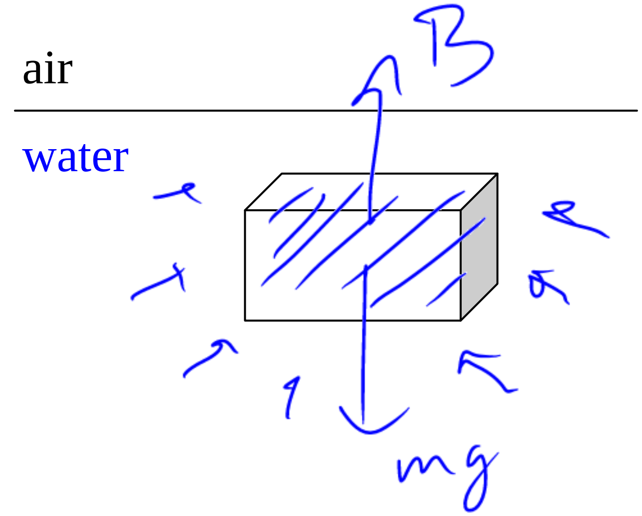
Announcements – 30 Oct 2014

1. Prayer

2. **Exam 2** starts today!
   a. Late fee on Monday Nov 3, after 2 pm
   b. Closes on Tuesday Nov 4, 2 pm
   c. Jerika exam reviews, both in room C295 ESC:
      i. Wed Oct 29 7 - 8:30 pm (already happened)
      ii. Thurs Oct 30 5:30 - 7 pm
   d. Exam covers through angular momentum
      i. Ch. 5, 6, 7.1-7.3, 8
      ii. HW 10-17

“Which of the problems from last night's HW assignment would you most like me to discuss in class today?”

Buoyancy



Water in a thin rectangular plastic bag…

Does the water inside the bag have mass?

$$\Sigma F = 0$$

$$B - mg = 0$$

Does the water inside the bag have weight?

$$B = mg$$

Why doesn't it accelerate down?

$$B = W_{\text{displaced fluid}}$$

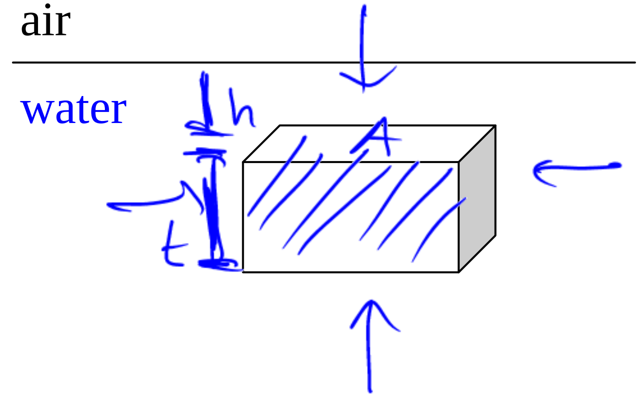
$P = F/A$ $\quad F = P \cdot A$

Buoyancy, view 2

$P = P_0 + \rho g h$

$\rho = m/V$

Water in a thin rectangular plastic bag…



How much force is pushing downward on top? $(P_0 + \rho g h)A$

How much force is pushing upward on bottom? $(P_0 + \rho g(h+t))A$

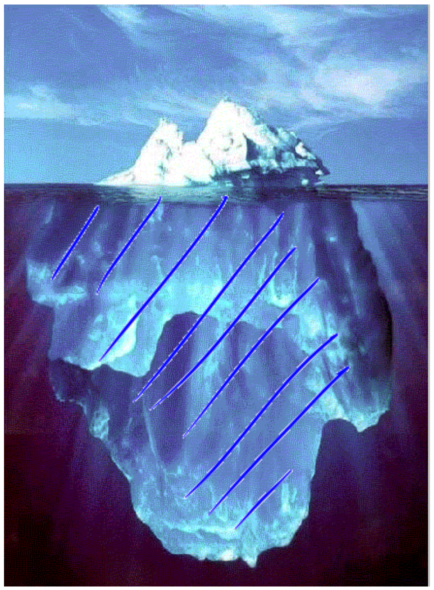
What's the net force? $(P_0 + \rho g(h+t))A - (P_0 + \rho g h)A$

