SMS 204: Integrative Marine Sciences, Physics & Chemistry

- Instructors: Jim Loftin & Mary Jane Perry
- Homework: Check magnitudes and units. Read directions.
- 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

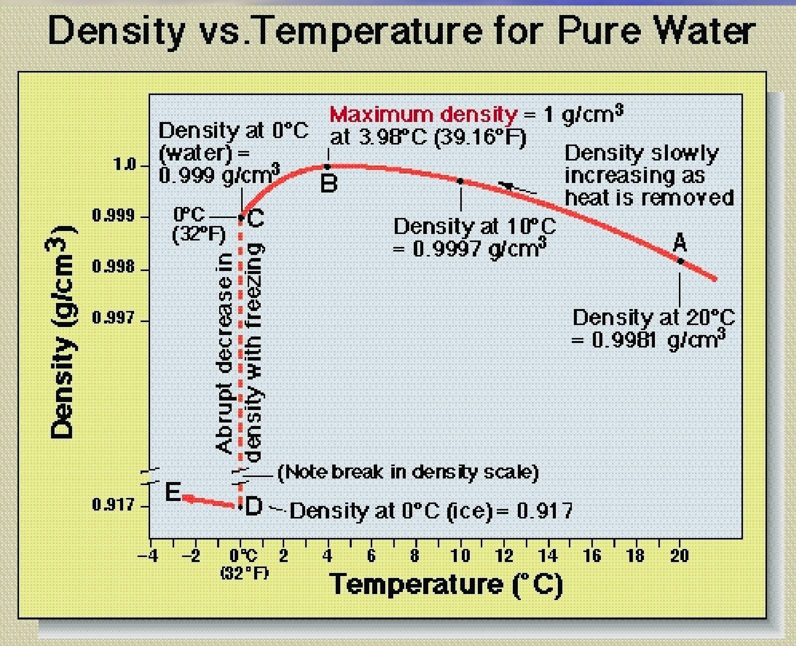
This week:

- Density of liquids
- Mass and volume fluxes
- Pressure

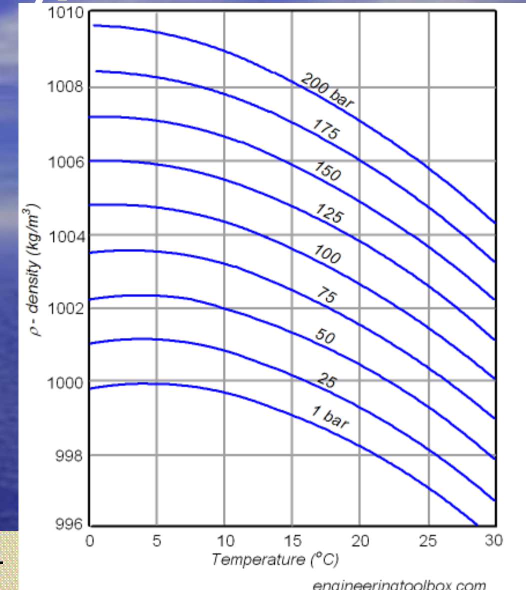
Density of water

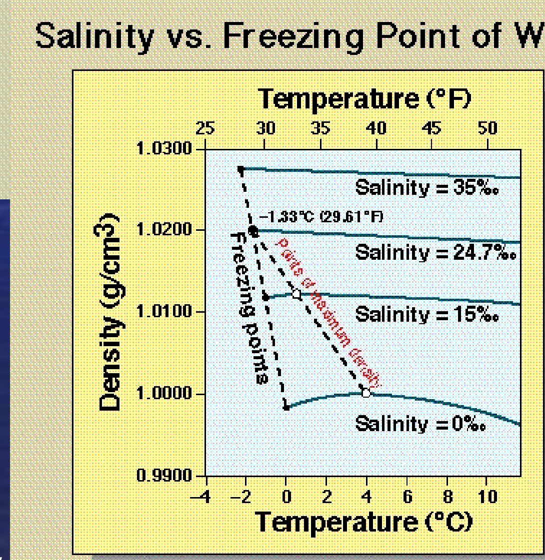
- Density = mass / volume
- Density of water depends on temperature
- Density of water depends on salinity
- Density of water depends on pressure
- Dense water sinks under less dense water

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



Density vs. T and P:





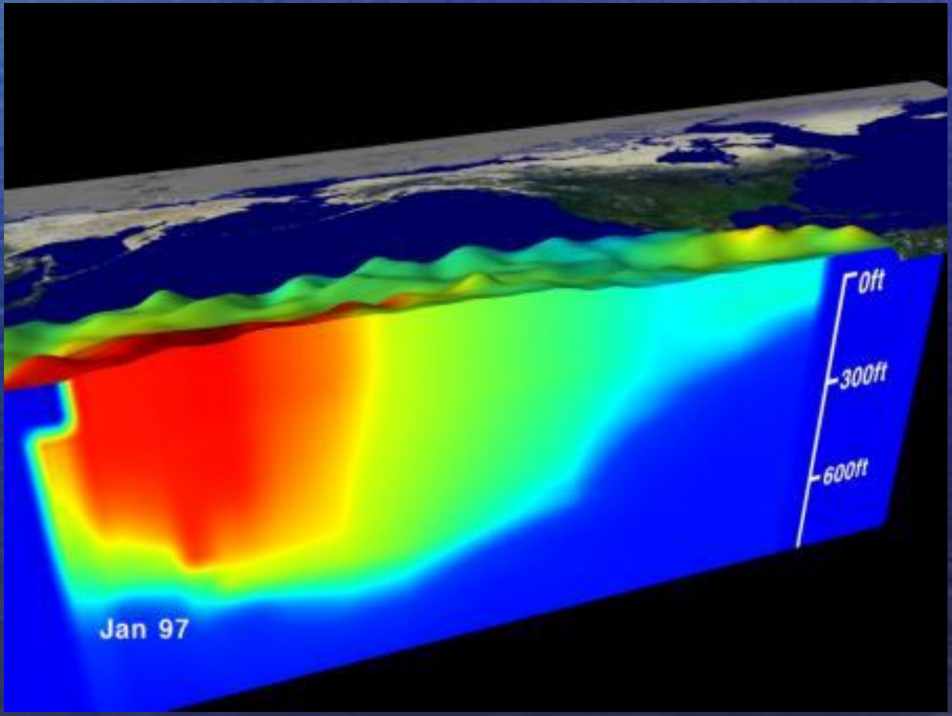
The dependence of freezing temperature and temperature of maximum density upon salinity. Pure water is densest at 3.98 degrees C (39.16 degrees F), and its freezing point is 0 degrees C (32 degrees F). Seawater with 15‰ salinity is densest at 0.73 degrees C (33.31 degrees F), and its freezing point is -0.80 degrees C (30.56 degrees F). The temperature of maximum density and freezing point coincide at -1.33 degrees C (29.61 degrees F) in seawater with a salinity of 24.7 ‰. At salinities greater than 24.7 ‰, the density of water always decreases as temperature increases.

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

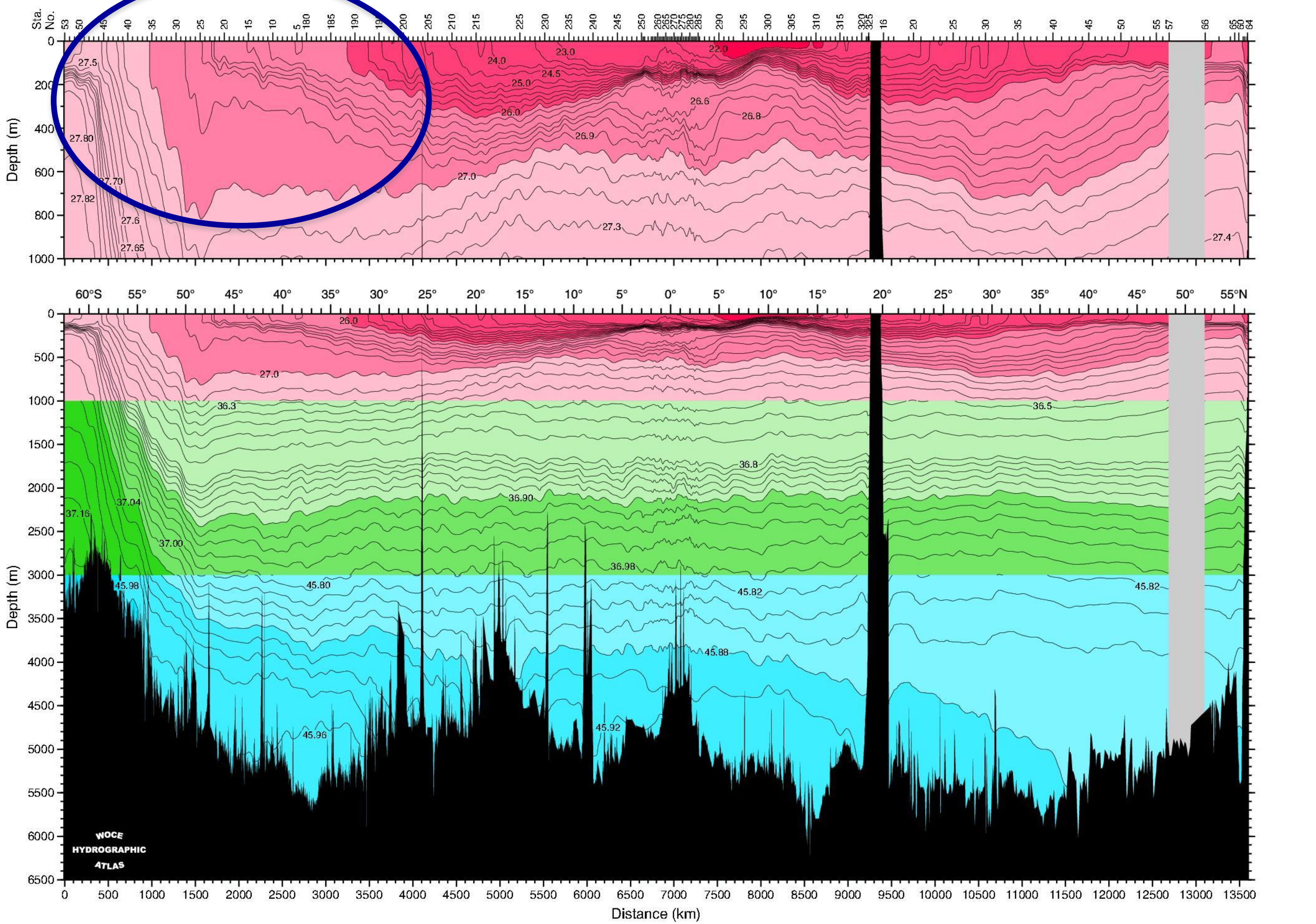
Density and water movement:

