SMS 204: Integrative Marine Sciences, Physics & Chemistry

- Instructors: E. Boss & L. Karp-Boss
- Office hours: 3-4 on Mon. Aubert 458
- Significant digits, graphs.

- Class web site:

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

- Some important concepts from last week:
  - No-slip
  - Treatment of fluid as Continuum (1ml ~ 3×10^{22} water molecules)
  - Viscosity
  - Density of solids

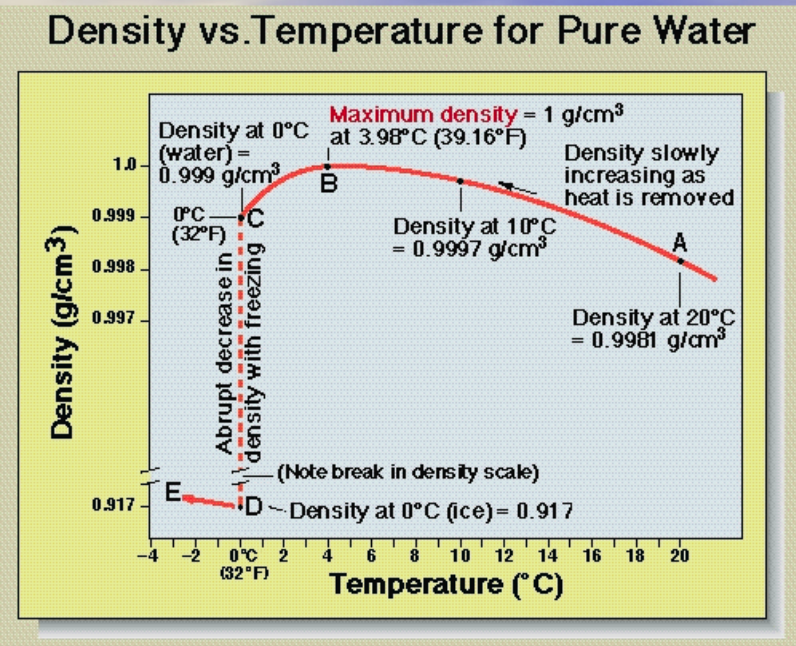
This week:

