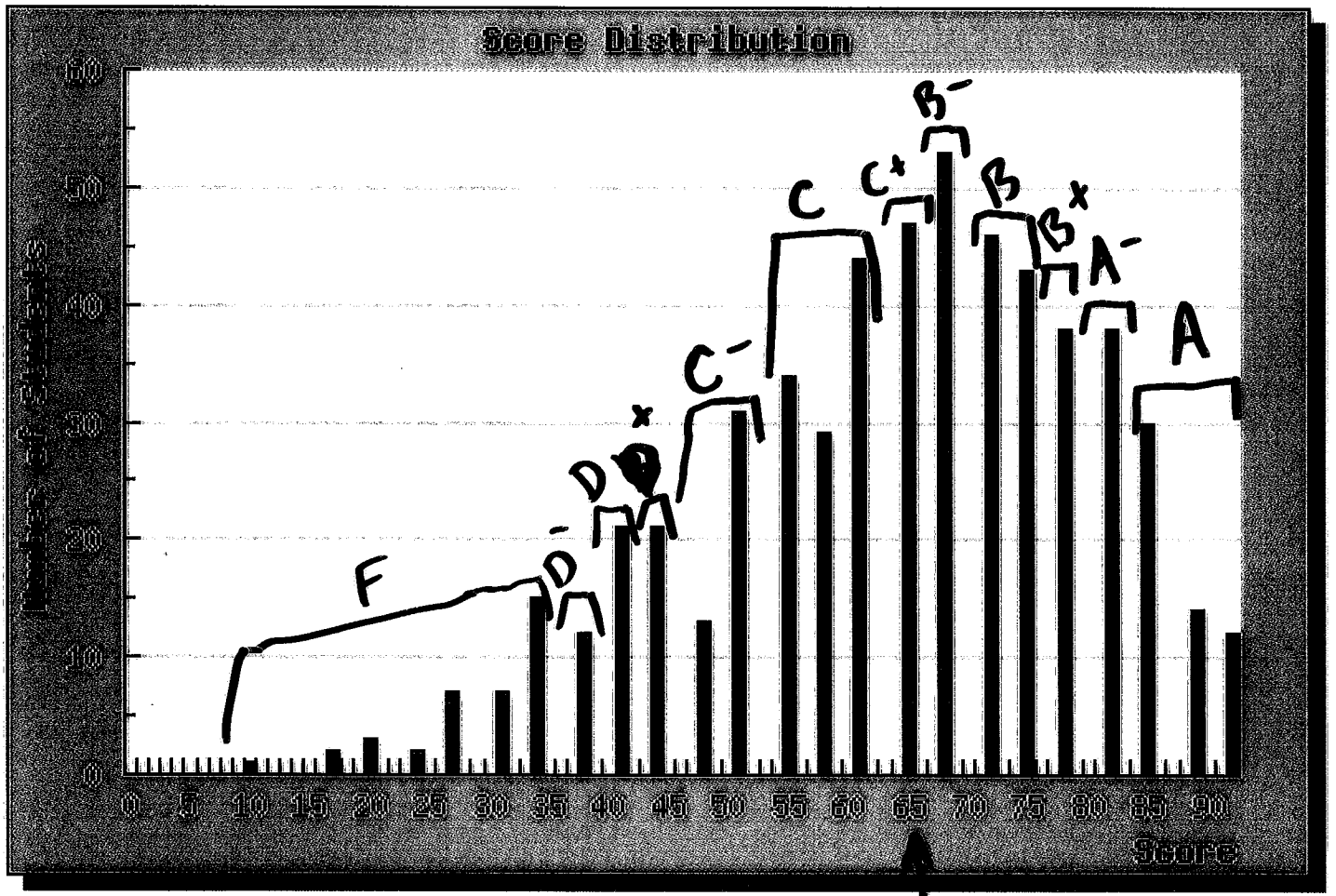
Physics 105 – Exam 3 scores out of 92 [redacted]