$P_0 A + \rho g h A + \rho g t A - (P_0 A + \rho g h A)$

$= \boxed{\rho g V} = m_{fluid}\, g$

Archimedes' Principle

The buoyant force equals the weight of the fluid that the object is displacing at the moment.



$$F_{Buoyant} = B = m_{displaced\ fluid} \times g$$
$$= \rho_{fluid} V_{object}\, g$$

just the submerged volume

From warmup

The buoyant force of a submerged object always equals:

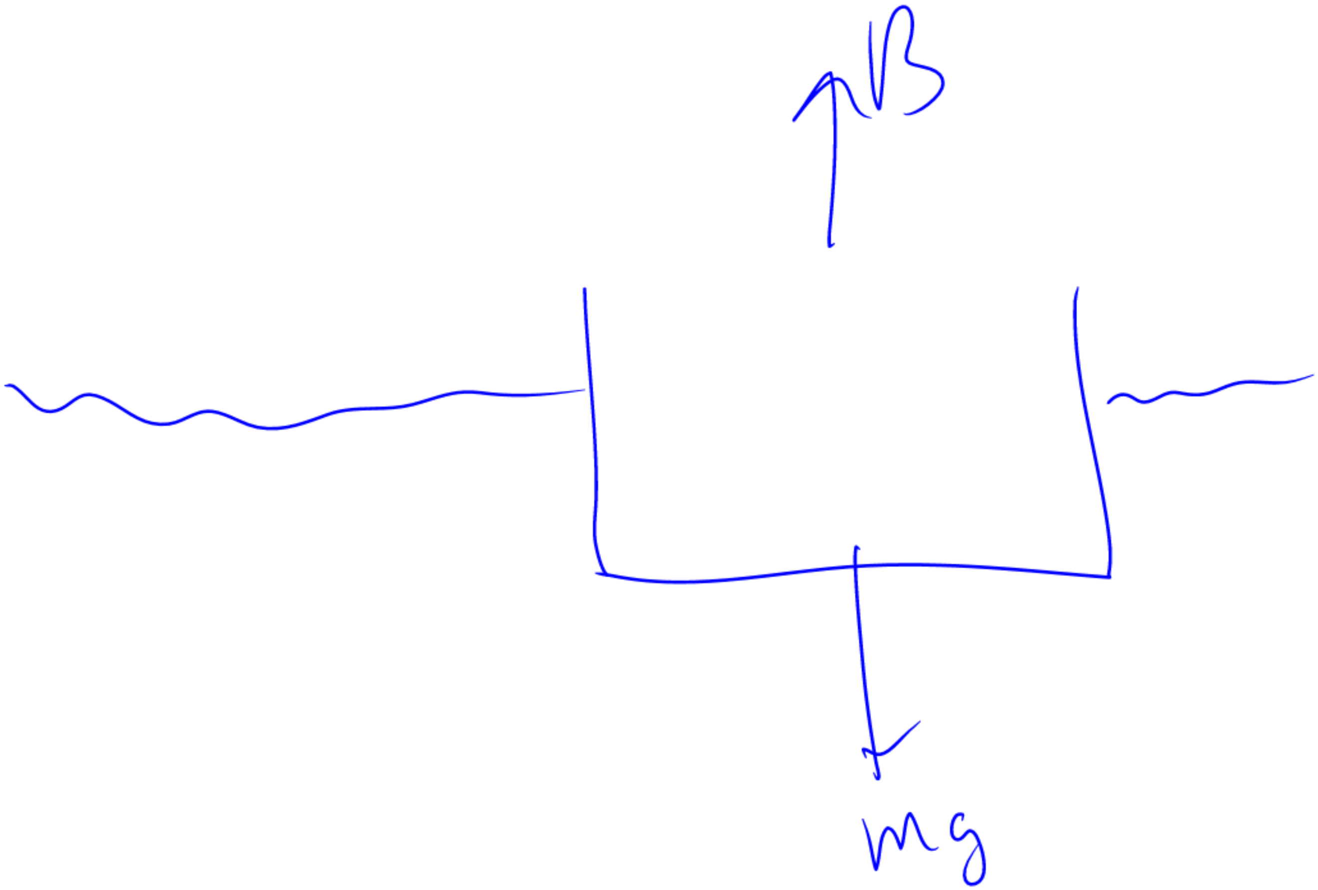
a. the weight of the object
b. the net force on the object
c. the weight of the water that would otherwise occupy the object's space

Demos

- Does a can of soda sink or float?
- Does aluminum foil sink or float?