- Density of water
- Mass and volume fluxes
- Ideal gas
- Pressure

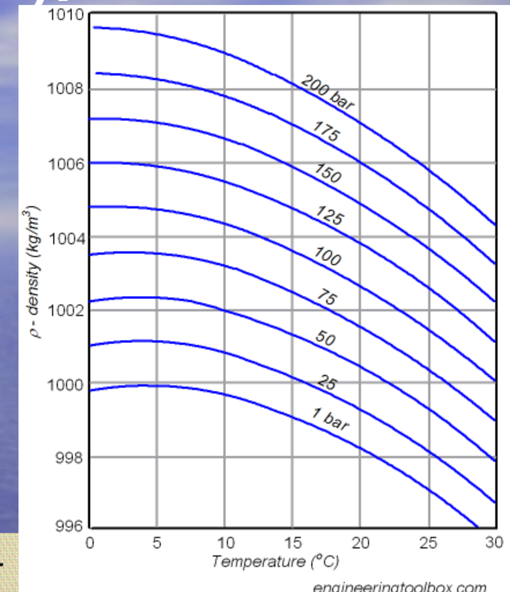
Density of Water

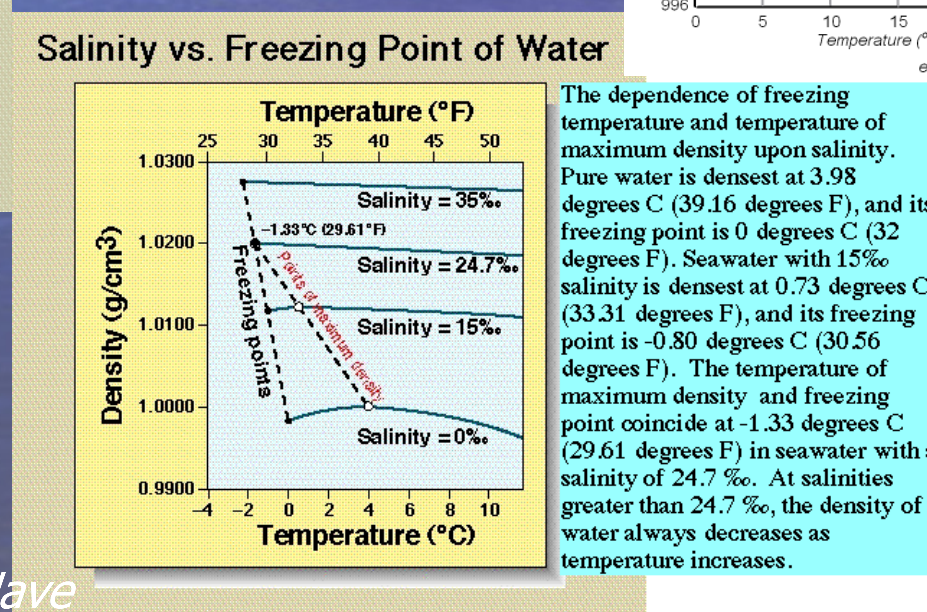
- Density = mass / volume
- Density of water depends on temperature
- Density of water depends on salinity
- Density of water depends on pressure
- Dense water sinks under less dense water

Equation of state of water:
relates density to other variables (S, T & P).



Density vs. T and P:



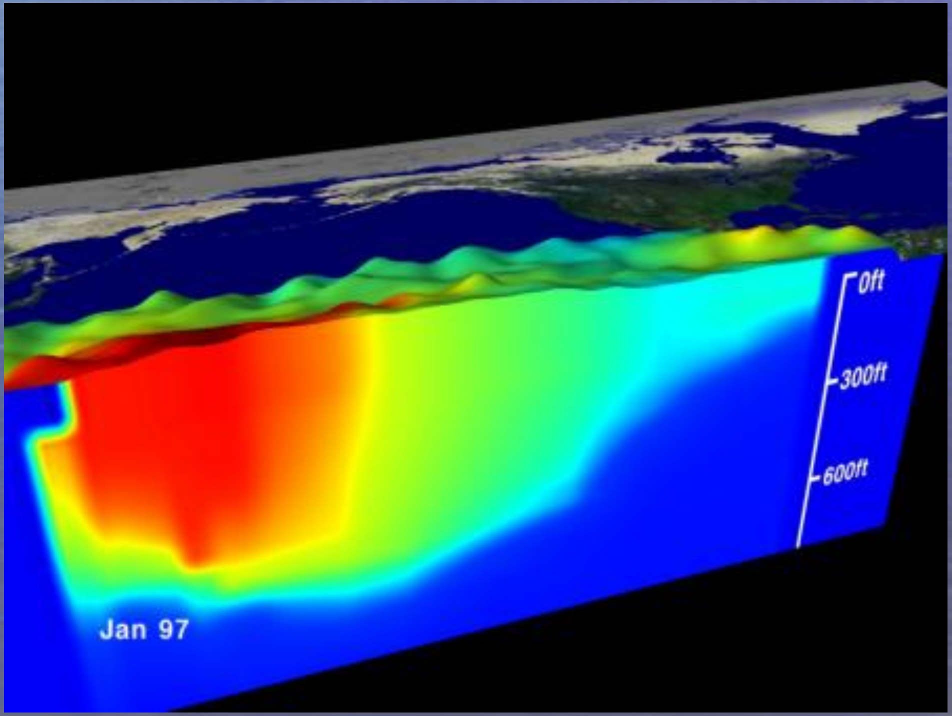


From:
http://geoserv.geology.wmich.edu/dave

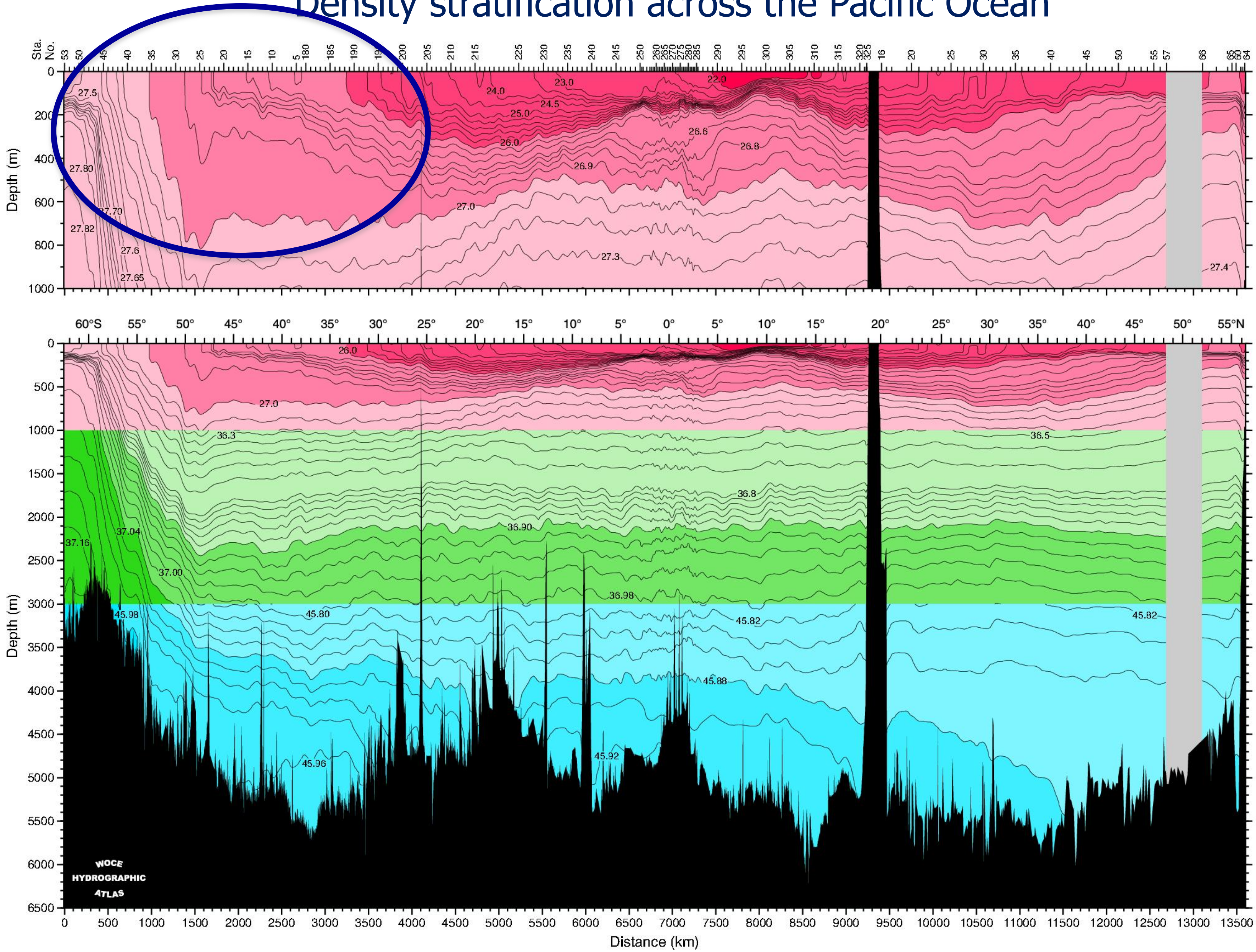
Density and water movement:

What happens when:

1. Dense water is above less dense water?
2. Dense water is next to less dense water? ←Demo
3. What about:



Density stratification across the Pacific Ocean



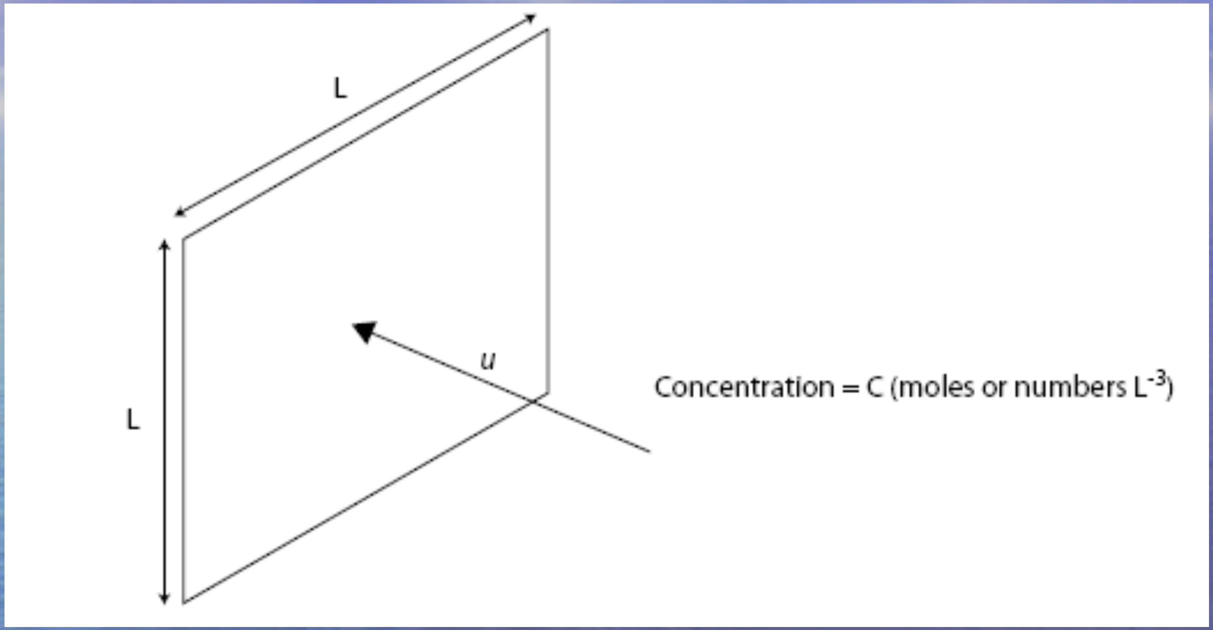
Flux: movement of fluids

- Volume of moving water
- Mass of moving water
- Momentum or heat of moving water
- Matter in moving water

Flux through a channel (or blood vessel)

- Fluid passing through a certain area at a given time.
- Volume flux: cross-section(⊥) x velocity
- Mass flux: Volume flux x density
- Material flux: Mass flux x concentration

- Advective flux of matter (molecules, fish)