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



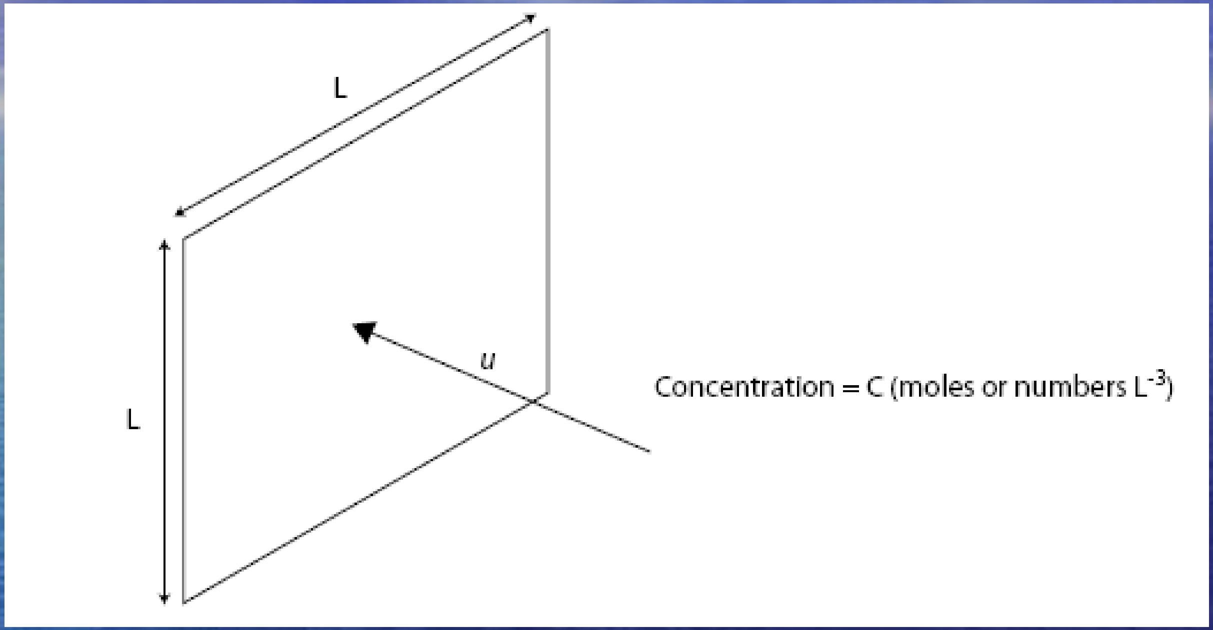
Flux: movement of fluids

- Volume of moving water
- Mass of moving water
- Momentum of moving water
- Number of items carried in moving water

Flux of liquid through a channel

- Water moving past a certain point in a channel in a certain time
- Volume flux = cross section area x velocity
- Mass flux = volume flux x density
- Flux of particles = volume flux x concentration