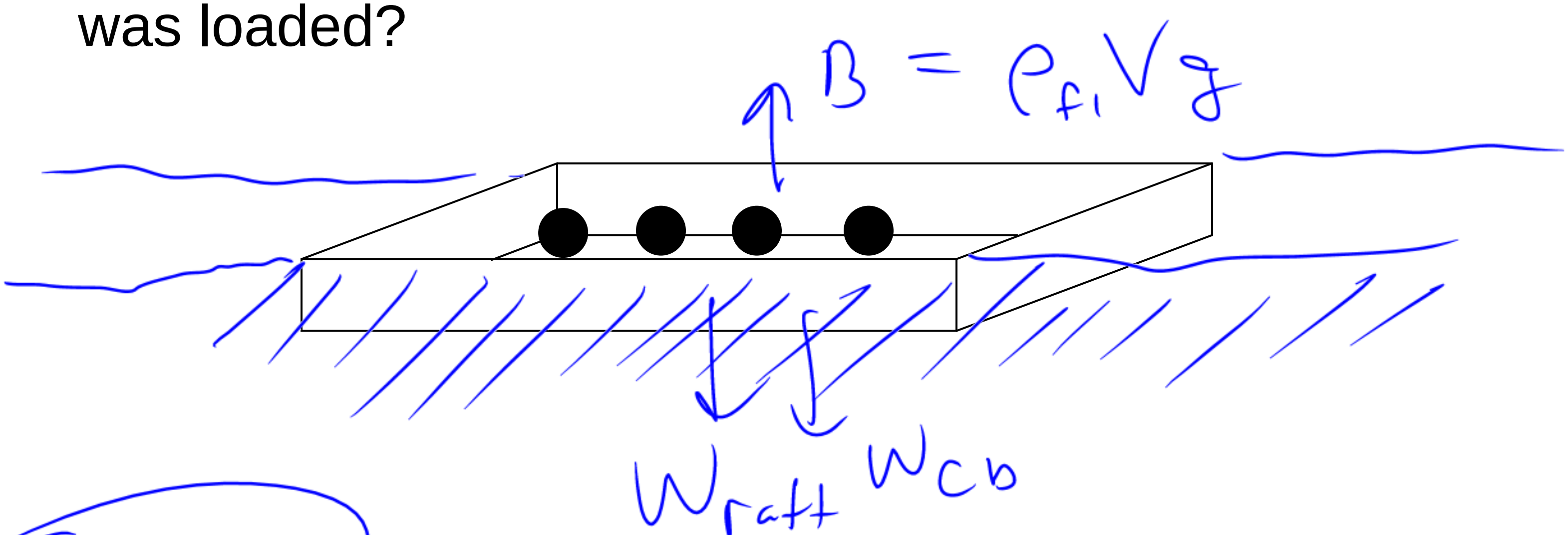
Floating objects

Floating objects will rise out of the water until…



Worked Problem

A raft of wood of size 0.5 m × 6 m × 5 m weighs 30,000 N. It is loaded with cannon balls until it is (barely) completely submerged. How much weight was loaded?



$\Sigma F = 0$

$B - W_{raft} - W_{cb} = 0$

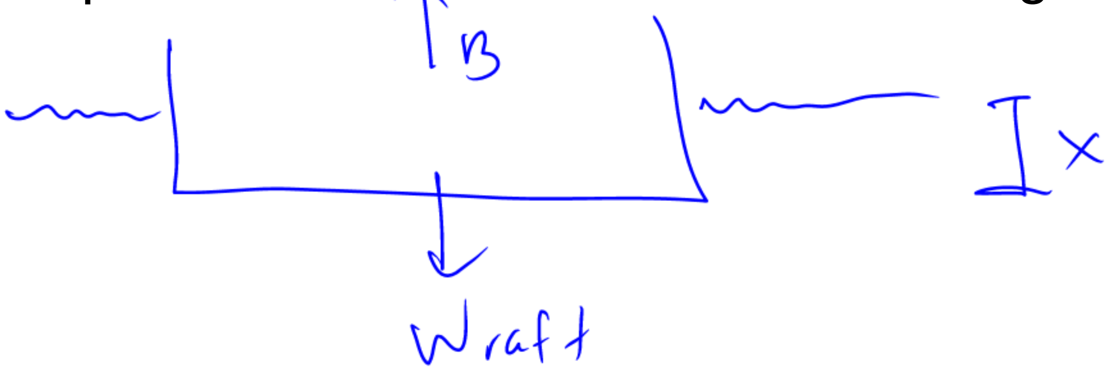
$\rho_{fl} V g - W_{raft} = W_{cb}$

$(1000\ \frac{kg}{m^3})(.5\ m \times 6\ m \times 5\ m)\ 9.8\ m/s^2 - 30000\ N = W_{cb}$