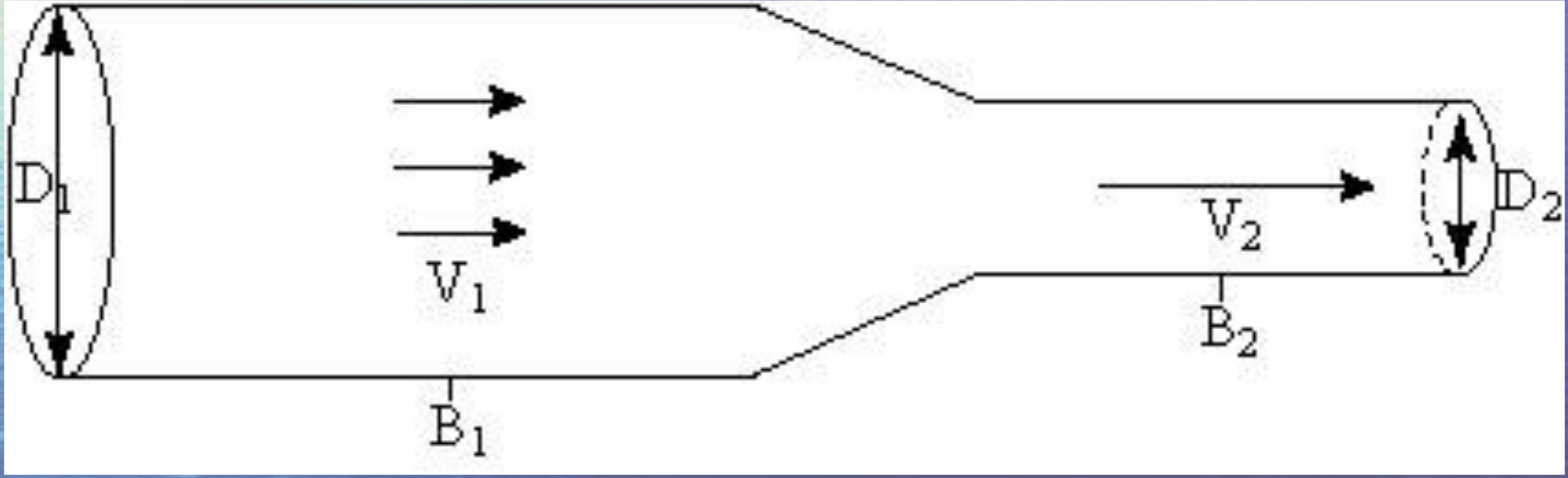


Advective flux = Area x Velocity x Concentration

$$\text{mol } T^{-1} = L^2 \times L\,T^{-1} \times \text{mol } L^{-3}$$

- Mass, volume and density.
  - In fluids we often cannot follow a coherent mass.

- Conservation of mass is described by mass continuity (incompressible flows):



- Volume flux: vA [m^3/sec], $A \perp v$
- Mass flux: ρvA [Kg/sec], $A \perp v$
- How do you get a hose to squirt further?

- Newton's laws of motion:
  - –Without force a body will continue its motion
  - –d(momentum)/dt=Force
  - –When a body 1 applies a force on body 2, an equal and opposite force is applied on body 1 by body 2.
  - –In continuum mechanics , this formulation generalizes body 1 and its surrounding medium.

- Momentum=mv
- Momentum flux=mass flux × v=

  $\rho v^2 A$ [Kg m s^{-2}], $A \perp v$

  Note: v-velocity, V-volume

- Pressure (P):
  - Force per unit area
  - Sharp vs. blunt objects
  - Hydrostatic pressure: the weight (divided by A) of the fluid above-

$$P = Mg/A = \rho g h \text{ (for constant } \rho\text{)}$$

Pressure (depth)= density x depth x gravity + Pair

Problem solving in class: force on a diver's face

In class demonstrations

- Pressure vs. depth
- Hydrostatic pressure: $p=\rho g h$ (for constant ρ)
- In the ocean ρ changes by only a few percents.

