

- Week 1: Everything Is Electric
- Week 2: Is It Magic, or Is It Magnets?
- Week 3: On Your Wavelength: Electromagnetic Waves
- Week 4: Physics of Sound & Music
- Week 5: Energy, Thermodynamics & The Arrow of Time
- Week 6: Push and Pull: Force & Motion
- Week 7: **Go With the Flow: Physics of Fluids**
- Week 8: A Warm Planet in a Cold Universe: How the Earth Stays Warm, and Why It's Getting Warmer (Different Room!)

# Physics Principles

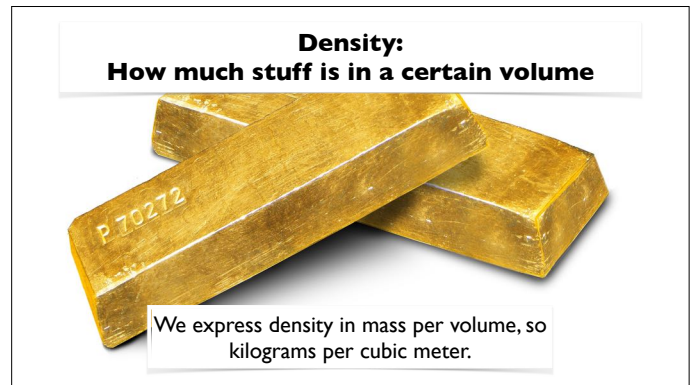
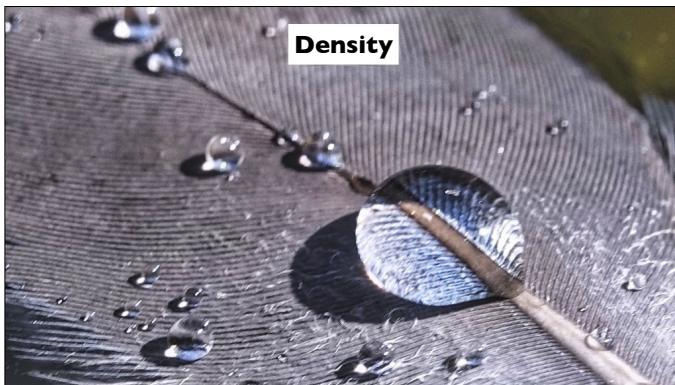
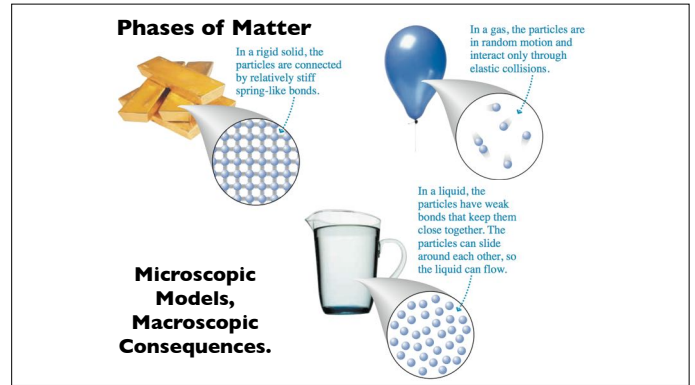
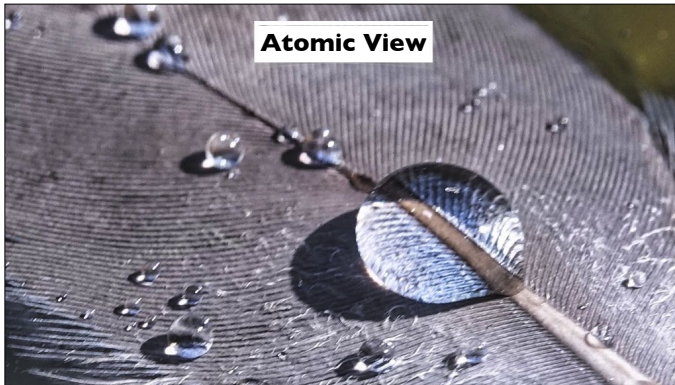
The Source of Pressure