$117000\ N = W_{cb}$

Answer: 117,000 N

Additional part: the balls are unloaded, and the raft now sits at equilibrium. How far is the raft submerged?



$$\Sigma F = 0$$

$$B = W_{raft}$$

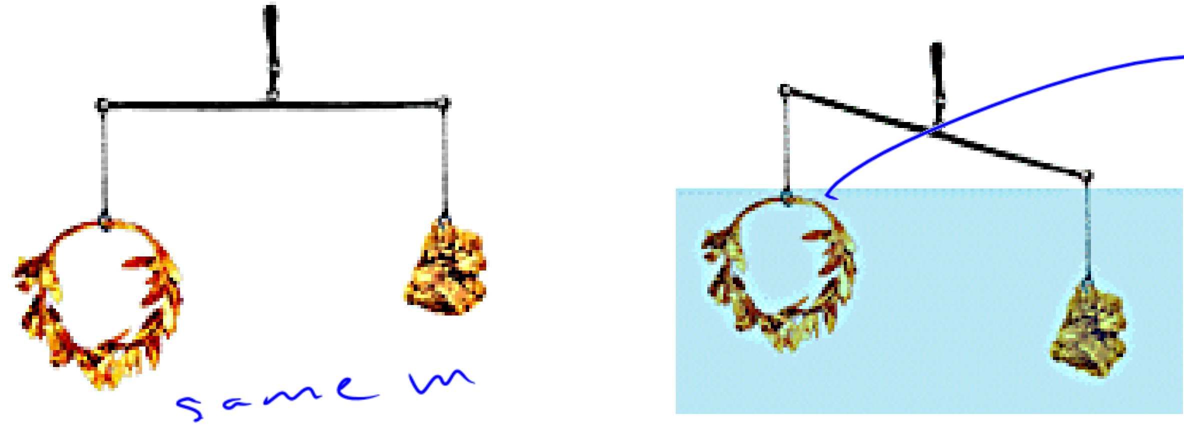
$$\rho_{fl} V_{obj}\, g = W_{raft}$$

$$\left(1000\ \frac{kg}{m^3}\right)(x \cdot 6m \cdot 5m)\left(9.8\ m/s^2\right) = 30000\ N$$

$$x = \frac{30000}{1000 \cdot 30 \cdot 9.8} = .102\ m$$

Answer: 10.2 cm

Archimedes: "Eureka"



Archimedes was charged with determining if a crown was pure gold. One method he may have used: he balanced the crown with pure gold outside water. After immersing, the balance tipped as shown.

