SMS 204: Integrative marine sciences II

- Instructors: Jim Loftin & Mary Jane Perry

- Class web site:

http://misclab.umeoce.maine.edu/boss/classes/SMS_204/Syllabus.htm

Today we will discuss the following topics:

Buoyancy.

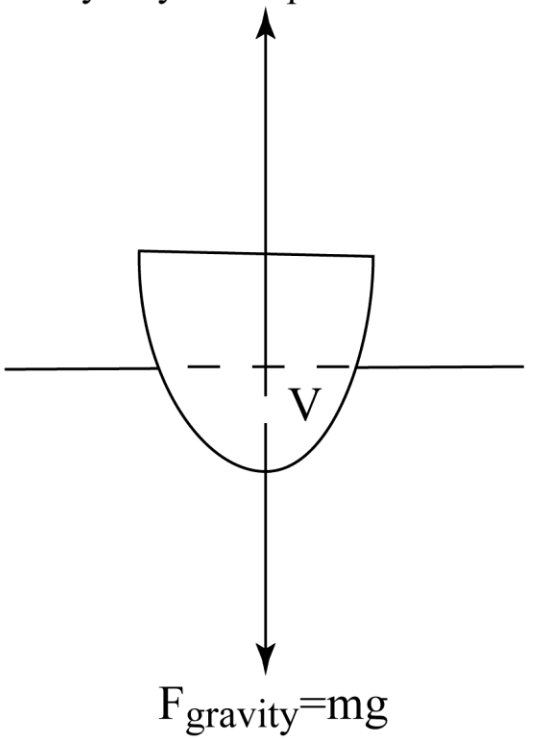
Energy conservation in fluids.

Dynamic pressure.

- Archimedes's principle:
  - The buoyancy force is equal to the weight of the liquid displaced by the object (where is this force coming from?).

For a floating object:

$F_{buoyancy}=V_{displaced}\rho_{water}g$



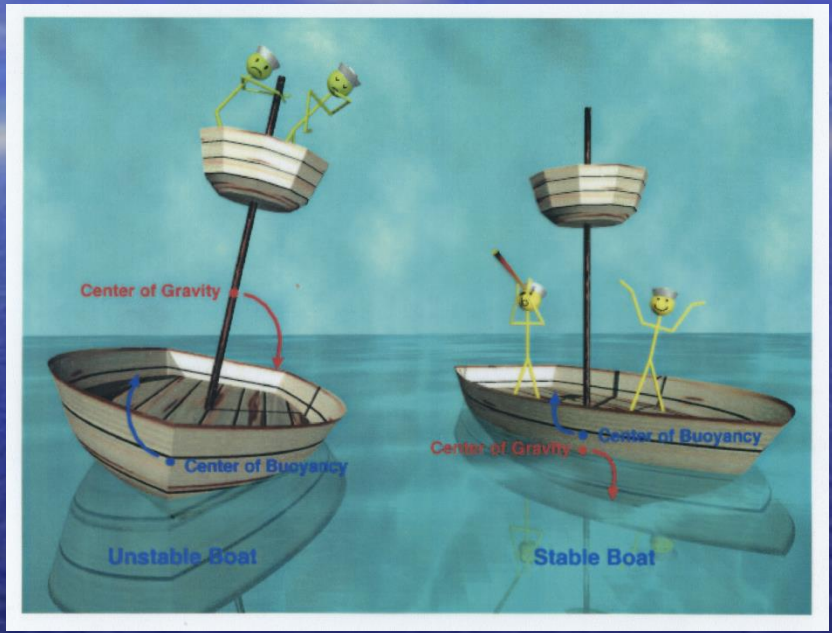
$ma=F_{gravity}-F_{buoyancy}=0$

What is the balance of forces for a sinking object?

- Center of buoyancy vs. center of gravity:

Center of gravity:

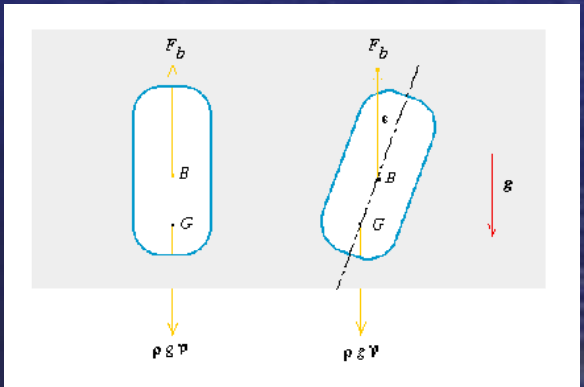
$$\vec{r}_c = \sum_i \frac{\vec{r}_i m_i}{m_i}$$



Center of buoyancy:
Center of gravity of displaced fluid.