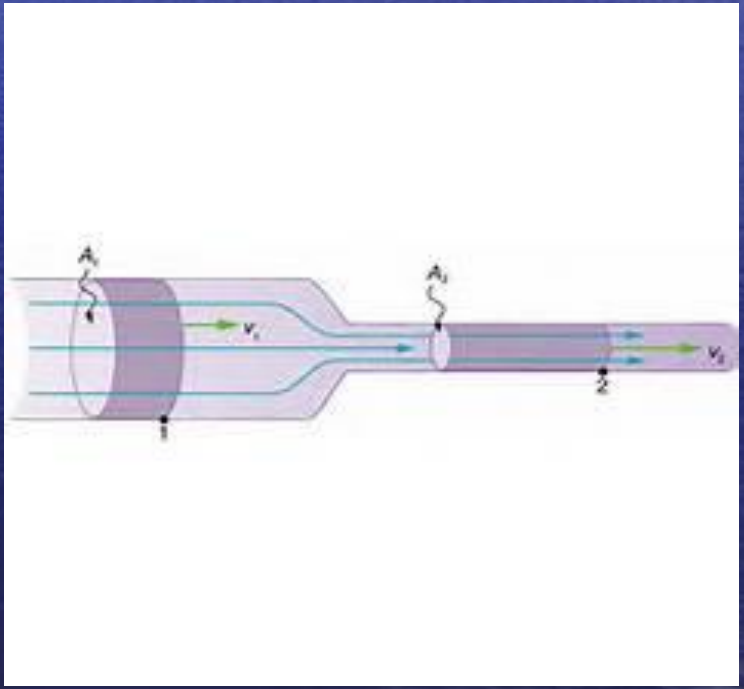
- Advective flux of particles (molecules, fish)



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):



- Mass flux: $\rho v A$ [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 :
  - Pressure = Force / area
  - Hydrostatic pressure: the weight (divided by Area) of the fluid above-