Pressure Forces

Pressure and Flow

Buoyancy

Surface Tension

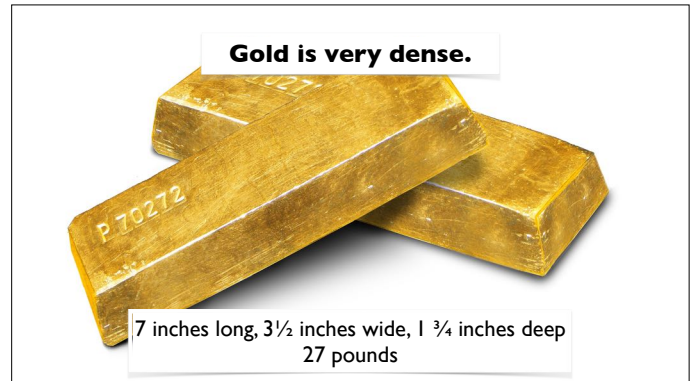


Substance	$\rho$ (kg/m <sup>3</sup> )	<b>Density</b>	
Hydrogen gas (20°C)	0.083		
Helium gas (20°C)	0.166		
Air (20°C)	1.20		
Air (0°C)	1.28		
Gasoline	680		
Ethyl alcohol	790		
Oil (typical)	900		
Water	1000		
Seawater	1030		
Blood (whole)	1060		
Glycerin	1260		
Mercury	13,600		

Body Component	Density (kg/m <sup>3</sup> )
Fat	900
Water	1000
Blood	1050
Muscle	1060
Bone	1280

Fat is less dense than water, muscle is more dense than water.



**From Wikipedia**

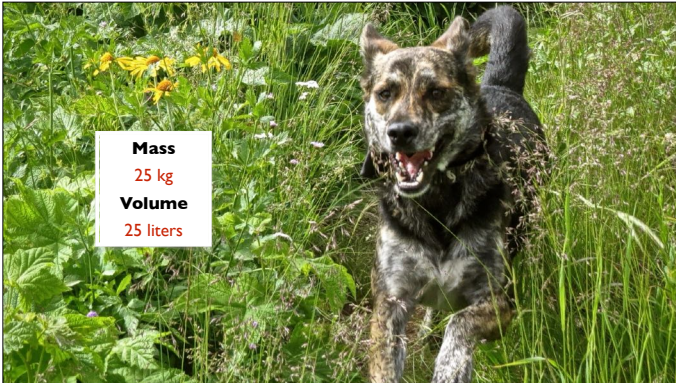
Gold cost \$38.69 per troy ounce in 1968, so four million dollars in gold bars would have weighed about 3,200 kg (7,100 lb), requiring each of the three Minis to carry about 1,070 kg (2,360 lb) in addition to the driver and passenger. Since a 1968 Mini only weighs 630 kg (1,390 lb), each of these vehicles would have had to carry 1½ times its own weight in gold.