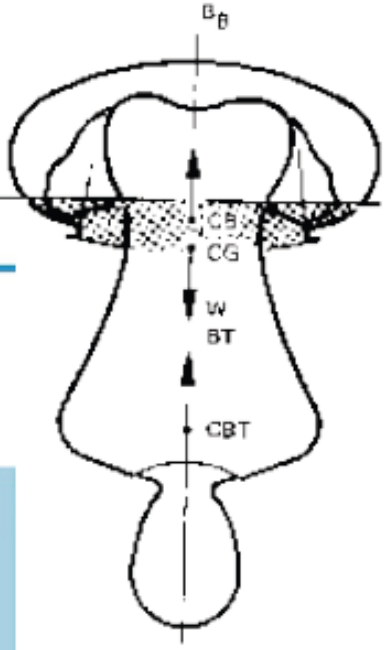
When center of buoyancy is bellow the center of gravity the situation is unstable.

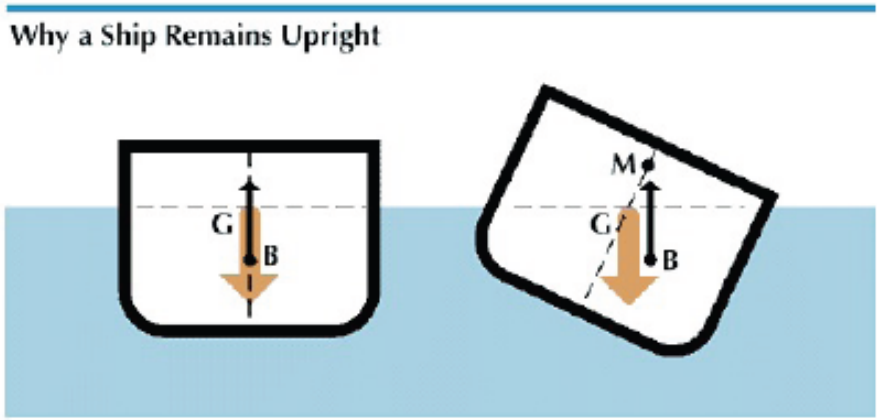
Separate centers of gravity and buoyancy allow organisms and plants to orient relative to the gravitational field:
e.g. dinoflagellates, kelp.



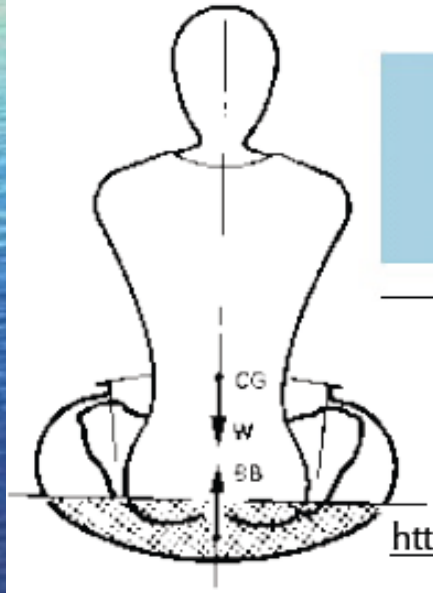
Floating hull stability

Explain why the kayak (in the picture with the head up) is less stable than the ship.





http://student.britannica.com/comptons/art-53972/The-weight-of-a-ship-acts-through-the-ships-center



http://www.atlantickayaktours.com/pages/ExpertCenter/Rolling/Rolling4.shtml

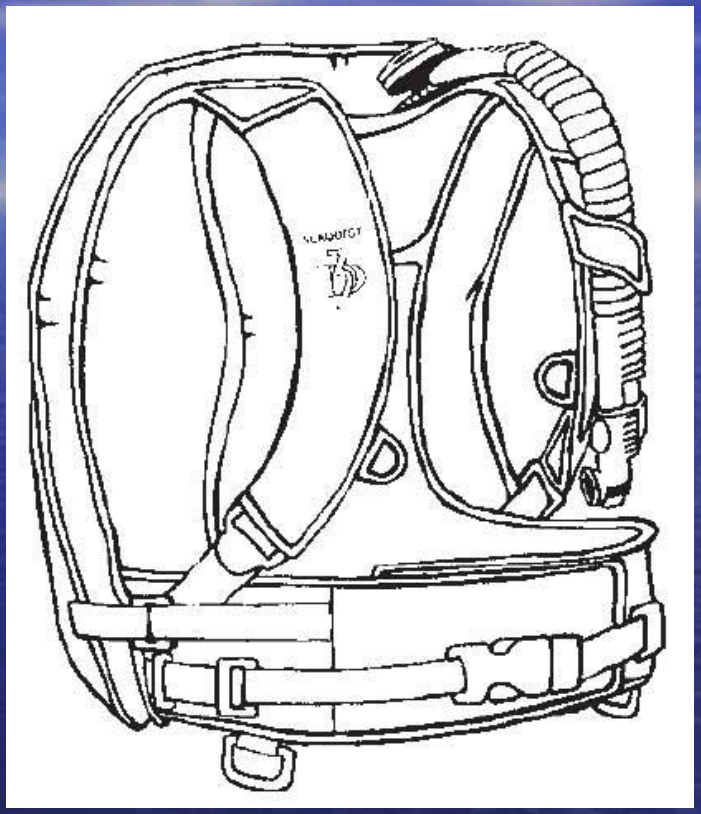
Buoyancy issues for marine organisms:

- Blubber is buoyant (0.7-0.9g cm^{-3})
- Muscles (1.08g cm^{-3}) and bones (1.9g cm^{-3}) are denser than water
- Air is buoyant (but compressible, that is buoyancy changes with pressure (depth))

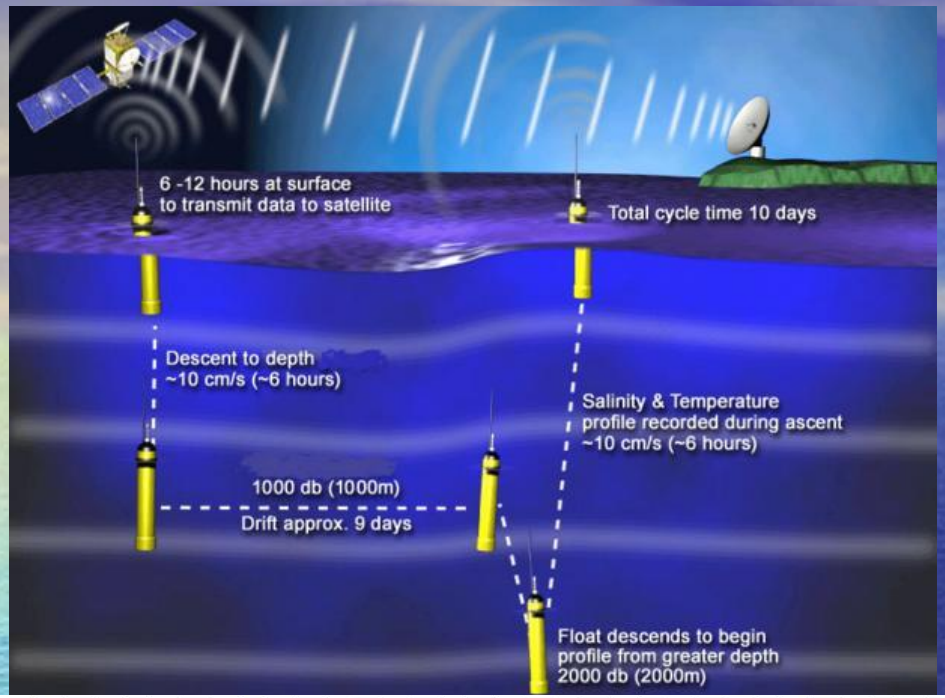
Some strategies:

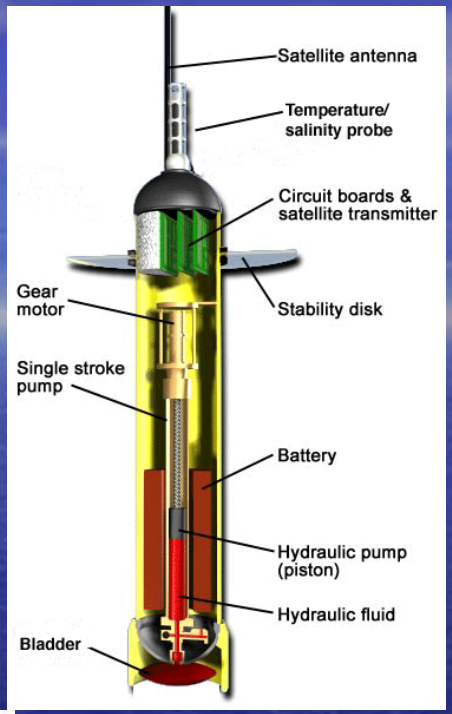
- Air in stomach (some sharks).
- Swim bladder (many bony fishes, physiologically regulated).
- Large oily liver (Sharks).