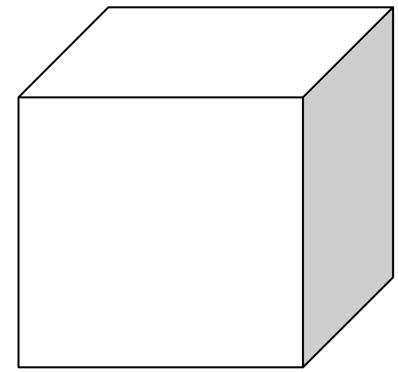
Clicker quiz: The crown has density

a. more than gold
b. less than gold
c. same as than gold

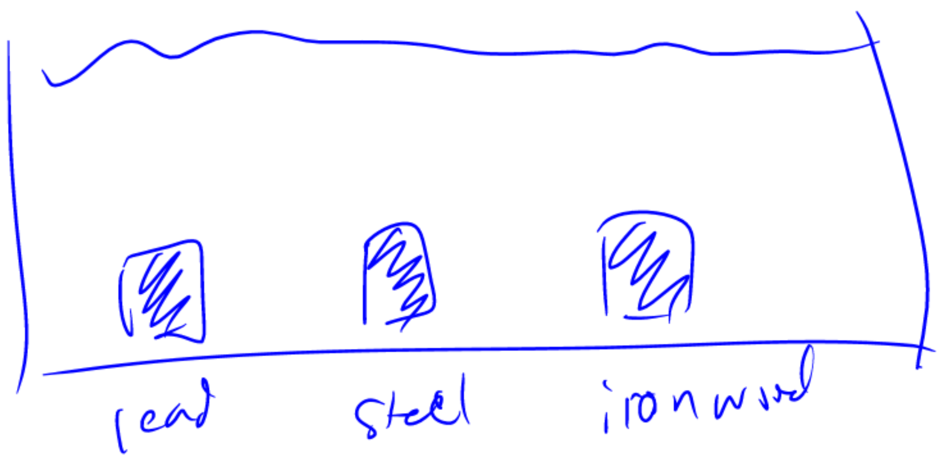
$B = \rho_{fl} V_{obj} g$

Clicker quiz

Three cubes of the same size and shape are put in water. They sink. One is lead, one is steel and one is a dense wood (ironwood). $\rho_{lead} > \rho_{steel} > \rho_{ironwood}$. The bouyant force is greatest on the ________ cube



a. lead
b. steel
c. wood
d. same buoyant force

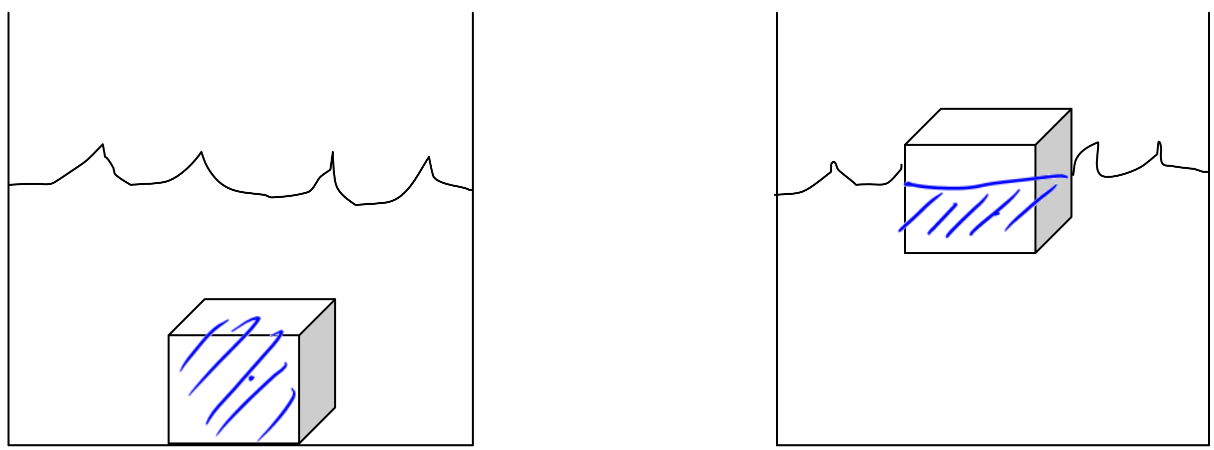


$$B = \rho_{fl} V_{obj} g$$

Clicker quiz

Two cubes of the same size and shape are made out of wood. The ironwood cube **sinks**, but the walnut cube **floats**. The bouyant force is greatest on the ________ cube

a. ironwood
b. walnut
c. same buoyant force



Moving fluids

Disclaimer: **viscosity** exists → *Viscosity is friction* in fluids

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

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

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

The power of viscosity (watch on your own):
http://www.youtube.com/watch?v=W3YZ5veN_Bg

That being said, we'll now ignore all viscosity effects…
…assume "frictionless fluids" unless otherwise stated

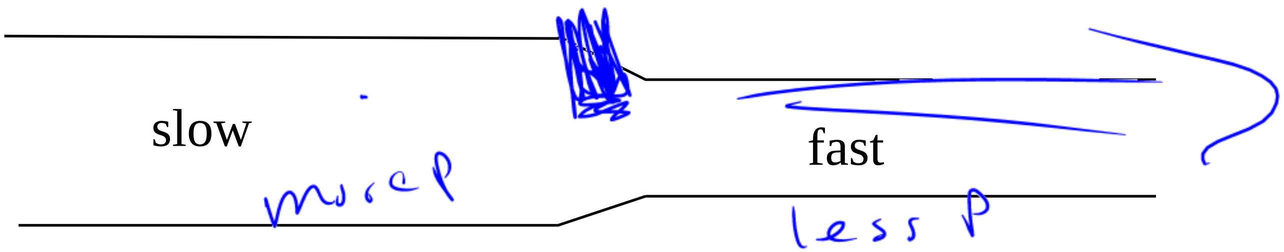
Bernoulli effect

The pressure in a fluid changes with the s<u>peed</u>__________ of the fluid.