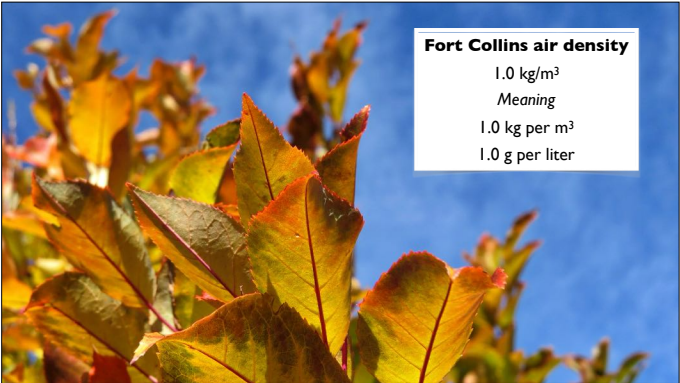
**The Italian Job**



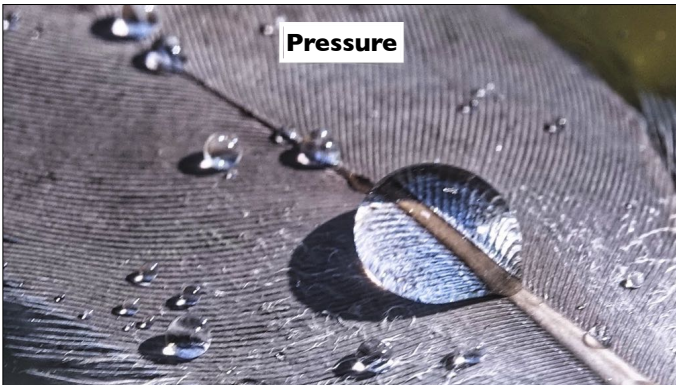
**Water density**  
1000 kg/m<sup>3</sup>  
meaning  
1.0 kg per liter



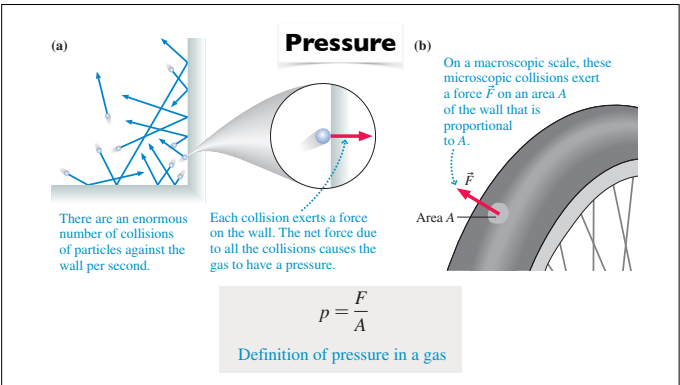
**Mass**  
25 kg  
**Volume**  
25 liters



**Fort Collins air density**  
1.0 kg/m<sup>3</sup>  
Meaning  
1.0 kg per m<sup>3</sup>  
1.0 g per liter



**Pressure**



Typical tire pressure: 32 pounds per square inch  
221,000 Pascals = 221 kPa

$$p = \frac{F}{A}$$

Definition of pressure in a gas



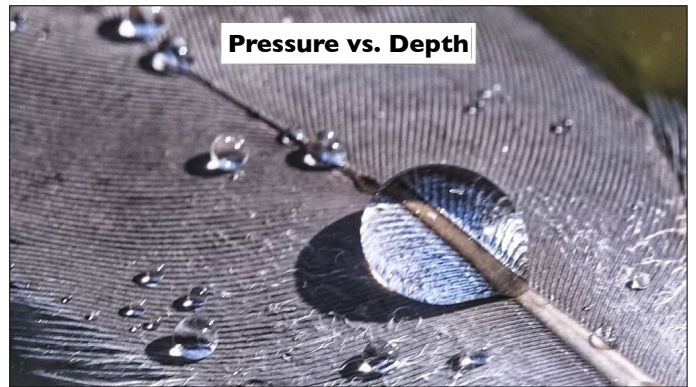
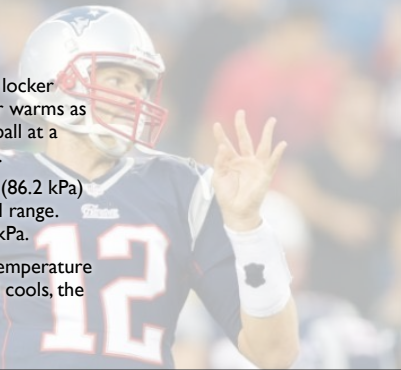
### Pressure changes with temperature

A football is inflated in a 70°F locker room before the game. The air warms as it is pumped, so it enters the ball at a temperature of 80°F (26.7°C).

The ball is inflated to 12.5 psi (86.2 kPa) at the lower end of the official range. Atmospheric pressure is 100 kPa.

The ball is used for play at a temperature of 50°F (10°C). Once the ball cools, the pressure is 11.0 psi.