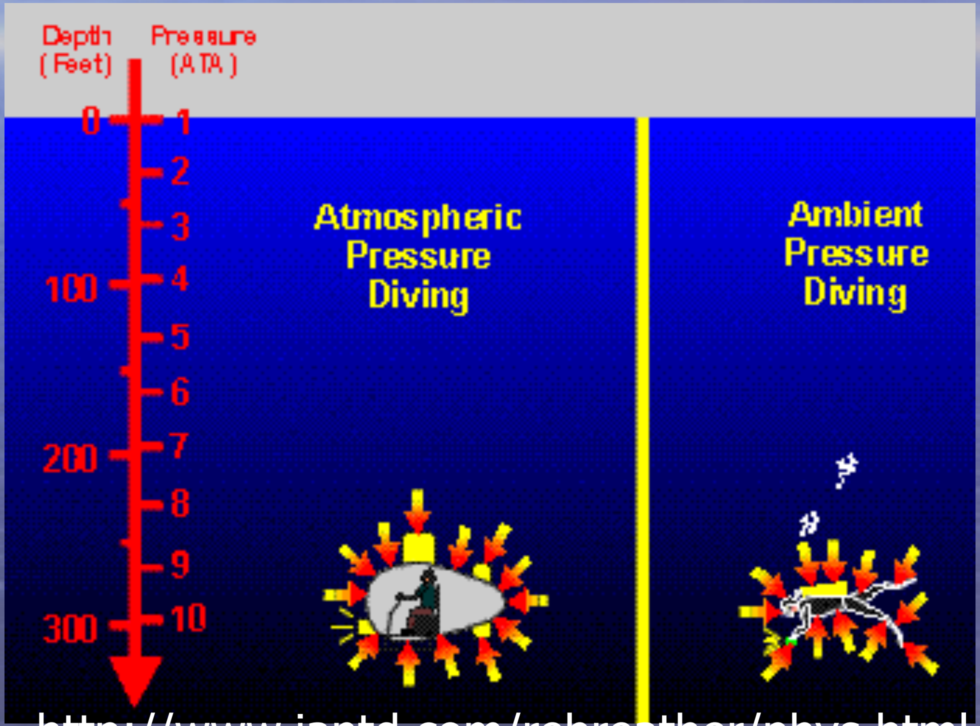
→ $h=p/\rho g$,

→ Depth in oceanography is often denoted by pressure.

The pressure of 1dbar = 10,000Pa is similar to 1m of water.

Diving and pressure

- Equalizing pressure in cavities.
- Why we can't snorkel deep? Why does SCUBA work?
- Gas solubility and pressure.
- How do some marine mammals prevent lungs from collapsing?



http://www.iantd.com/rebreather/phys.html

Fluid moves from regions of high to regions of low pressure:

$F=ma \rightarrow dv/dt=F/m=F/(AL\rho)$

$\rightarrow dv/dt=-\rho^{-1}dp/dx$

If fluid is not moving – pressure is equal.

If I have dense fluid at one side of a container and less dense at the other. How will pressure be distributed?