$$Mg/\mathrm{A}=\rho gh \text{ (for constant } \rho\text{)}$$

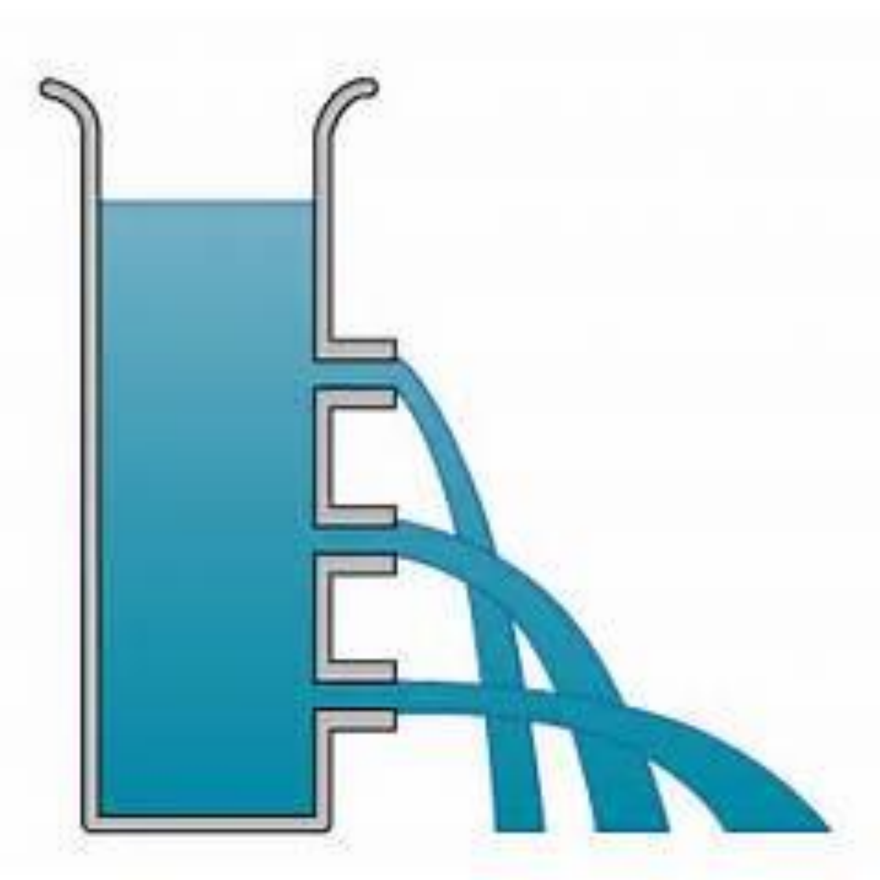
Pressure = density x gravity x depth

Problem solving in class

Average pressure on a Dam, force on a diver's face

In class demonstrations

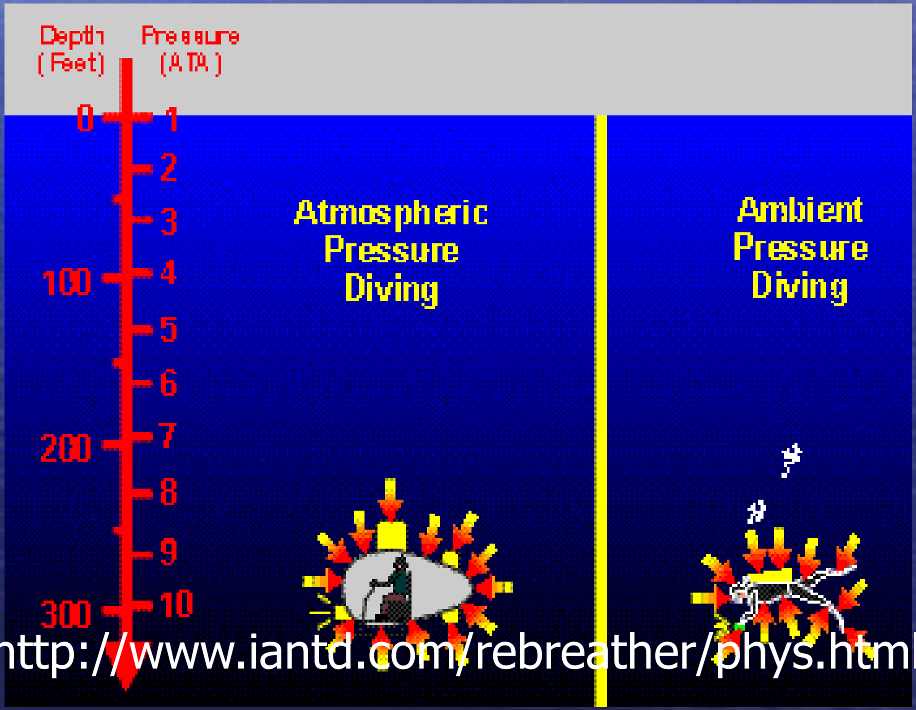
Pressure increases with depth



Diving and pressure

10 meters seawater = 33 feet = 1 atmosphere

- Equalizing pressure in cavities.
- Why we can’t snorkel deep? Why does SCUBA work?
- Gas solubility and pressure.



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

Fluid moves from high pressure to low pressure:

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

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

If fluid is not moving, pressures must be equal

Two liquids of different densities in a manometer

- Yellow liquid less dense
- Blue liquid more dense
- Pressure at dotted line must be equal

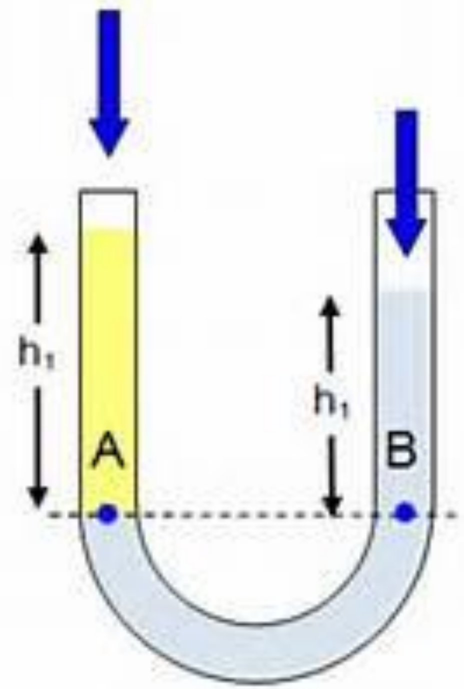
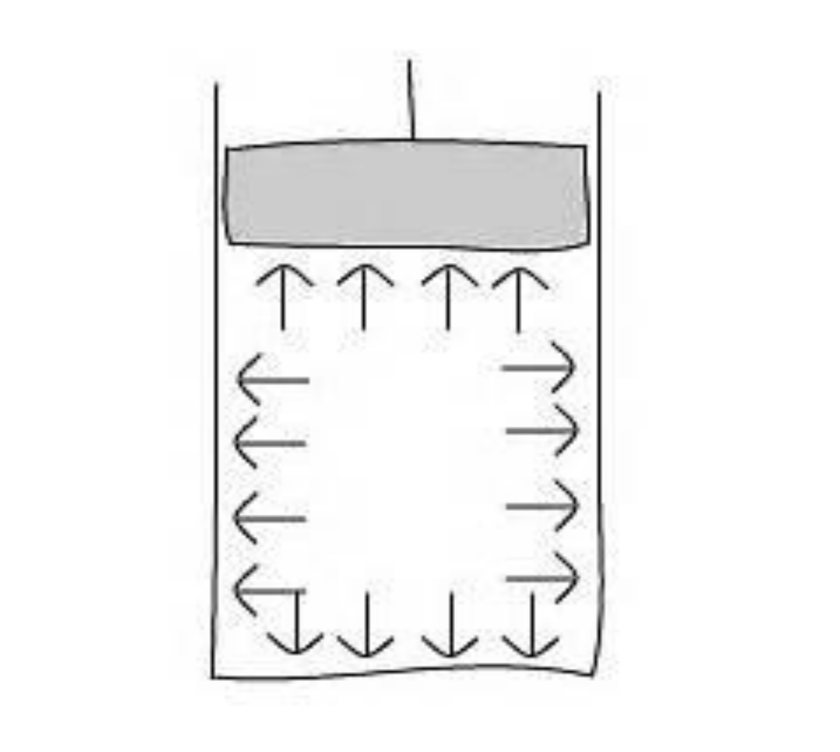


