SMS 204: Integrative marine sciences II

- Instructors: E. Boss and Lee Karp-Boss.
- Class web site:

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

From last week: Equation of state of an ideal gases

$PV=nRT$

- Temperature: kinetic energy of molecules (applet).
- Pressure: momentum transfer (normal) to sides of container.
- Viscosity: momentum transfer between molecules.

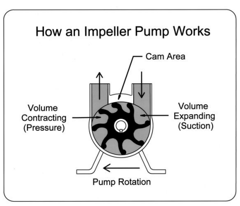
In class demonstration (change of volume with pressure)

The magic of the hydraulic press:

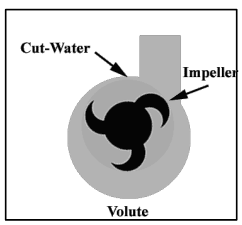
- Pressure (non-hydrostatic) is equal within the fluid.
- → F1/A1=F2/A2
- → F2=F1 A1/A2
- → F1 < F2
- We can use a small force to lift a heavy object if we apply it over a long distance (remember work=force x distance).

Two kinds of pumps:

- Positive displacement pump (decrease in volume raises pressure , *e.g.* a bicycle pump)
- Fluid dynamic pump (add thrust to the fluid through moving parts).
- Positive displacement pumps tend to be better at producing high pressures. Fluid dynamic pumps are better at producing large volumetric flow rates.



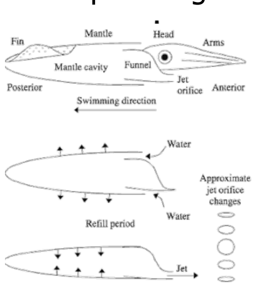
From: http://captnpauley.typepad.com



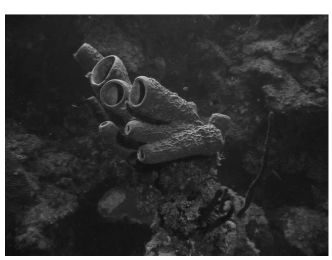
http://www.perfusionkorea.org/kosect/img/ImpellerAnim.gif

Which kind of pump are these?

Pumps in organisms:



Movie



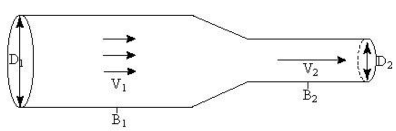
Wikimedia

Movie

Summary

- Water organizes itself by density if there are no forces acting on it.
- Water flows from high to low pressure.
- Pumps are useful as tools to get food and get rid of waste products.
- If you care about diving (or organisms that dive) you should worry about pressure.

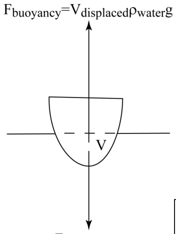
- Some important concepts from last week:
  - Hydrostatic pressure- weight of water/area
  - Continuity $v \times A$=constant



- 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:

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



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

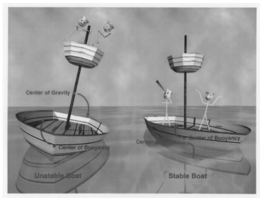
$F_{gravity}=mg$

What is the balance of forces for a sinking object?

- **Center of buoyancy vs. center of gravity:**

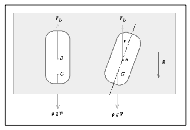
Center of gravity:

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



Center of buoyancy:
Center of gravity of displaced fluid.

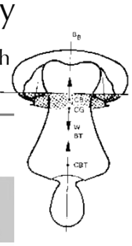
When center of buoyancy is bellow the center of gravity the situation is unstable.

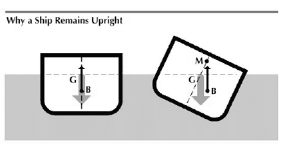


Separate centers of gravity and buoyancy allow organisms and plants to orient relative to the gravitational field:
e.g. dinoflagellates, kelp.