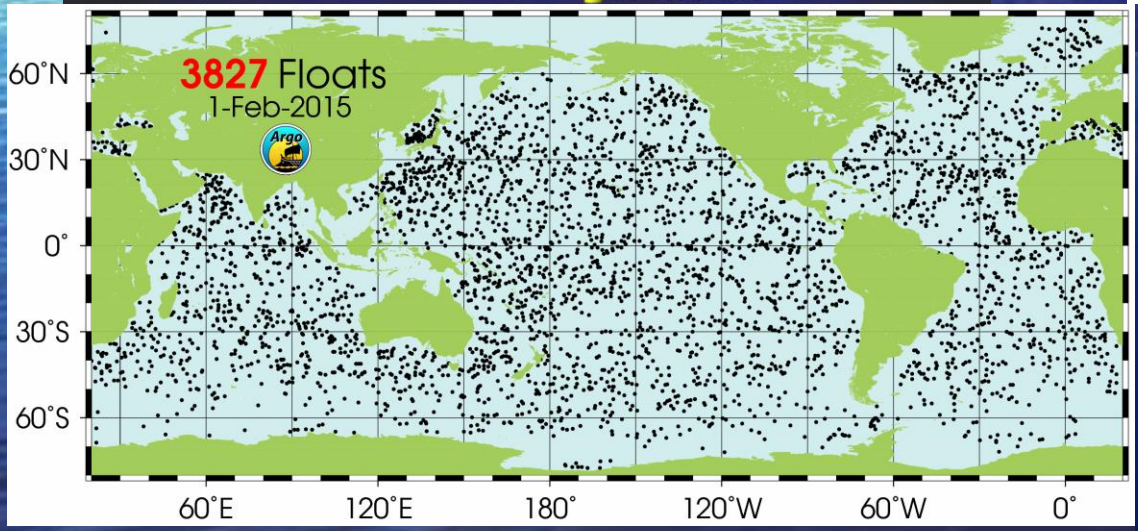
Buoyancy and diving

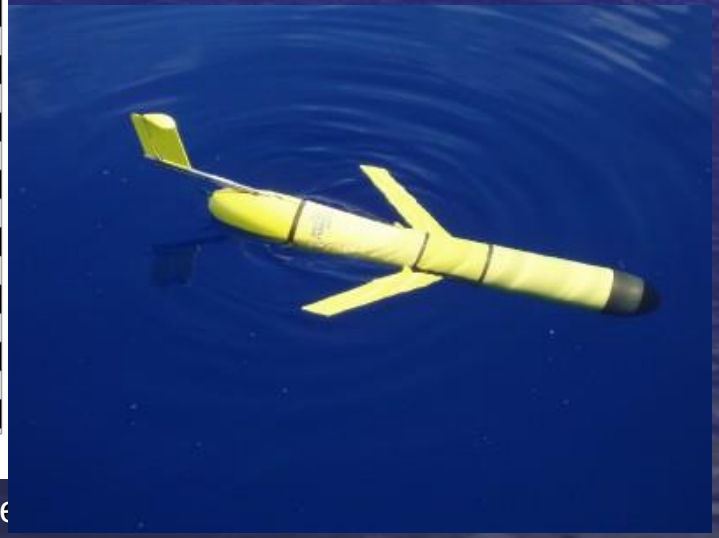


Buoyancy engines on floats and gliders

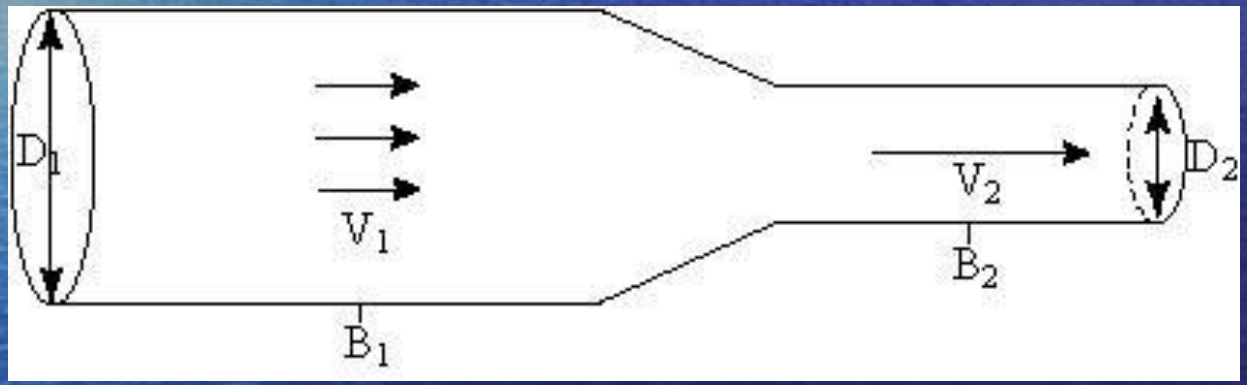








- Some important concepts from last week:
  - Hydrostatic pressure- weight of water/area
  - Continuity $v \times A$=constant



- Energy:
  - Capacity to do work (force x distance).

- Kinetic energy: $mv^2/2$ [(m) (L^2 T^{-2})]
- Pressure-volume energy: PV [(m L^{-1} T^{-2})(L^3)]
- Potential energy: mgh [(m) (L T^{-2}) (L)]
- Other: internal energy, heat, light.

Conservation of energy: $mv^2/2+mgh+PV=constant$ where we neglected friction.

Conservation of energy *per unit mass*: $v^2/2+gh+P/\rho=constant$ ← Bernoulli's principle

Important to remember:

1.Holds only along a streamline (within a parcel of water)

2.Can convert kinetic energy here to pressure somewhere else.