Average = 65/92
70%

Probably will be
≃ 71 or 72 %
after handwritten part
is graded

From last time…

Clicker quiz 1: A cannon is put in a boat. The boat sinks down to displace more water. The amount of new water displaced is

a. a volume of water that weighs **more than** the cannon
b. a volume of water that weighs **as much as** the cannon
c. a volume of water that weighs **less than** the cannon

Clicker quiz 2: If the cannon falls from the boat into the water and sits on the bottom of the lake, the amount of water now displaced by the cannon is

a. a volume of water that weighs **more than** the cannon
b. a volume of water that weighs **as much as** the cannon
c. a volume of water that weighs **less than** the cannon

Clicker quiz 3: Therefore…if the cannon falls from the boat into the water and sits on the bottom of the lake, will the overall water level of the lake rise, fall or stay the same? (compared to when the cannon was in the boat)

a. rise
b. fall
c. stay the same

(Another way of looking at it: same questions, but instead of a cannon use a pinhead of very VERY dense matter.)

Today's topic: moving fluids

Disclaimer: **viscosity** exists

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

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

Friction effects depend on radius ✓
and length ✓

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

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

…assume "frictionless fluids" unless otherwise stated

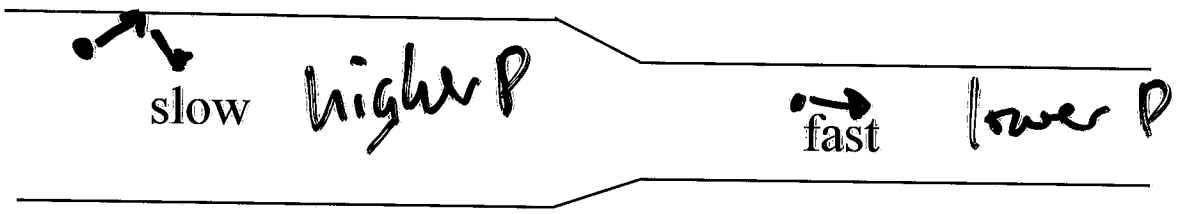
Bernoulli effect

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

One way to change speed: change cross-section area

→ think garden hoses

Demo: Bernouilli effect in glass tube with varying diameter



Why does this happen?

View #1: pressure on walls caused by molecules hitting in the perpendicular direction

In which case is that going to happen the most?

left

(This pressure change is **on top** of pressure lost from viscosity effects.)

Detour: fluid speeds

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

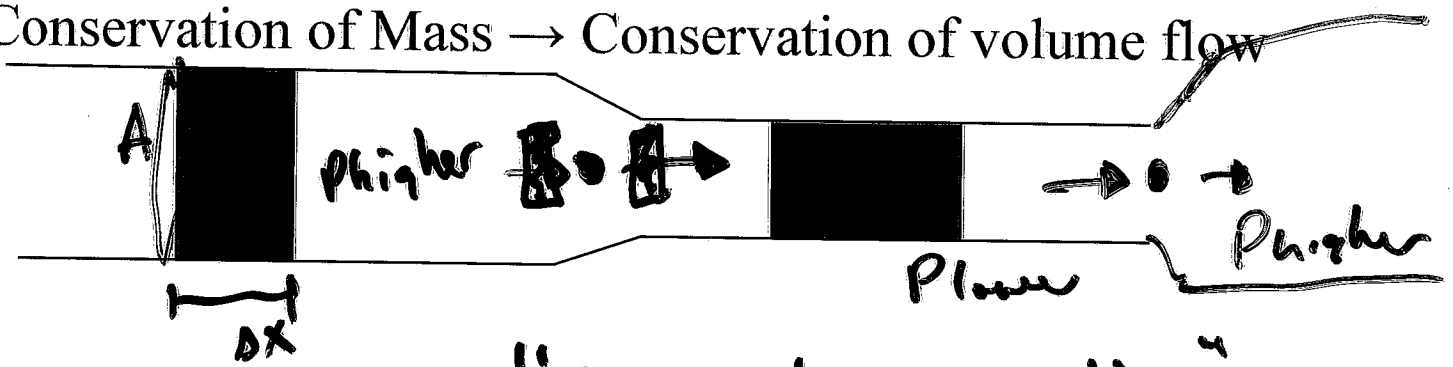
$$\text{VFR} = \frac{\Delta Volume}{\Delta t} = \frac{Area\ \Delta x}{\Delta t} = A \cdot speed$$

