Announcements – Tues 3 Nov 2009

1. Exam 3 results:
   a. Scores:
      i. 75th percentile =
      ii. 50th percentile (median) =
      iii. 25th percentile =
   b. Exams will be returned soon (Wed?), pick them up in usual place (boxes near N357 ESC)
   c. Solutions will be posted on website soon (Wed?)

2. We have now covered about everything that Physics 121 does in a whole semester.* We're on the home stretch! Topics remaining:
   a. Fluid motion (today)
   b. Heat & calorimetry (2 lectures)
   c. Basic thermodynamics & engines (2 lectures) [then Exam 4]
   d. Waves & sound (3½ lectures)

* They go into more detail, though

Archimedes Principle Review

When an object is in a fluid, the fluid itself helps support some of the object's weight. This buoyant force is equal to the weight of the fluid that would otherwise occupy that volume:

$$F_B = m_{displaced\ fluid} \times g$$
$$= \rho_{fluid} V_{object} g$$

Demo: hanging mass into water
Clicker quiz: what happens when the mass is submerged?
   a. scale reading increases
   b. scale reading decreases
   c. nothing changes

Analysis:

Today's topic: moving fluids

Disclaimer: **viscosity** exists

→ ***Viscosity***: ***friction*** in fluids

Friction cases a loss in _____ along the tube as fluid flows.

Friction effects depend on radius:
bigger effects if radius is _____

Friction effects depend on length:
bigger effects if length is _____

As friction grows, pressure at inlet
must _____ to compensate.

That being said, we'll now ignore all viscosity effects…

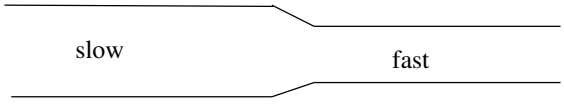
…assume "frictionless fluids" unless otherwise stated

Bernoulli effect

The pressure in a fluid changes with the s_____ of the fluid.

One way to change s_____: change the a_____
→ think garden hoses

Demo: Bernouilli effect in glass tube with varying diameter



Result of demo: Where is pressure the largest?

Disclaimer: This pressure change is **on top** of pressure lost from viscosity effects.

Why does this happen?

View #1: pressure on walls caused by _____
in the _____ direction

In which case is that going to happen the most?

Detour: fluid speeds

Volume flow rate: m^3/sec past any point

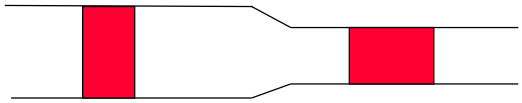
$$VFR = \frac{\Delta Volume}{\Delta t} = \frac{Area\ \Delta x}{\Delta t} =$$

Assume:

- No viscosity (friction)
- Incompressible (constant density) – *must be modified for gases* (we won't do modification)
- No turbulence

Then…

Conservation of Mass → Conservation of Volume Flow



"Equation of Continuity": $\boxed{A_1 v_1 = A_2 v_2}$ Only if no density change!

View #2: You're a molecule at the boundary. Which way is the net force?

→ So which side had the larger pressure?

Back to Bernoulli…

View #3: Think **work/energy** instead of forces

Moving water has *kinetic energy*

KE/volume =

Water going from slow to fast _____

…increasing its _____

Work/volume =

Add in PE/volume:

PE + KE + work = $KE_f + PE_f$

$$\boxed{P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2}$$

"Bernoulli's equation"

(I think our final blueprint of the semester)

From warmup: In the reading assignment for today, Ralph noticed two different equations labeled "Bernoulli's Equation". One said, "$P_1 + ½\,\rho v_1^2 + \rho g h_1 = P_2 + ½\,\rho v_2^2 + \rho g h_2$", the other said, "$P + ½\,\rho v^2 + \rho g h = C$". He wants to know how they can both be the same equation when they look so different. And what does C stand for, anyway?

Answer from the class:

From warmup: Water flows from a pipe with large diameter into a pipe with smaller diameter. The speed of the water in the small tube is:

a. greater than
b. less than
c. equal to

the speed in the large tube

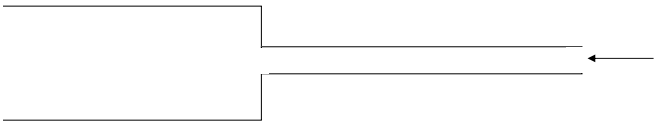
From warmup: Same situation. The pressure in the small tube is

a. greater than
b. less than
c. equal to

the pressure in the large tube

Water flows from the little pipe into the big pipe. Ignore any friction or height change.