Demo

Bernouilli effect in glass tube with varying diameter

→ why does the speed change?



Result of demo: Where is pressure the largest?

Disclaimer 1: This pressure change is **on top** of pressure lost from viscosity effects.

Disclaimer 2: What this *doesn't* mean (i.e. must compare speed in same overall flow)

Detour: fluid speeds

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

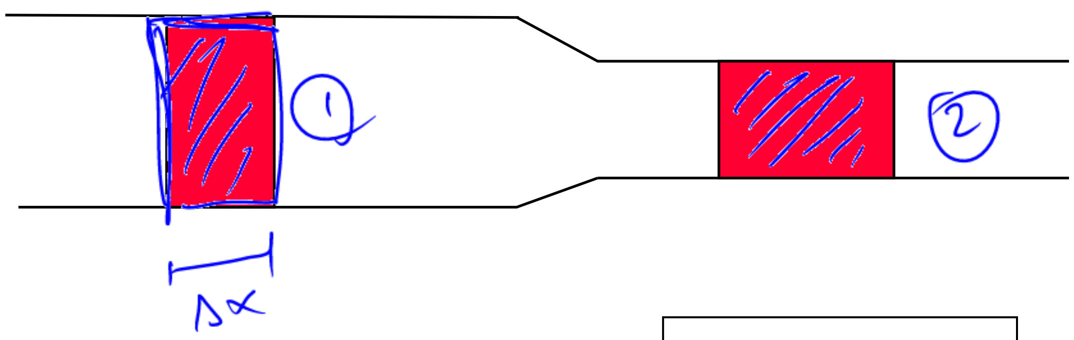
$$VFR = \frac{\Delta Volume}{\Delta t} = \frac{Area\,\Delta x}{\Delta t} = A \cdot v$$

Assume:

- No viscosity (friction)
- Incompressible (constant density) – *not true for gases*
- No turbulence

Then…

Conservation of Mass → Conservation of Volume Flow

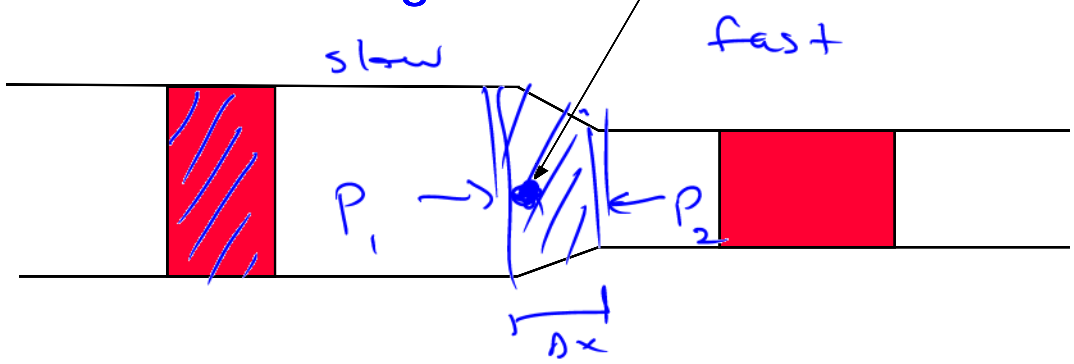


"Garden Hose Equation": $A_1 v_1 = A_2 v_2$

Book: "Equation of Continuity"

Why does the pressure depend on speed?

View #1: If you're a molecule right there



in what direction is the net force?

$P_1 > P_2$

$$F_{net} = P_1 A - P_2 A$$

$W = F \cdot d$

View #2: Energy & work, per volume

$E_{bef} + W = E_{aft}$

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

divide by V

pressure

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

rho
density

if same height

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

if faster

lower

"Bernoulli's equation"

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

Another blueprint!