### Pressure vs. Depth



### Pressure

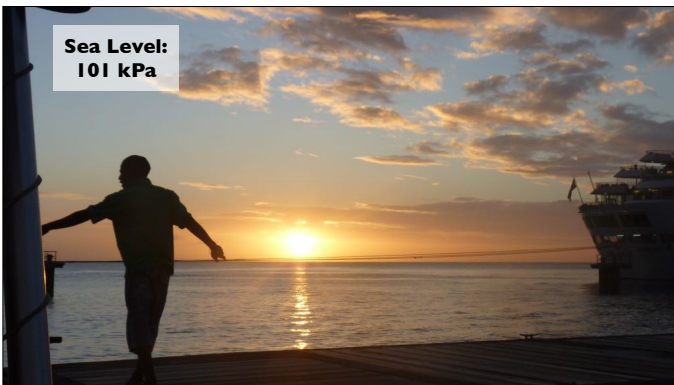
The air at the earth's surface supports the weight of all the air above it. That's the source of atmospheric pressure.

We define the pressure at sea level as **1 atmosphere**.

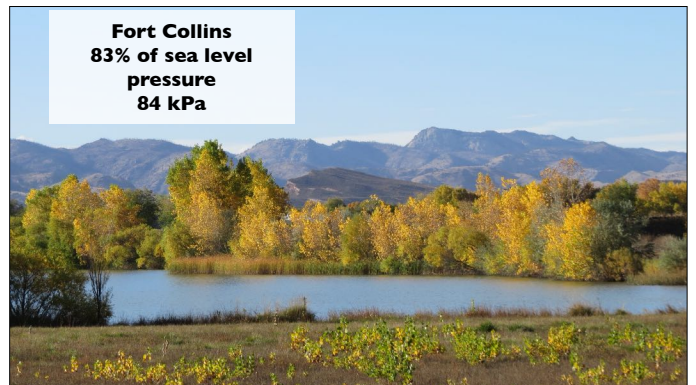
### Pressure vs. Height

As you go higher in the atmosphere, there is less air above you. So the pressure is lower.