Different forms:

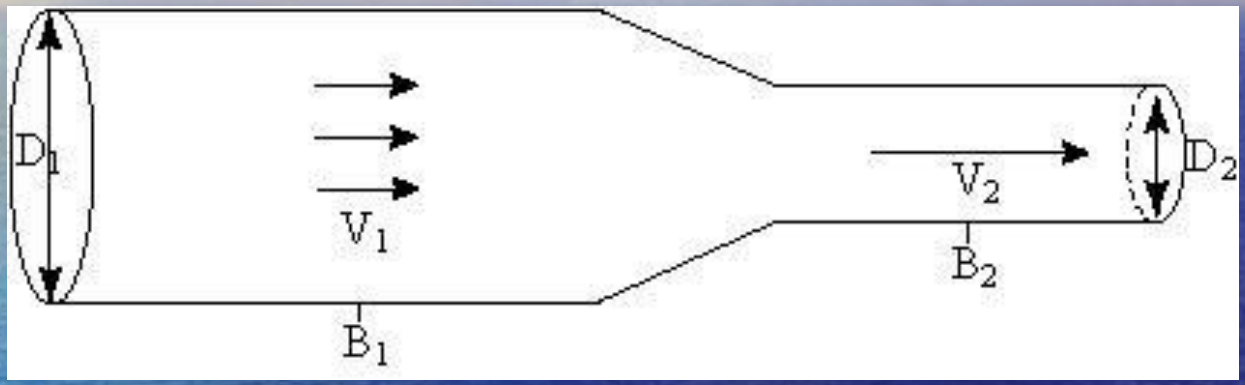
$$v^2/2+gh+P/\rho=constant$$

What is this?

$$\rho v^2/2+\rho gh+P=constant$$

$$v^2/2g+h+P/g\rho=constant$$

Based on Bernoulli's principle:
How would pressure change along a fluid as it flows through a constriction?