From warmup: In the reading assignment for today, Ralph noticed two different equations labeled "Bernoulli's Equation". One said,

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

the other said, "$P + \frac{1}{2}\rho v^2 + \rho g h = C$".

He wants to know how they can both be the same equation when they look so different. And what does *C* stand for, anyway? What can you tell him?

"Think-pair-share"

- Think about it for a bit
- Talk to your neighbor, find out if he/she thinks the same as you
- Be prepared to share your answer with the class if called on

Clicker: I am now ready to share my answer if randomly selected.

a. Yes

Note: you are allowed to "pass" if you would really not answer.

Review

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 _____________ the speed in the large tube.

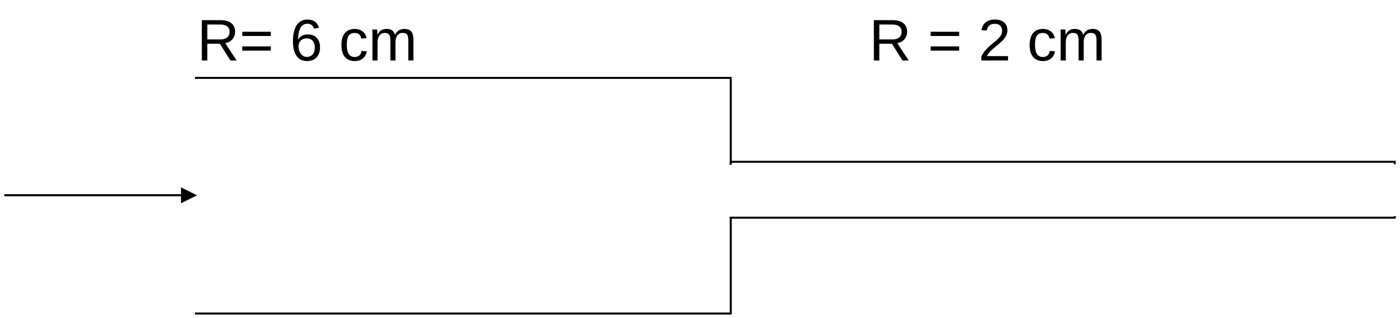
a. greater than
b. less than
c. equal to

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

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

Worked Problem

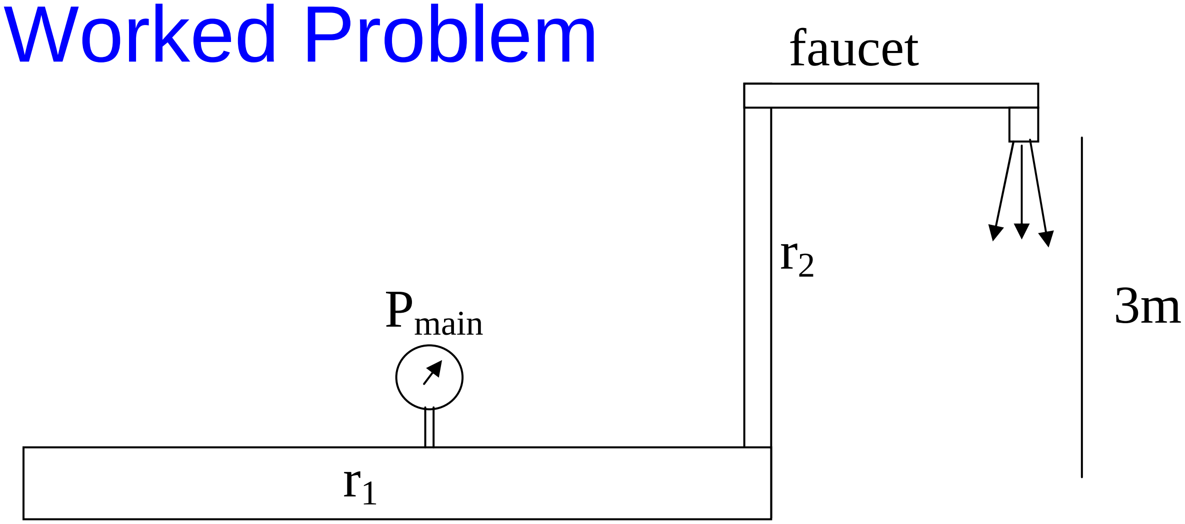
Water flows from the big pipe into the little pipe. Ignore any friction or height change.