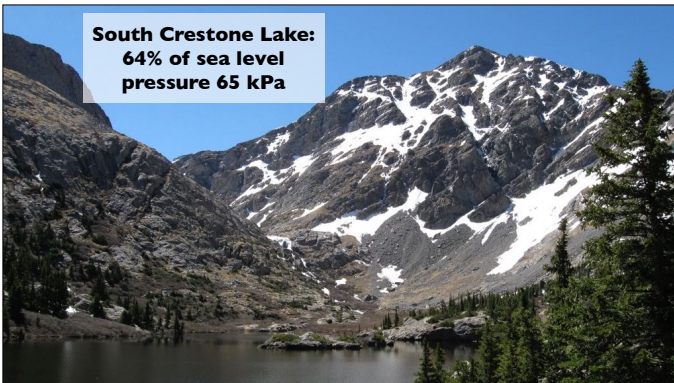
**Sea Level:  
101 kPa**



**Fort Collins  
83% of sea level  
pressure  
84 kPa**

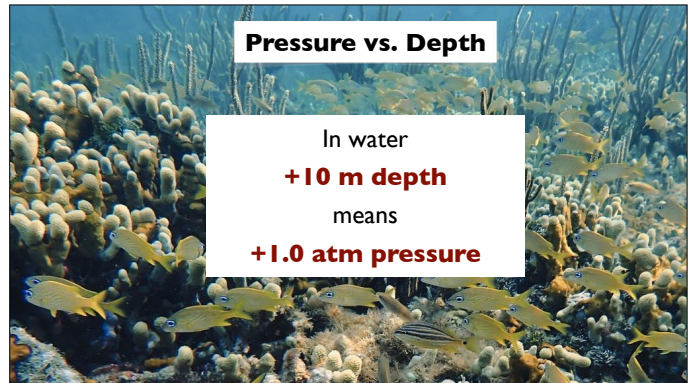


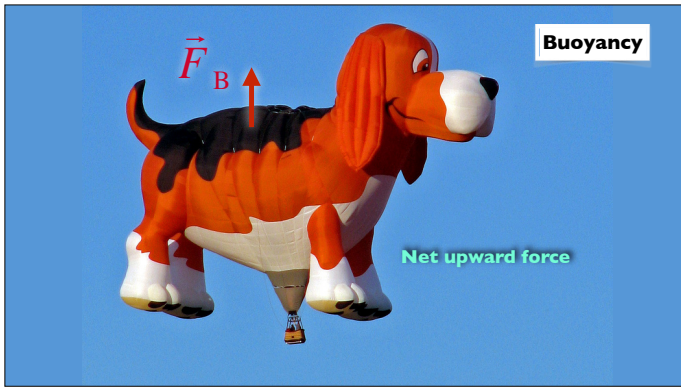
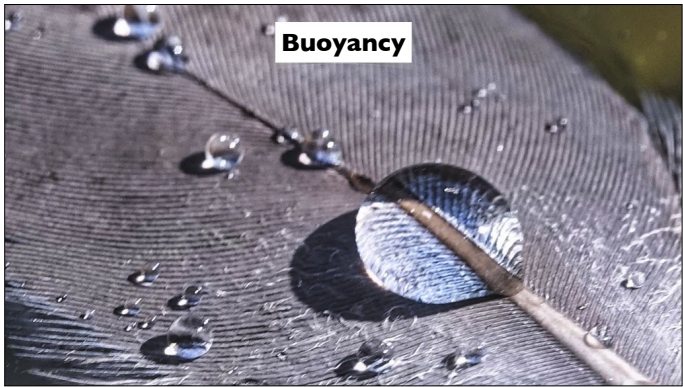
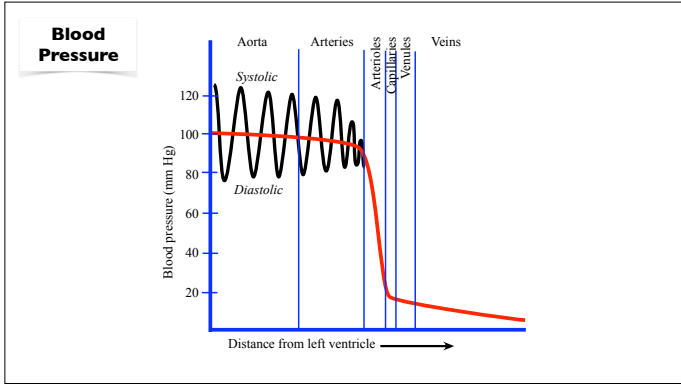
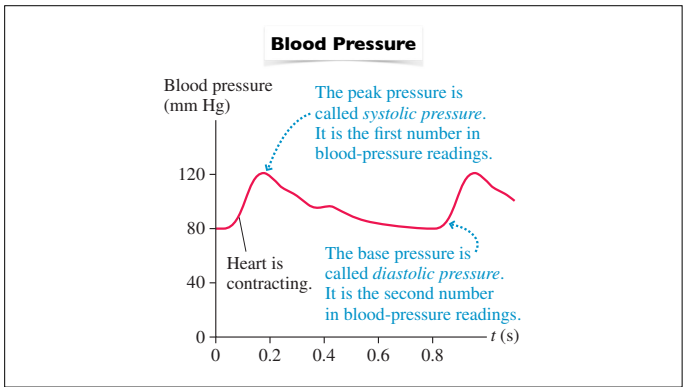
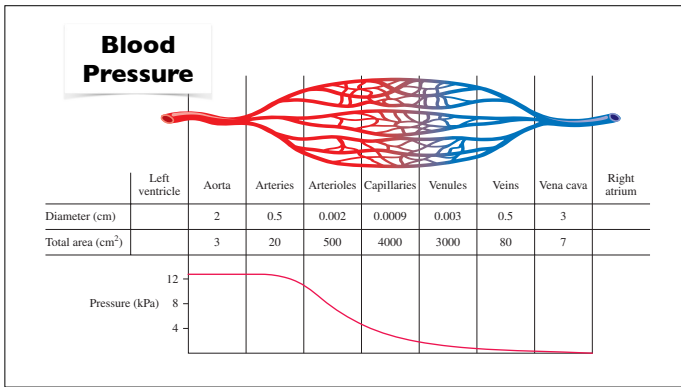
**South Crestone Lake:  
64% of sea level  
pressure 65 kPa**



### Pressure vs. Depth

In water  
**+10 m depth**  
means  
**+1.0 atm pressure**





### Buoyancy

$$F_B = \rho_f V_f g$$

Buoyant force      Density of the fluid      Volume of fluid displaced

**It's a real force.**  
It exists whenever an object is immersed in a fluid.

The net force of the fluid on the cylinder is the buoyant force  $F_B$ .

