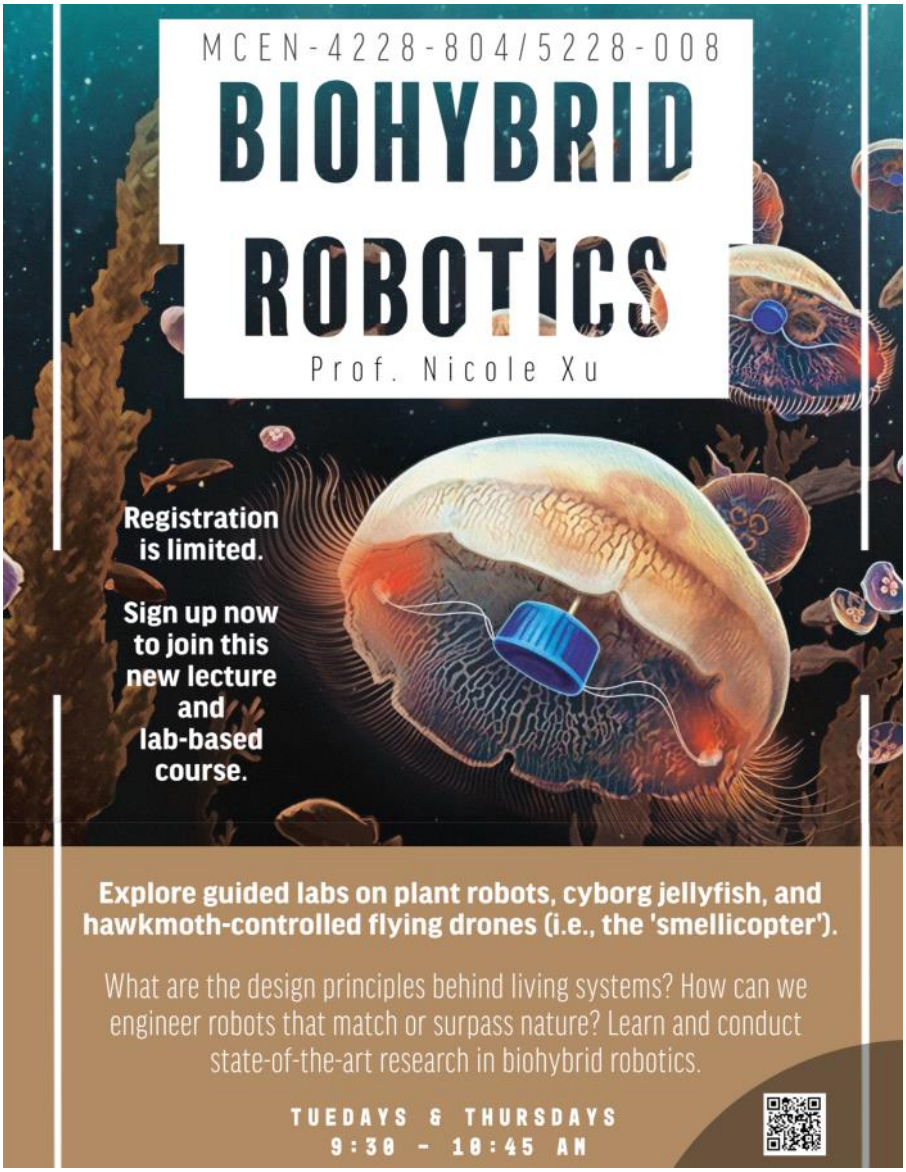
26.Particles 4 Water

Friday, November 15, 2024

Today:

Particles - Hydrogen Bubble technique
Refractive Index = Index of Refraction techniques



Yes, conflicts with Sr Design.

Solid Particle Sources

Neutral buoyancy

- Corn starch (diluted)
- Glass or polystyrene microspheres. Specific size and density. $$
- Latex bubbles
- Rust (filtered)
- Mica powder for makeup
- Alumina, sold as polishing powder. Available in 1 to 100 micron size ranges
- Wax beads (Pine Sol)
- Pine pollen (floats on surface)

Lycopodium powder (also used as flash powder)
http://vimeo.com/89491724 Cymatics by Susie Sie

Hydrogen Bubbles

https://www.youtube.com/watch?v=nuQyKGuXJOs&t
NCFMF film 'Flow Visualization'
National Committee on Fluid Mechanics Films
Hydrogen bubble technique, but also discusses streamline vs streakline vs pathline

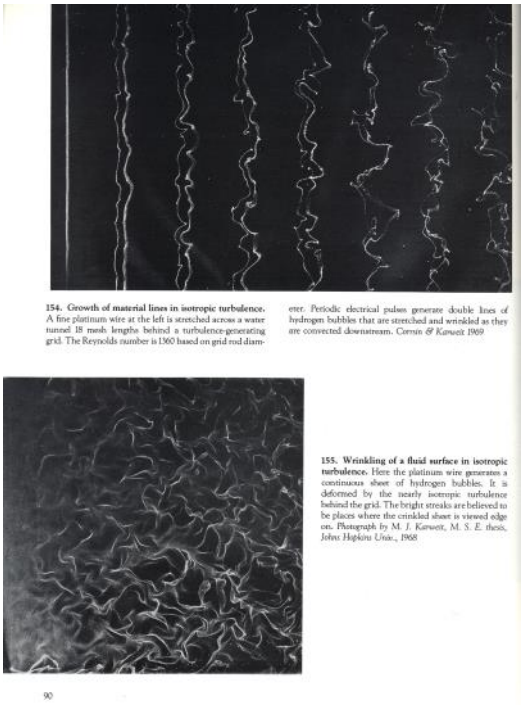
Streamline: tangent to the velocity field
Pathline: path one particle takes
Streakline: path of all particles starting at a single location

In steady flow, all three of these are the same.