Equation of state of an ideal gases

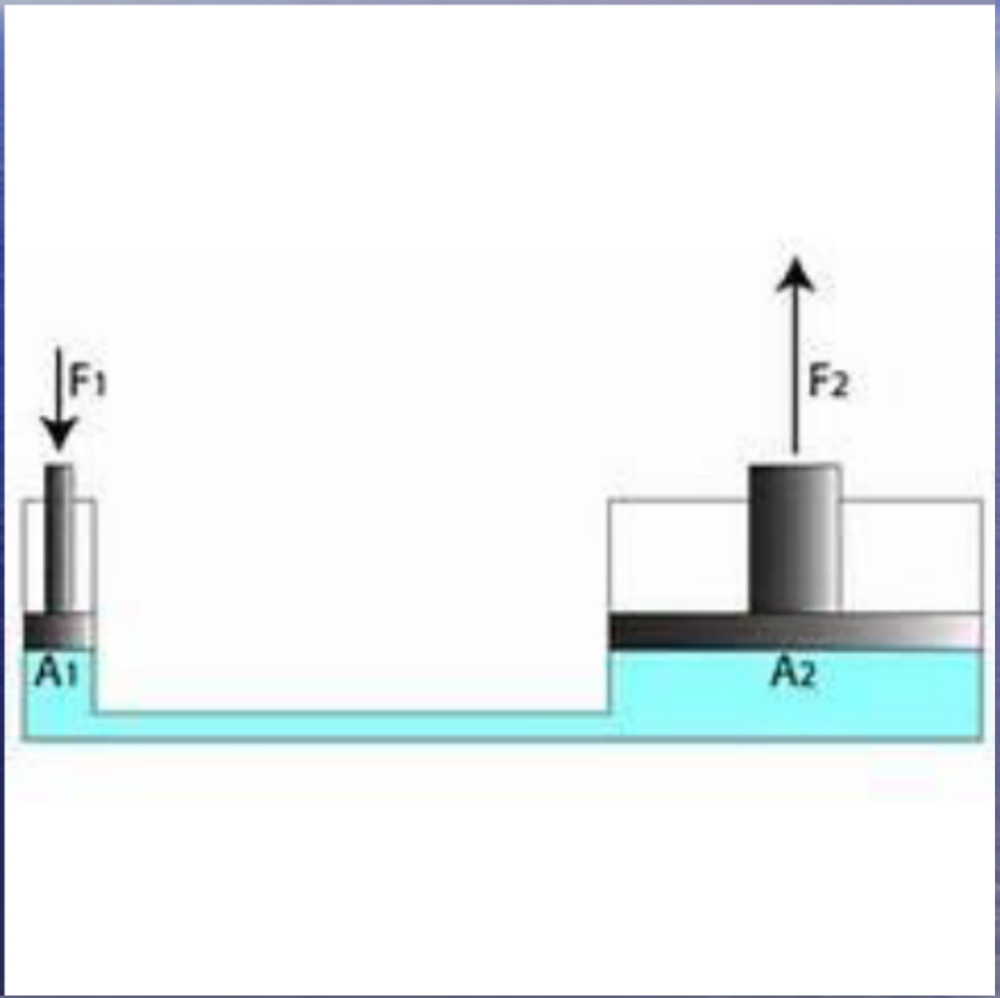
$PV=nRT$

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

In class demonstration (change of volume with pressure)

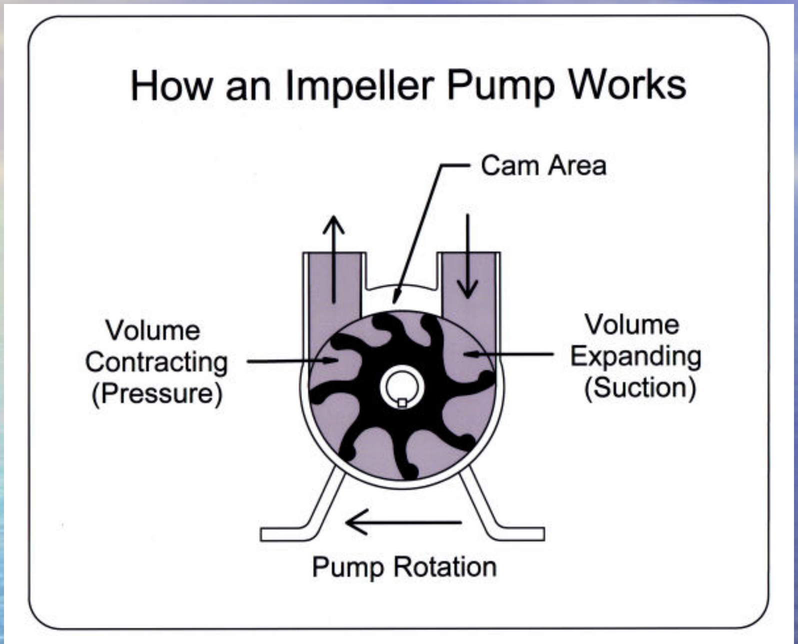
The magic of the hydraulic press:

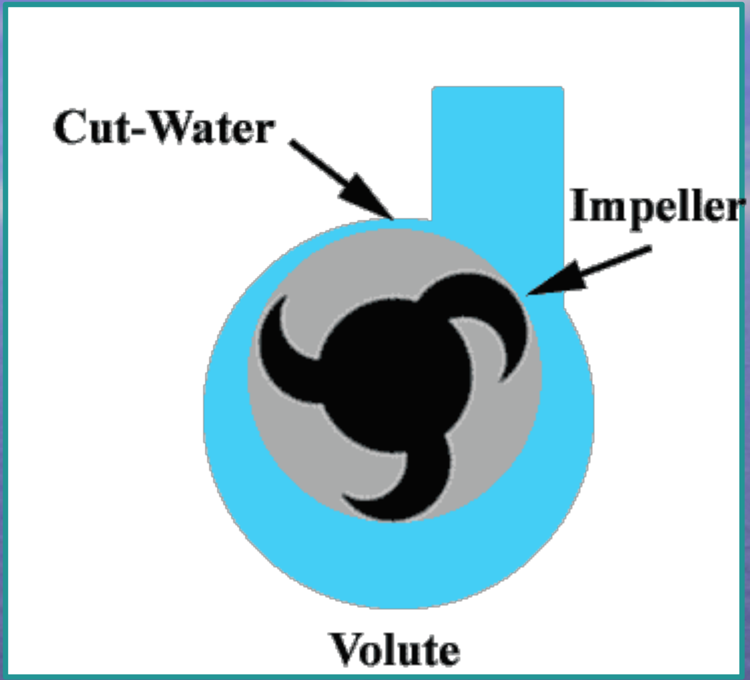
- Pressure (non-hydrostatic) is equal within the fluid.
- → F1/A1=F2/A2
- → F2=F1 A1/A2
- → F1 < F2
- We can use a small force to lift a heavy object if we apply it over a long distance (remember work=force x distance).



Two kinds of pumps:

- Positive displacement pump (decrease in volume raises pressure , *e.g.* a bicycle pump, diaphragm pump, peristaltic 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.



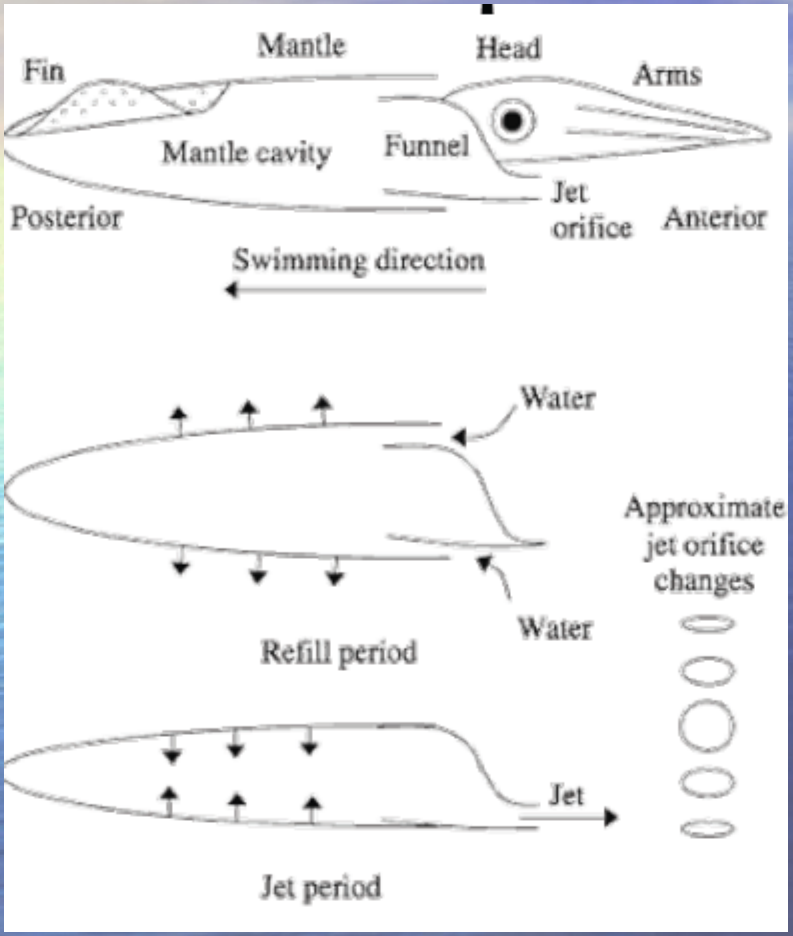


From: http://captnpauley.typepad.com

http://www.perfusionkorea.org/ko sect/img/ImpellerAnim.gif

Which kind of pump are these?

Pumps in organisms:



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.