Assume:

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

"Perfect fluid"

Conservation of Mass → Conservation of volume flow



"Garden hose equation"

"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? Right

→ So which side had the larger pressure? Left

Back to Bernoulli…

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

Moving water has *kinetic energy* $\frac{1}{2}mv^2$

KE/volume = $\frac{\frac{1}{2}mv^2}{\text{volume}} = \frac{1}{2}\rho v^2$

Water going from slow to fast speeds up

…increasing its KE

Work/volume = $\frac{F_{net}\, d}{\text{Area}\, d} = \frac{F_{net}}{\text{Area}} = P_1 - P_2$

Add in PE/volume: $\frac{mgh}{\text{volume}} = \rho g h$

PE + KE + work = $KE_f + PE_f$

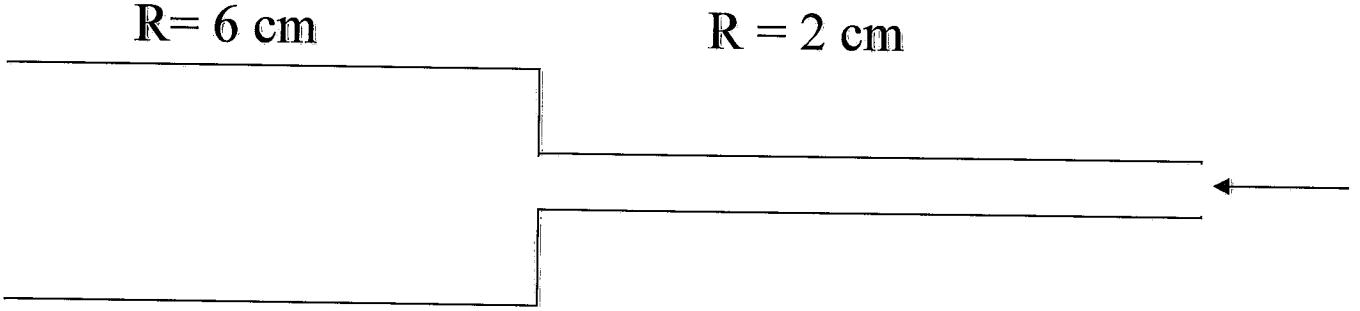
$$\rho g h_1 + \frac{1}{2}\rho v_1^2 + (P_1 - P_2) = \frac{1}{2}\rho v_2^2 + \rho g h_2$$

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

"Bernoulli's equation"

→ Ralph's question?