Figure 2

Fluid pressure pushes on all surfaces at a “normal” angle

– Within a fluid pressure is omni-directional while the force due to it is ⊥ to the container’ s walls.



Equation of state of an ideal gases

$PV=nRT$

- Temperature: kinetic energy of molecules (applet).

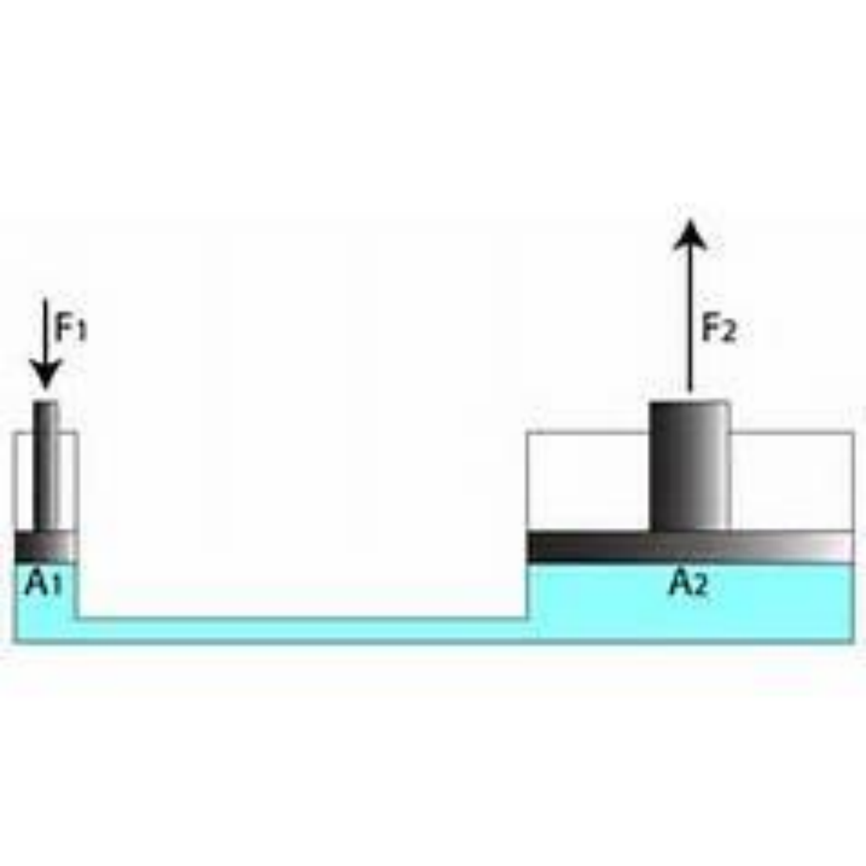
- n and R are constants

- If T is constant, if volume goes down, pressure must go up

In class demonstration (change of volume with pressure)

The magic of hydraulics:

- Pressure is equal throughout the liquid
- F2 / A2 = F1 / A1
- F2 = F1 x (A2/A1)