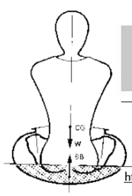
Floating hull stability

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:

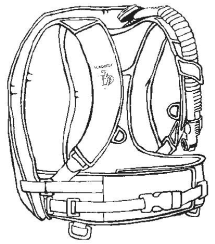
- Blubber is buoyant (0.7-0.9g cm^{-3})
- Muscles (1.08g cm^{-3}) and bones (1.9g cm^{-3}) are denser than water
- Air is buoyant (but compressible, that is buoyancy changes with pressure (depth))

Some strategies:

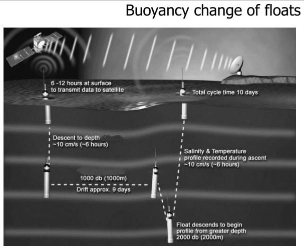
- Air in stomach (some sharks).
- Swim bladder (many bony fishes, physiologically regulated).
- Large oily liver (Sharks).

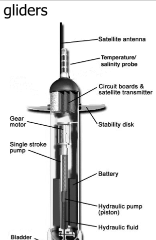
Buoyancy and diving

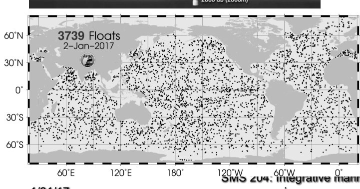


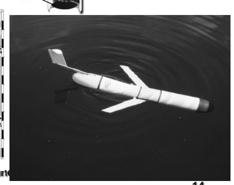


Buoyancy change of floats and gliders









- 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.

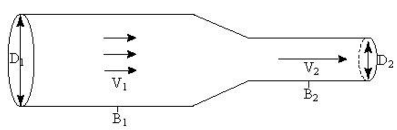
Different forms:

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

$\rho v^2/2+\rho gh+P=constant$ ← What is this?

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

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

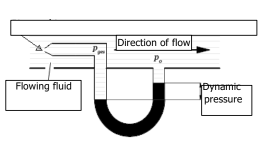


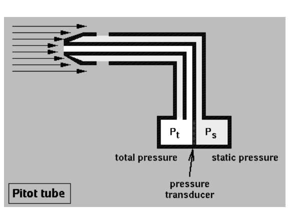
Movie clip

Demo

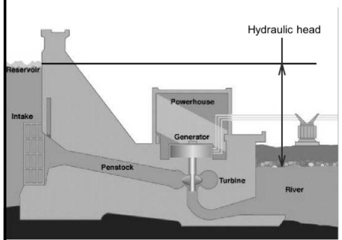
Based on Bernoulli's principle: How can we measure the velocity of a fluid using only pressure?

Answer: the pitot tube

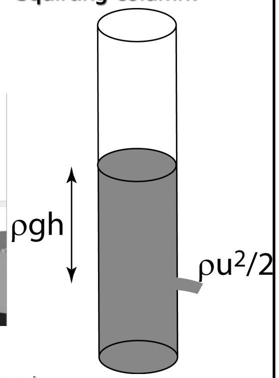




Hydro-electricity:



Squirting column:

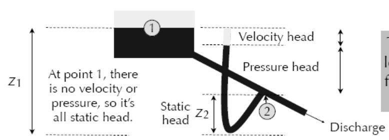


Homework question

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

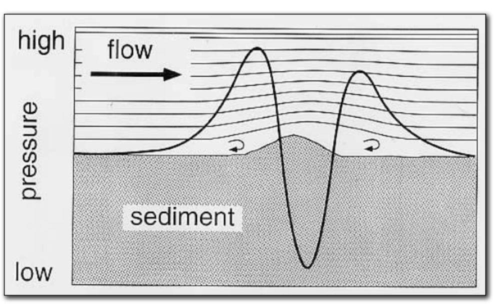


There is some loss of head as friction (shear) to heat.

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

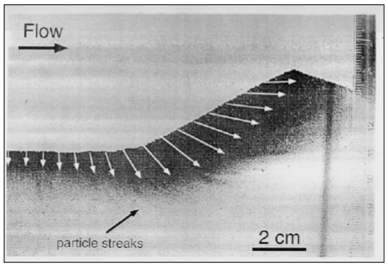
Application: flow above a disturbance (Clams, ripples, houses, etc').



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.



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)

Today we discussed the following topics:

Buoyancy.

Energy conservation in fluids.

Dynamic pressure.

Questions?