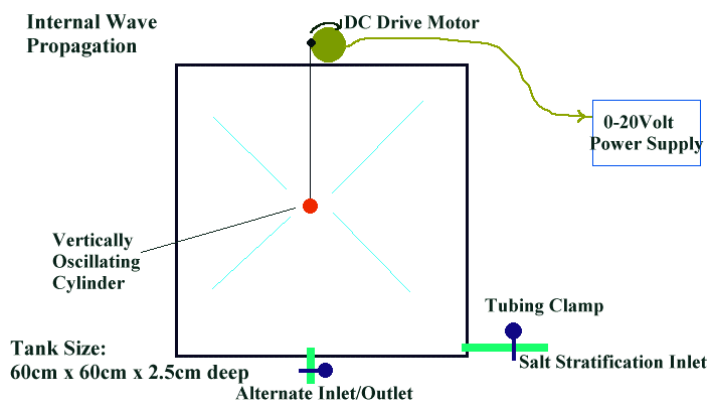


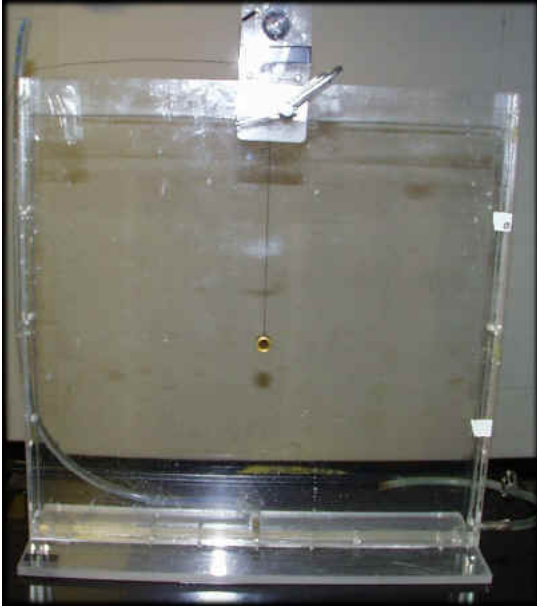
Salinity and temperature diffusion rate differences result in vertical mixing within a statically stable fluid.

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

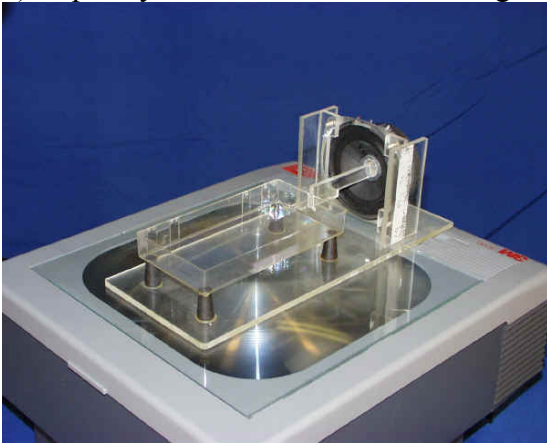


5) Internal gravity waves in a continuously stratified fluid- shadowgraph or Schlieren visualization

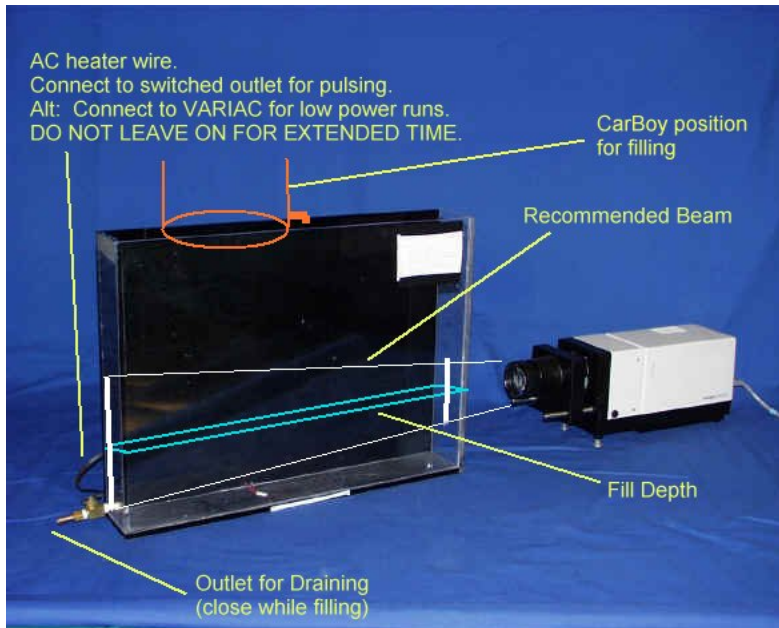




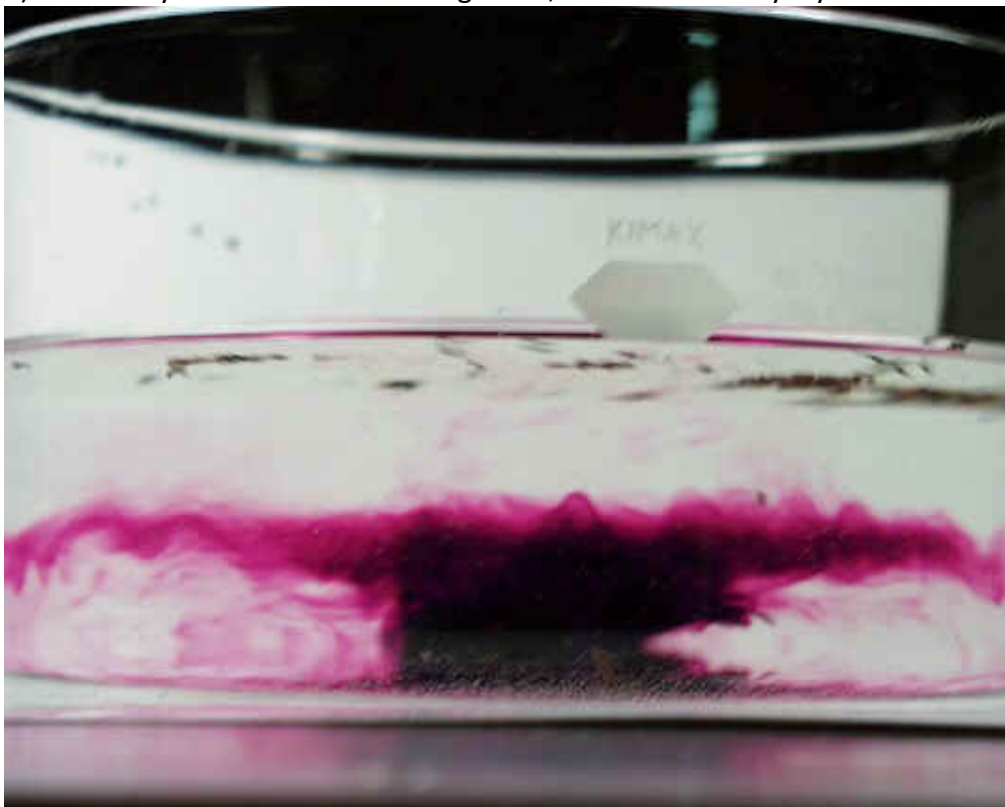
6) Capillary waves - visualization using a view graph projector.



- 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.