Application: the hydraulic press

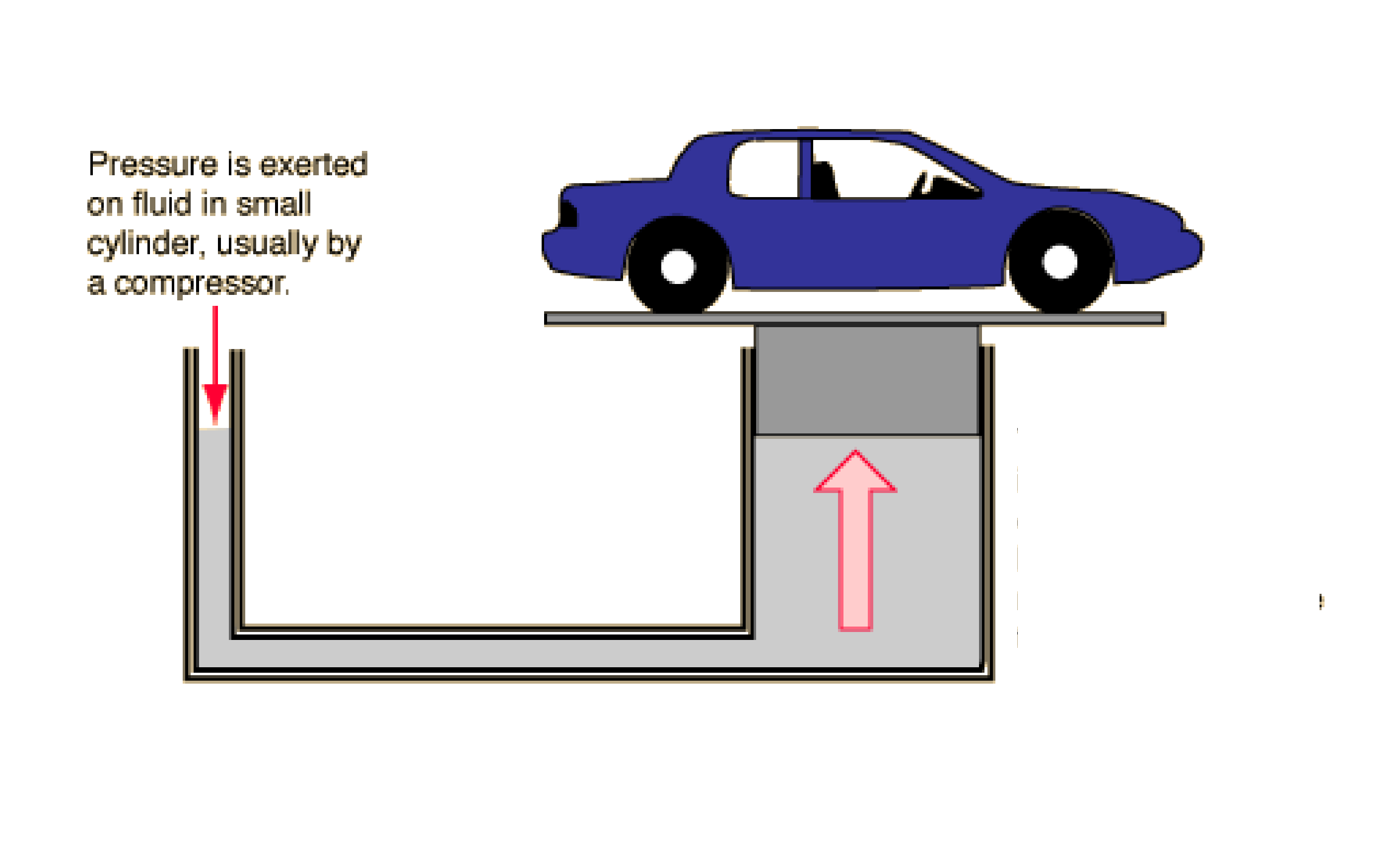


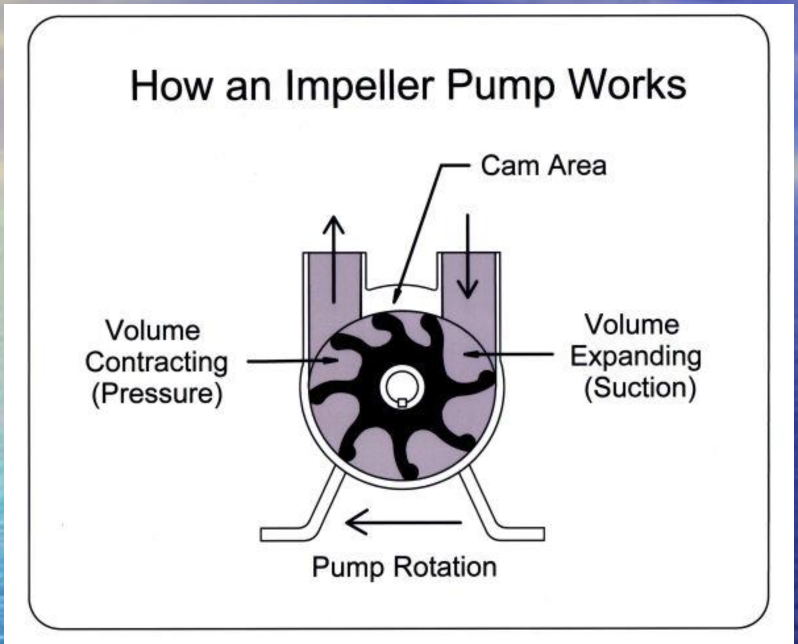
Figure from: http://hyperphysics.phy-astr.gsu.edu/hbase/pasc.html#pp