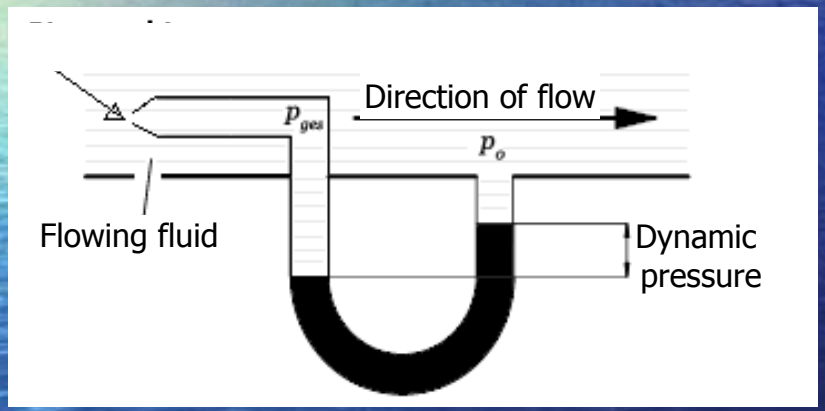


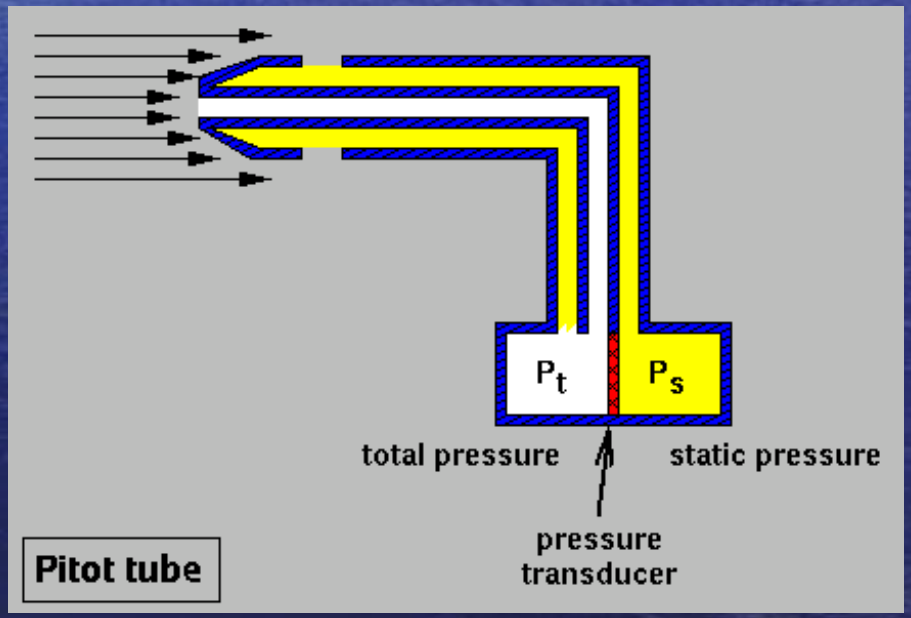
Movie clip

Demo

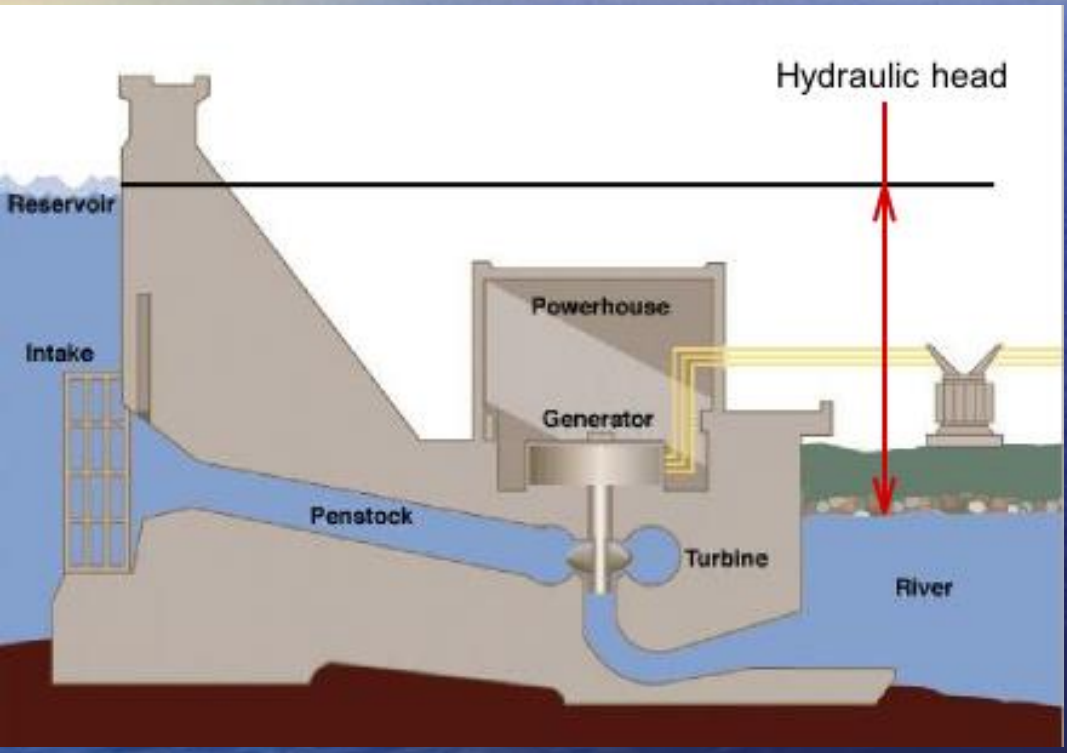
Based on Bernoulli's principle: How can we measure the velocity of a fluid using only pressure?

Answer: the pitot tube

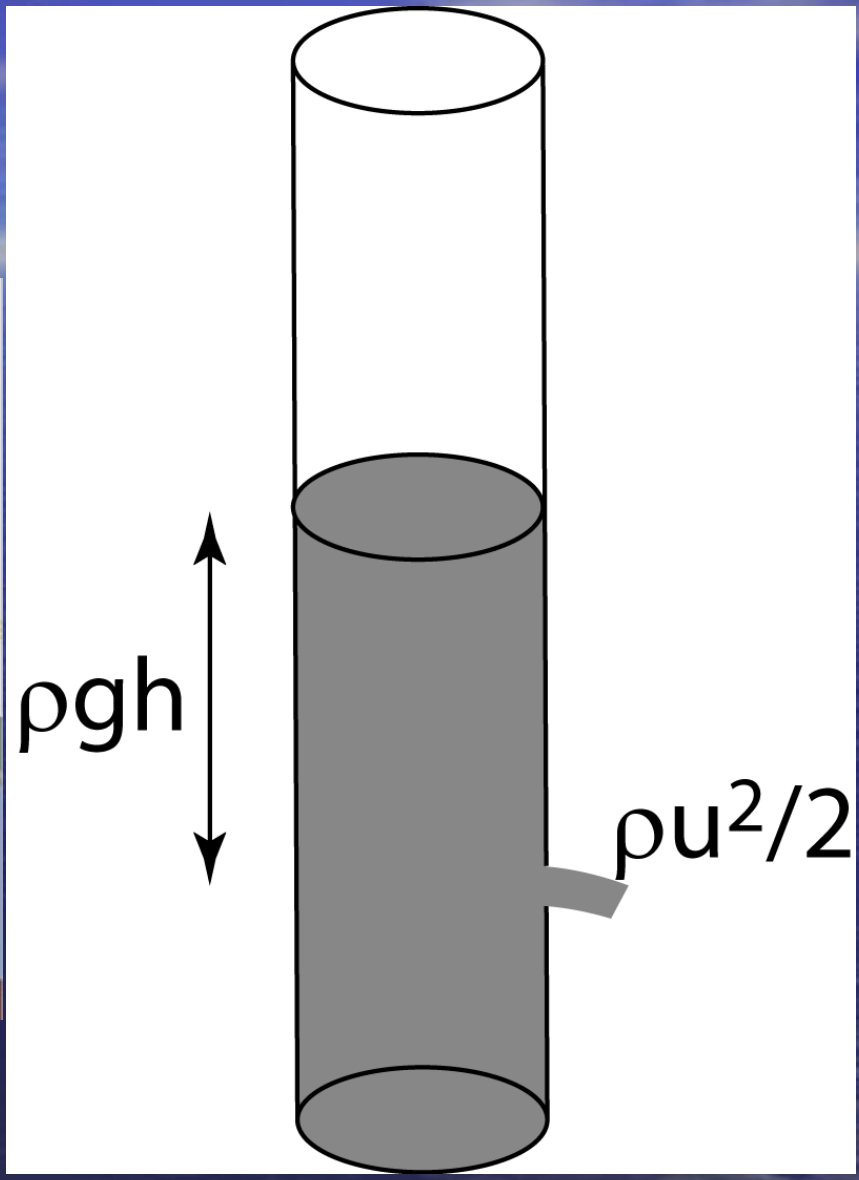




Hydro-electricity:



Squirting column:

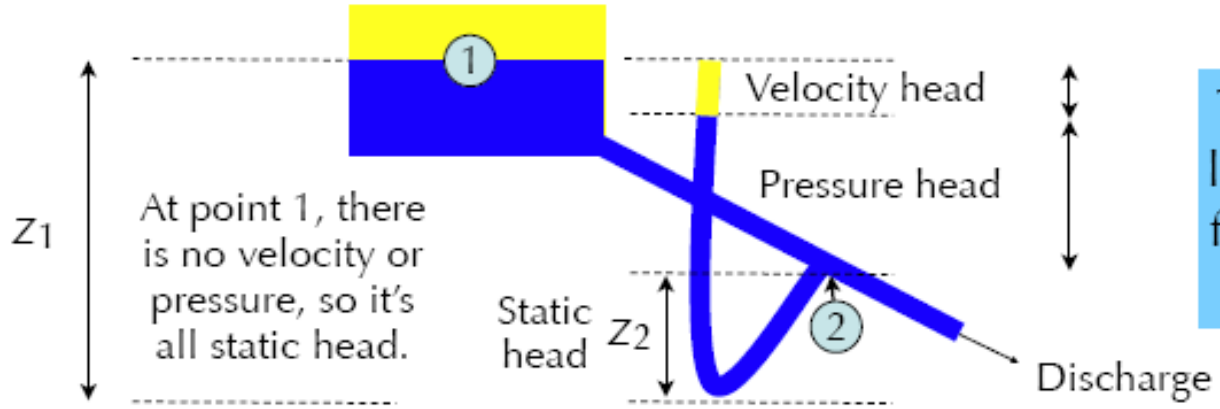


Homework question

Velocity, static and pressure heads for pipe flow

$$u^2/2g+z+P/g\rho=constant$$

At point 2, there are all three kinds of heads



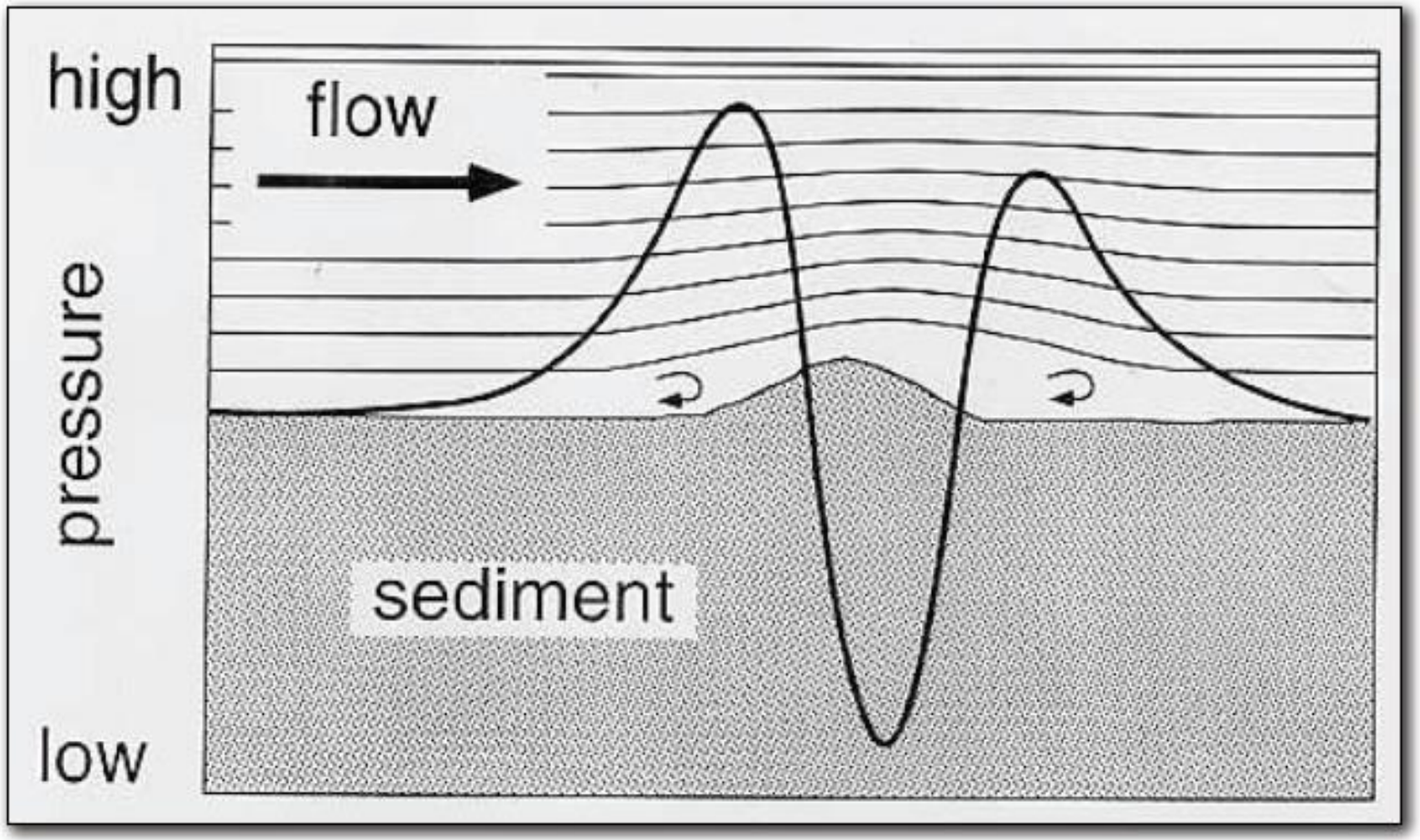
There is some loss of head as friction (shear) to heat.