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



Clicker quiz: The pressure in the right side is _____ than on the left

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

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

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

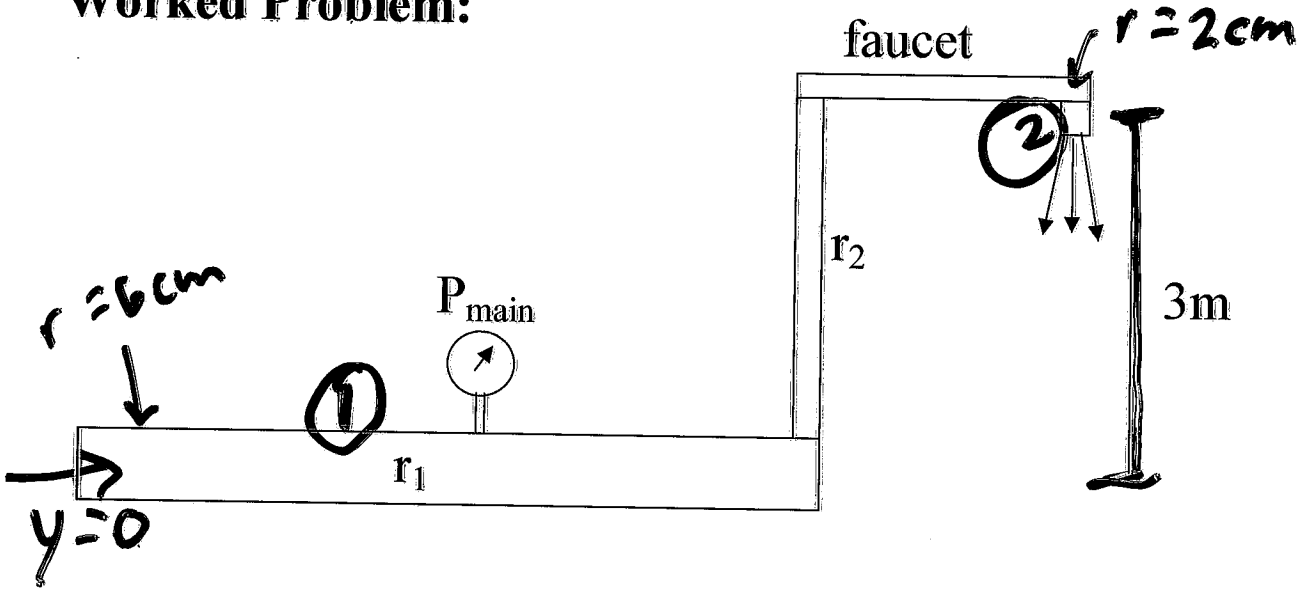
Clicker quiz: The speed on the right is ____ times the speed on the left.

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

$A_1 v_1 = A_2 v_2$

9x bigger → $\frac{1}{9}$ slower

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?

$$VFR = 15\frac{L}{min} \times \frac{1min}{60s} \times \frac{1m^3}{1000L} = Av$$

$$= \pi(.02)^2 v$$

$$v_2 = .199\ m/s$$

Also $v_1 = \frac{1}{9}(.199)$

b. What is the pressure in the water main?

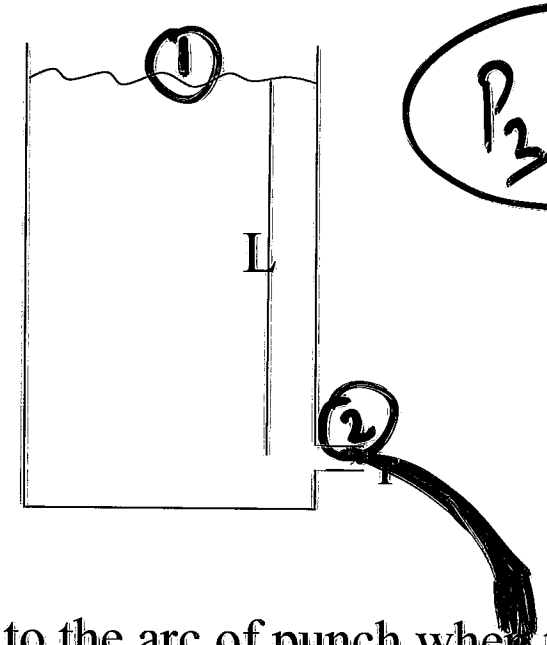
$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

$$P_1 + (1000)(9.8)(0) + \tfrac{1}{2}(1000)\left(\tfrac{.199}{9}\right)^2 = (1.01\cdot10^5) + (1000)(9.8)(3) + \tfrac{1}{2}(1000)(.199)^2$$

$$P_1 = 1.3\cdot10^5\ Pa$$

Answers: 0.199 m/s, 1.304×10^5 Pa

Fruit Punch out of a Cooler:



$P_2 = P_1 + \rho g h$ only for static fluids

What happens to the arc of punch when the level goes down?

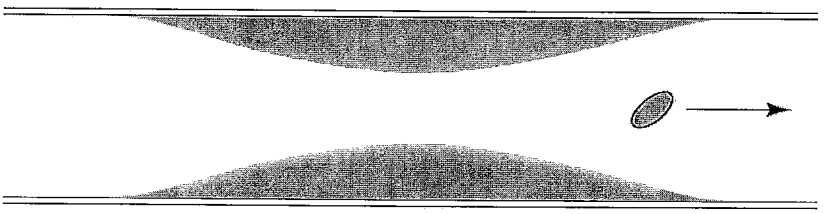
What happens if a smaller hole is used?