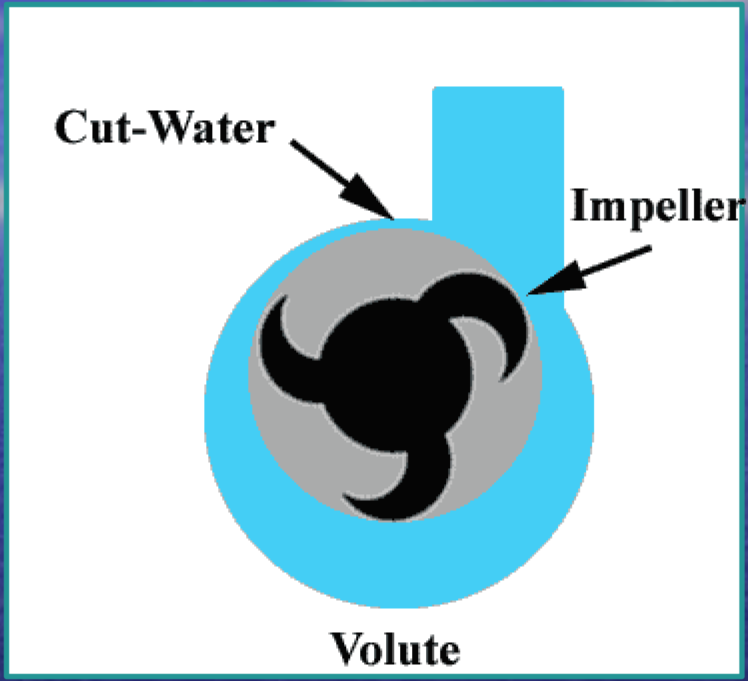
Two kinds of pumps:

- 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.



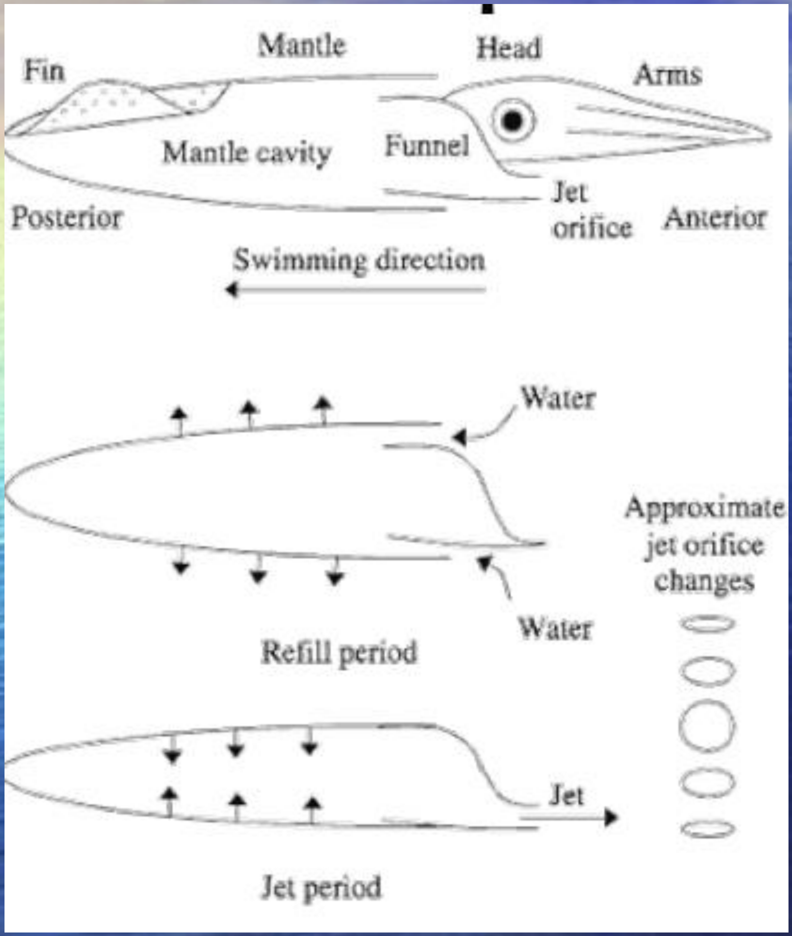


From: http://captnpauley.typepad.com

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

Which kind of pump are these?

Pumps in organisms:



Wikimedia

Movie

Movie