Clicker: What does motion blur in a flow vis image show?

A) Streamline
B) Pathline
C) Streakline

Want neutral buoyancy, but for very small particles viscous forces are high. Can use up to 100 µm bubbles. Good scatterers.



154. **Growth of material lines in isotropic turbulence.** A fine platinum wire at the left is stretched across a water tunnel 18 mesh lengths behind a turbulence-generating grid. The Reynolds number is 1360 based on grid rod diameter. Periodic electrical pulses generate double lines of hydrogen bubbles that are stretched and wrinkled as they are convected downstream. *Corrsin & Kistler 1969*

155. **Wrinkling of a fluid surface in isotropic turbulence.** Here the platinum wire generates a continuous sheet of hydrogen bubbles. It is deformed by the nearly isotropic turbulence behind the grid. The bright streaks are believed to be places where the crinkled sheet is viewed edge on. *Photograph by M. J. Karweit, M. S. E. thesis, Johns Hopkins Univ., 1968*

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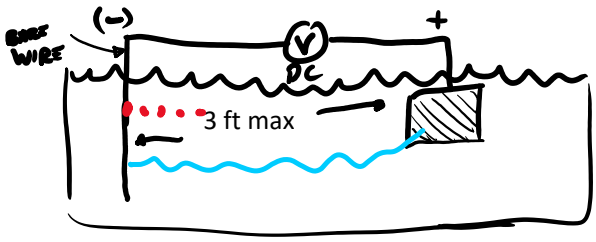
Van Dyke's Album of Fluid Motion

Hydrogen Bubbles



NaCl
Na^+Cl^-

H_2 bubbles
anode

O_2 & Cl_2 bubbles
cathode

large plate or
pipe

Cl_2= Chlorine gas. Used as sterilizer in 'salt pools' and hot tubs. NaCl = table salt. Small device electrolyzes water. Chlorine gas kills organic compounds, then returns to Cl ions. Nice to not have to add chlorine or bromine tablets.

H_2O → $2H_2$, O_2

Smallest H2 bubbles if wire is very thin. Bubbles = 1/2 to 1 wire diameter = 25 to 50 µm
Want small enough bubbles to track flow, and have a slow rise time, so < 100 µm needed.
Best if wire is platinum. Other wires oxidize, and don't provide a clean sheet of bubbles.

Minute paper: Why not use O2?

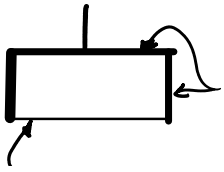
$2H_2O \rightarrow 2H_2 + O_2$

For same current, get half as much O_2
diffusivity
relative solubility
surface tension
Would oxidize thin wire

Depending on salt concentration, for a large rake, need 50 - 70 VDC, 1 amp minimum.
For long wires (200 mm) need 250 V, 2 amps
Expensive power supply.

The water must conduct well.
Add salt. Some refs say sodium sulfate is better than sodium chloride, table salt.
Weak acid or base would also conduct, but may eat wire.

Too much salt = bigger bubbles, Cl gas?



Pt wire, tight and smooth. Big bubbles form at kinks.

Any ions in the water are attracted to the electrodes, so material plates onto the electrodes, fouls the wire.
"Cleaning" = Reverse polarity briefly now and then for a few seconds

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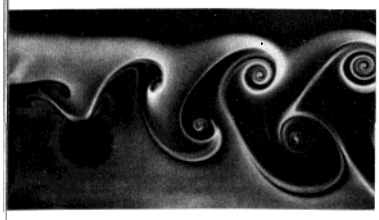
Electrolytic Precipitation Technique

Same circuitry as H2 bubbles, but 10VDC, 10 mA. Much more reasonable requirements but….
Tracer is electrolytically precipitated oxide at anode, of anode material.
Metal often used = solder = tin+lead. Two heavy metals you don't want to put down the drain; needs 5 um filter.

94. Kármán vortex street behind a circular cylinder at $R=140$. Water is flowing at 1.4 cm/s past a cylinder of diameter 1 cm. Integrated streaklines are shown by electrolytic precipitation of a white colloidal smoke, illuminated by a sheet of light. The vortex sheet is seen to grow in width downstream for some diameters. *Photograph by Sadatoshi Taneda*



95. Kármán vortex street behind a circular cylinder at $R=200$. This photograph, made using a different fluid (and in another country) happens to have been timed so as to resemble remarkably the flow pattern in the upper picture. A thin sheet of tobacco smoke is introduced upstream in a low-turbulence wind tunnel. *Photograph by Gary Koetmann*

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Van Dyke's
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