R= 6 cm R = 2 cm



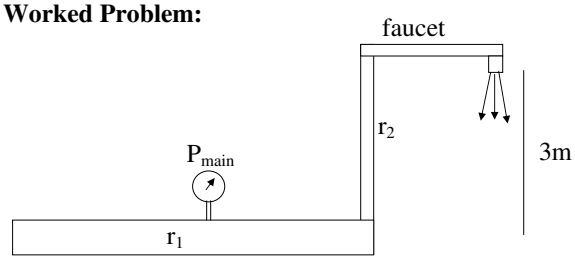
Clicker quiz: The volume flow rate on the right is _____ on the left.

a. greater than
b. same as
c. less than

Clicker quiz: The speed on the right is ____ times the speed on the left.

a. 1/9
b. 1/3
c. 1
d. 3
e. 9

Worked Problem:



The faucet of radius r_2=2 cm puts water out at 15 liters/minute. The pressure at the opening of the faucet is about 1atm. The water main (r_1=6 cm), is 3 meters below the faucet

a. What is the speed of the water in the narrow pipe?

b. What is the pressure in the water main?

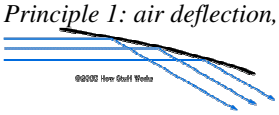
Answers: 0.199 m/s, 1.304×10^5 Pa

The Bernoulli effect – what good is it?

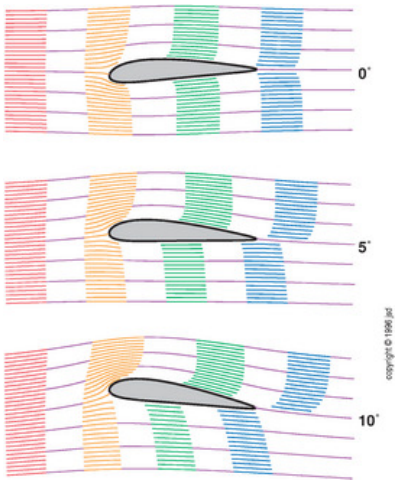
Demos: Blowing on paper, Ball over blower, Venturi blower, funnel, metal plate and wood cylinder

Airplane wings, and sails, and other "airfoils" (racecars!)

Principle 1: air deflection, aka "put hand out the window" effect



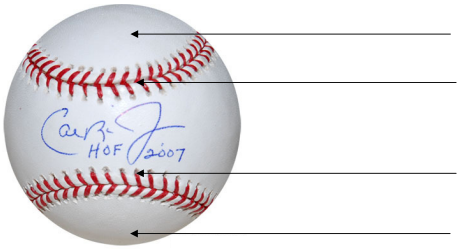
Principle 2: Bernoulli



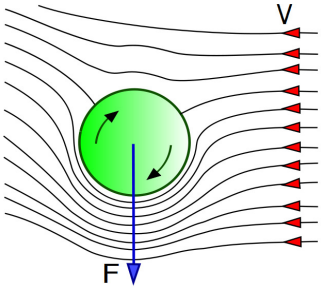
http://www.av8n.com/how/htm/airfoils.html#toc46

Curve balls

ball moving to the right (i.e. air moving to left) with **topspin**



1. Bernoulli
2. Air deflection?



From warmup: A ping pong player puts "topspin" on the ball as he hits it to you by causing it to rotate such that the top of the ball is spinning towards you. Where will the ball strike the table compared to if it were not spinning?

a. closer to you
b. farther from you
c. same distance

Clicker quiz: A ball is thrown toward you, spinning so that the right side of the ball spins toward you, and the left side away. The ball will

a. "float" more than a nonspinning ball
b. "sink" faster than a nonspinning ball
c. curve to your left
d. curve to your right

Demo: ping pong!

Worked Problem: A flat roof of area 400 m^2 will rip off if it is subjected to a lift force of 5×10^5 N. What speed of horizontal wind will rip off the roof? (weight of the roof is included in 5×10^5 N number). $\rho_{air} = 1.29$ kg/m^3

Clicker quiz: A blood platelet drifts along with the flow of blood through an artery that is partially blocked by deposits. As the platelet moves from the narrow region to the wider region, it experiences…

a. an increase in fluid pressure.
b. no change in fluid pressure.
c. a decrease in fluid pressure.

Answer: 44.0 m/s