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

$P_1 \approx 1\,atm$, $\rho g h_1 = \rho g L$, $v_1 \approx 0$, $P_2 \approx 1\,atm$, $h_2 \approx 0$

$$\rho g L = \frac{1}{2}\rho v_2^2$$

$$v = \sqrt{2gL}$$



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…

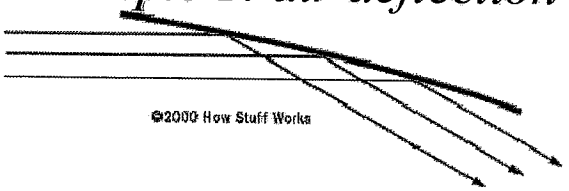
a. an increase in pressure.
b. no change in pressure.
c. a decrease in pressure.

The Bernoulli effect – what good is it?

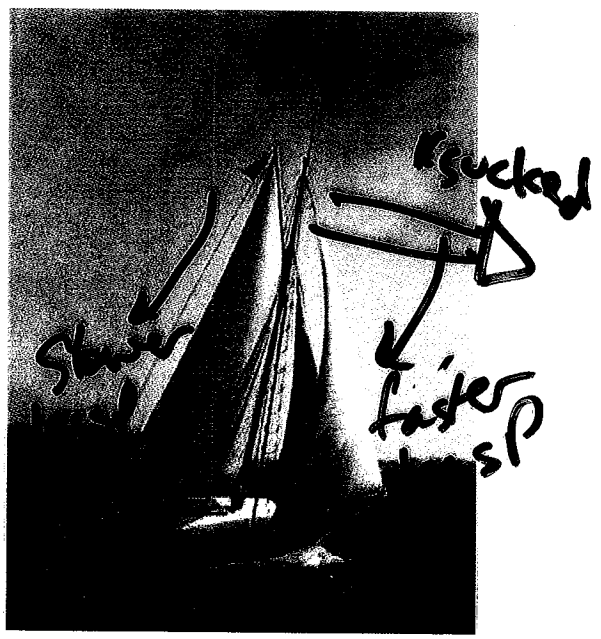
Demos: Blowing on paper, Ball over blower, Venturi blower, funnel, metal plate and wood cylinder

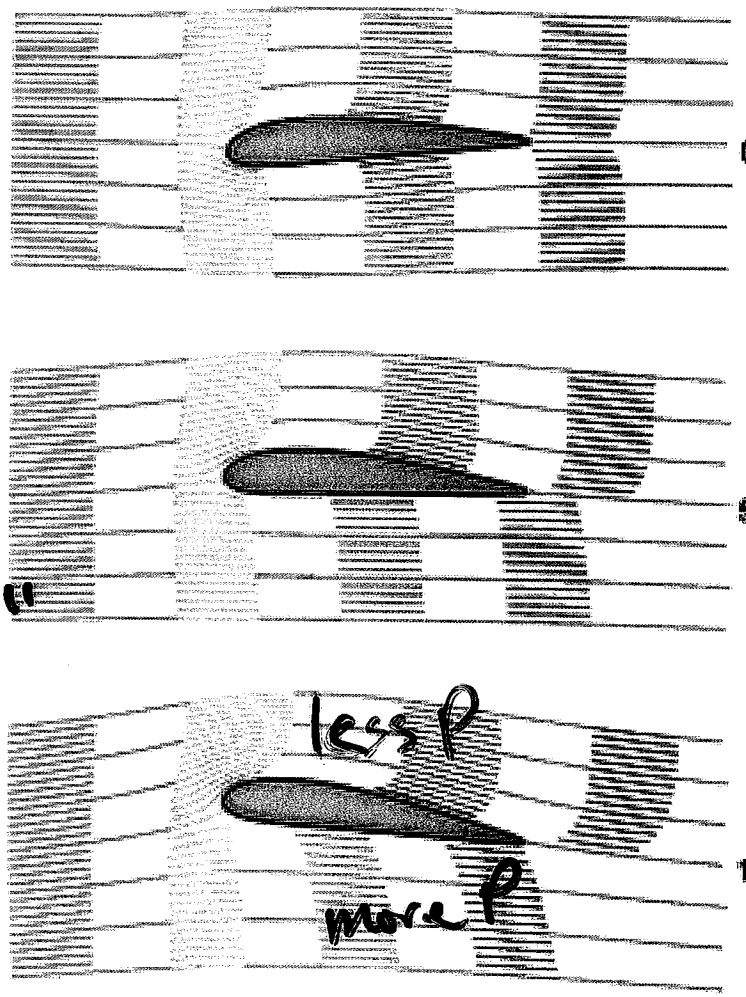
Airplane wings, and sails, and other "airfoils" (racecars!)