Increasing pressure

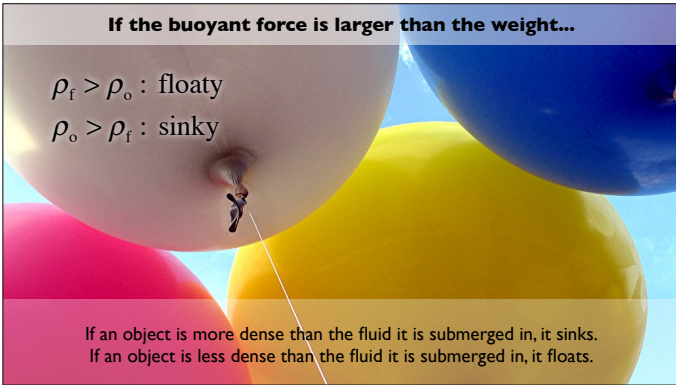
$F_{up} > F_{down}$  because the pressure is greater at the bottom. Hence the fluid exerts a net upward force.

If the buoyant force is larger than the weight...

$\rho_f > \rho_o$  : floaty

$\rho_o > \rho_f$  : sinky

If an object is more dense than the fluid it is submerged in, it sinks.  
If an object is less dense than the fluid it is submerged in, it floats.



### Heavy, but Floaty

The envelope of a typical hot air balloon has a volume of 2500 m<sup>3</sup>.

Assume that such a balloon is flying in Fort Collins, where the density of air is approximately 1.0 kg/m<sup>3</sup>.



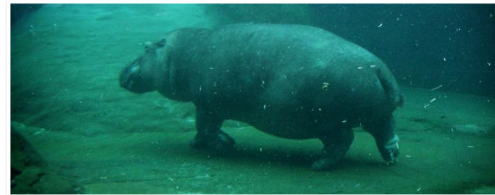
- What mass of air does the balloon displace?
- If heated to the maximum temperature, the air inside the balloon has a density of about 80% that of the surrounding air. What is the mass of air in the balloon?
- How much mass can the balloon lift?

Floating in the Dead Sea  
Water density = 1240 kg/m<sup>3</sup>



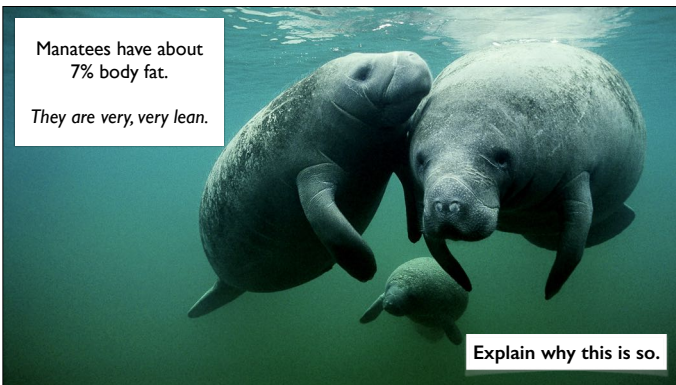
Hippos spend much of their lives in water, but amazingly, they don't swim. They also, despite appearances, have very little body fat. The density of a hippo's body is approximately 1030 kg/m<sup>3</sup>, so it sinks to the bottom of the freshwater lakes and rivers it frequents—and then it simply walks on the bottom.

A 1500 kg hippo is completely submerged, standing on the bottom of a lake. What is the hippo's apparent weight?



Manatees have about 7% body fat.

They are very, very lean.



Explain why this is so.

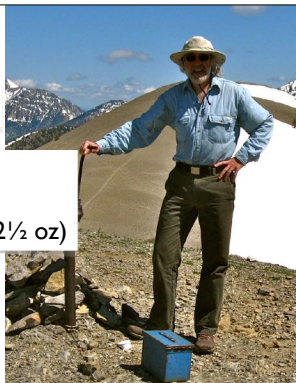
### Question:

Taking buoyancy into account, is the reading on the scale greater than, equal to, or less than your actual weight?