Relevant vertical distances at point 2 are:

Velocity head = $u^2/2g$
Pressure head = $p_2/\rho g$
Static head = z_1, z_2

} Sum = Total head

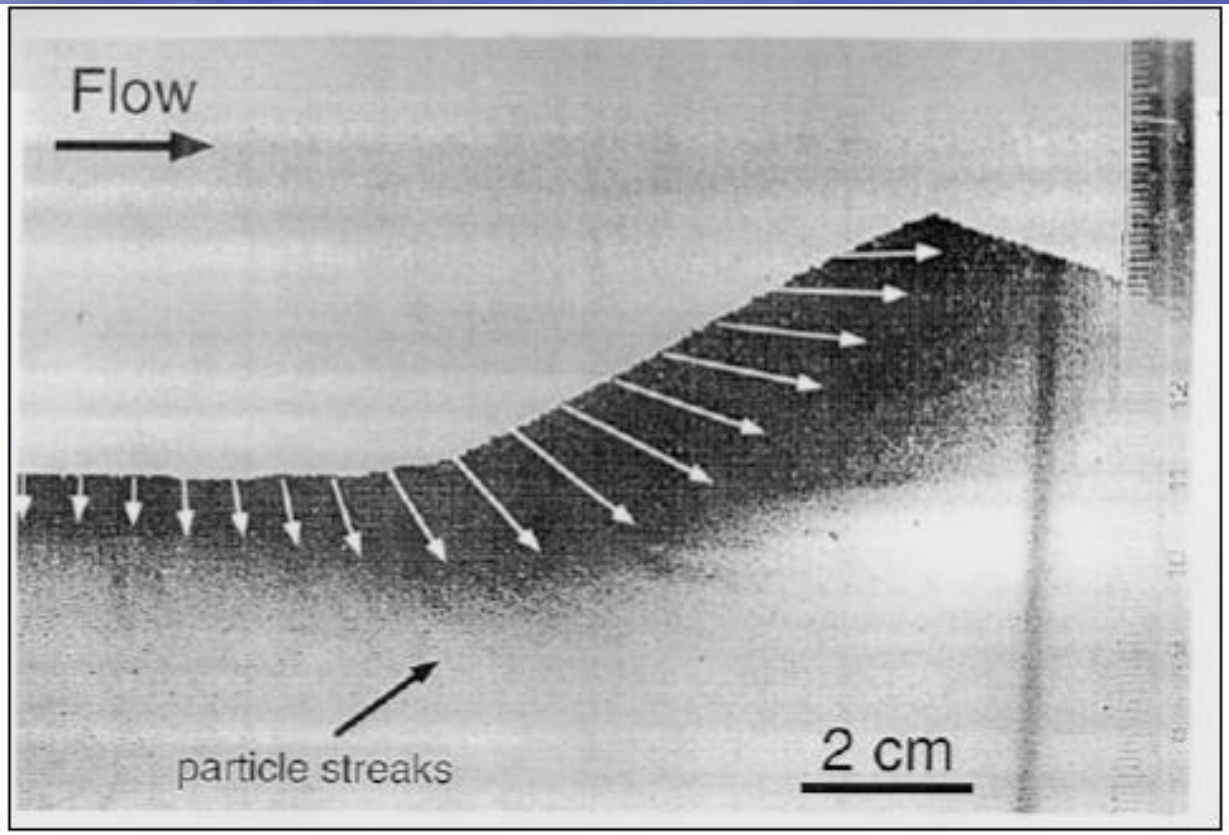
Application: flow above a disturbance (Clams, ripples, houses, etc').



Hüttel, M., W. Ziebis and S. Forster. 1996. Flow-induced uptake of particulate matter in permeable sediments. *Limnol. Oceanogr.* **41:** 309-322. (Source of figure)

Generate flow of small particles and solutes into/out of sediments:

1-µm particles are carried in.



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