If the speed on the left is 1 m/s, what's the speed on the right?

Answer: 0.111 m/s

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 1 atm. 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

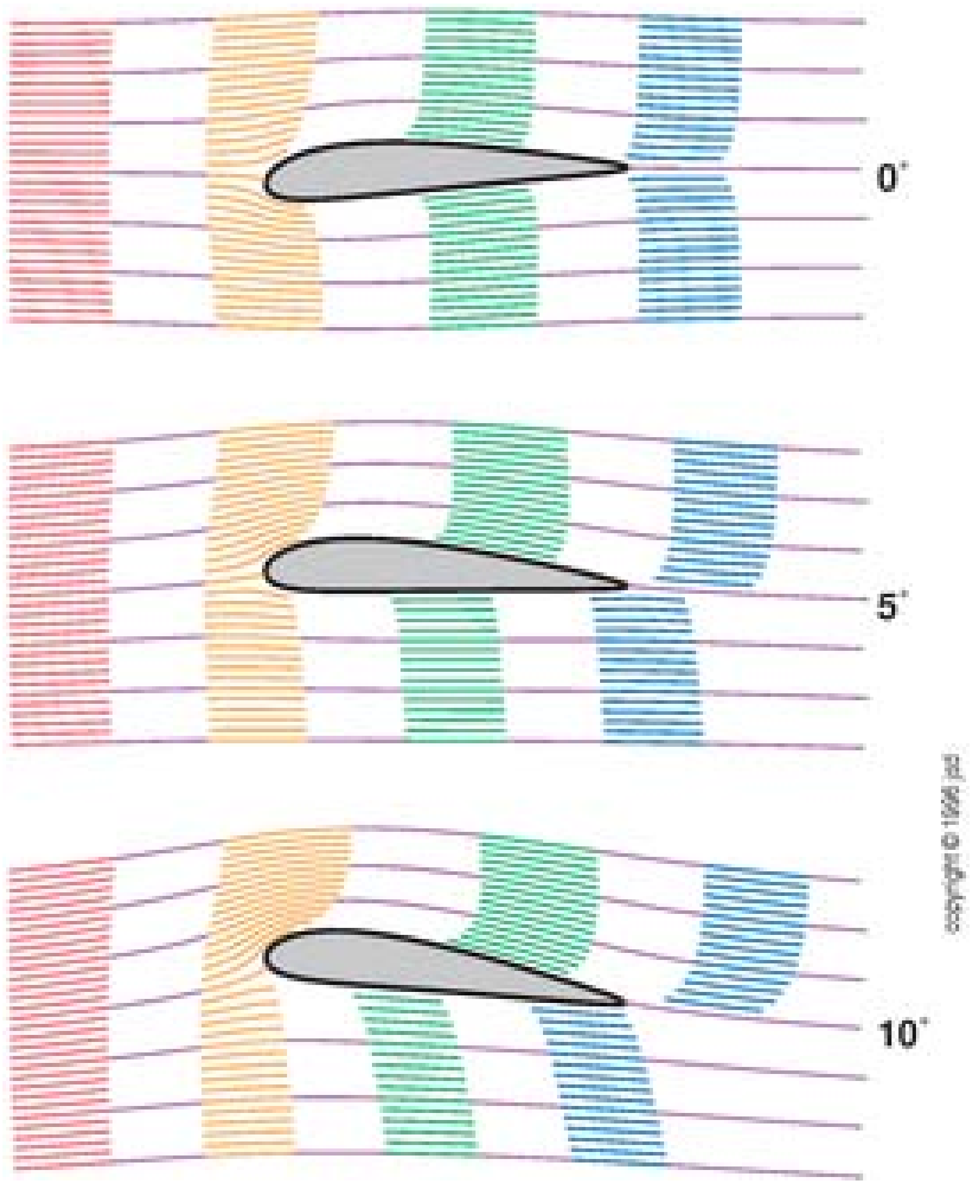
The Bernoulli effect – what good is it?

Demos: Blowing on paper, Ball over blower, Venturi blower, funnel, metal plate and wood cylinder
Video: Elder Nelson, April 1997 General Conference (1:58 - 3:45)

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

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

Principle 2: Bernoulli



http://www.av8n.com/how/htm/airfoils.html#toc4