Principle 1: air deflection



Principle 2: Bernoulli

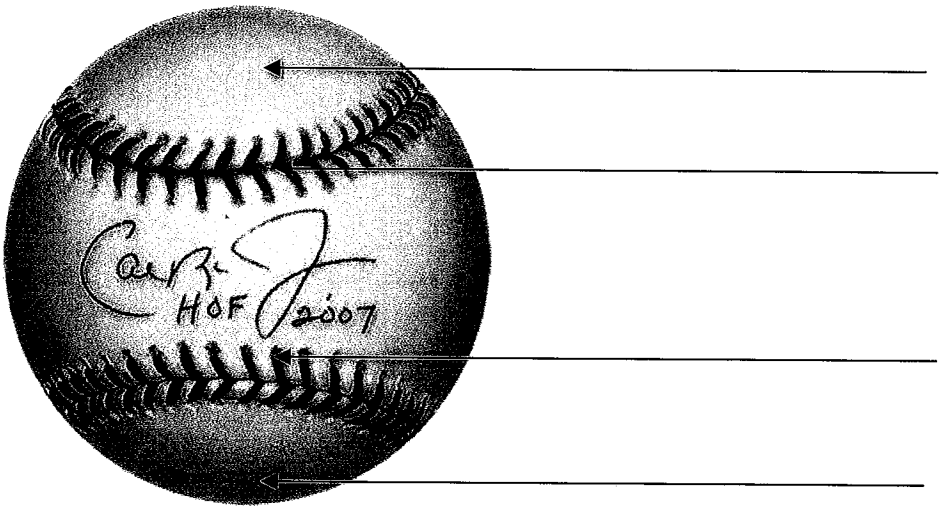




http://www.av8n.com/how/htm/airfoils.html#toc46

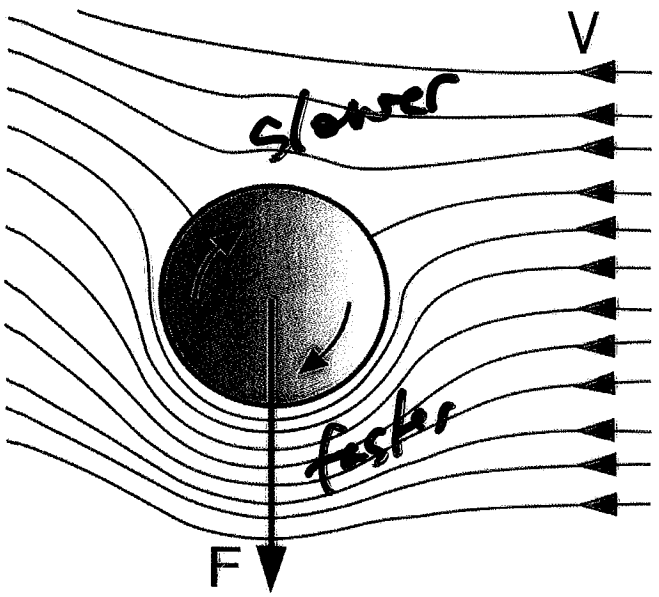
Curve balls

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



1. Bernoulli

2. Air deflection?



Demos: ping pong ball, scoop thrower and foam ball