### Submerged in Air

My volume: 70 liters  
Mass of air displaced: 70 grams  
Buoyant force: 70 grams (2½ oz)




My mass: 70 kilograms  
My volume: 70 liters  
Mass of water displaced: 70 kilograms  
**Bouyant force equals weight force!**


### Submerged in Water



Balloon volume:	12 liters
Mass of air displaced:	12 grams
Mass of balloon:	1 g
Mass of helium in balloon:	2 grams
Total lift:	9 grams (1/3 oz)




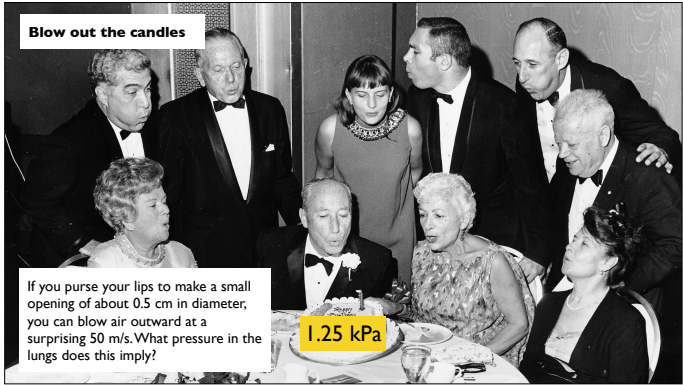
Balloon volume:	12 liters
Mass of air displaced:	12 grams
Mass of balloon:	1 g
Mass of helium in balloon:	2 grams
Total lift:	9 grams (1/3 oz)



↗  
Enough to lift 4 dimes



When you breathe deeply, you pull in 4.0 L of air in about 3.0 s. This requires a pressure difference of about 4.0 kPa between the air in your lungs and the outside air.

**Blow out the candles**

If you purse your lips to make a small opening of about 0.5 cm in diameter, you can blow air outward at a surprising 50 m/s. What pressure in the lungs does this imply?


**1.25 kPa**



**Fluid Flow**

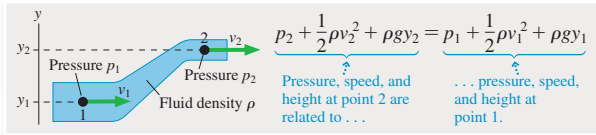
$$Q = \frac{\Delta V}{\Delta t} = vA$$

Volume flow rate for liquid moving at speed  $v$  through a tube of cross-section area  $A$



An increasing speed causes the diameter to decrease

### Fluid Flow: Bernoulli

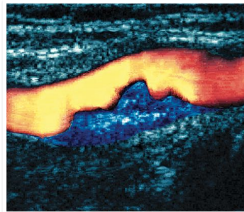


Along the flow: A reduction in pressure leads to a higher speed.

### Fluid Flow: Bernoulli

**Along the flow:  
High speed = low pressure**

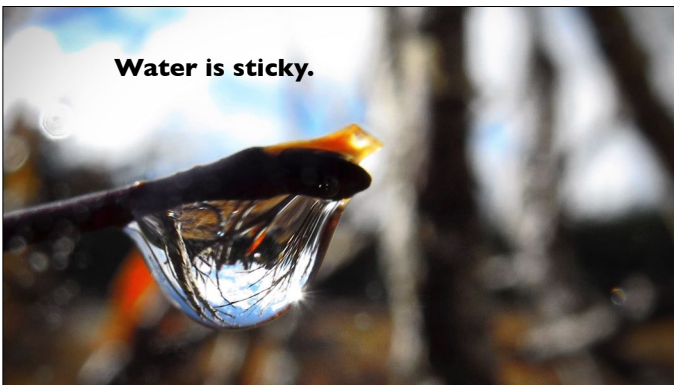
When blood passes a segment of an artery narrowed by a plaque, flow speed must increase. Does this lead to an increase or decrease of the pressure at the narrow spot?



### Surface Tension



### Water is sticky.



### Floating a coin

