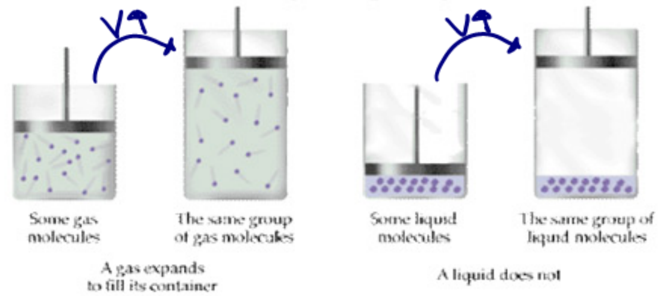
Fluids Notes

1 – Hydrostatic Pressure

Fluid: a substance that flows. Fluids can be both liquids and gases.

While gases can be compressed (due to empty space between particles) liquids (like solids) cannot.

Gases can also expand when volume is increased.



Density: the amount of something in a given space.

Mass Density… $\boxed{\text{mass}}$ of a substance in a given space

$\rho = \frac{m}{V}$

Where: ρ = Density (kg/m^3 or kg/L)
m = Mass (kg)
V = Volume (m^3 or L)

Material	ρ (kg/m³)
Air (20 °C)	1.2
Air (0 °C)	1.28
Helium (0 °C)	0.179
Liquid hydrogen	70
Mercury	13,546
Water (fresh)	1,000
Water (salt)	1,030
Gasoline	680
Ethyl Alcohol	790
Blood	1060
Glycerin	1260

Example:
Rank samples A,B,C in order of ascending densities.

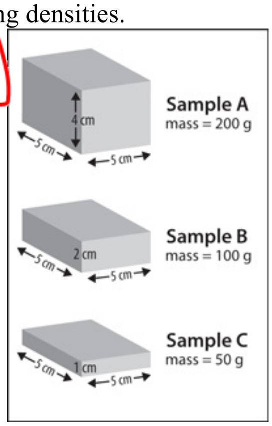
$\rho_A = \frac{200g}{(4\times5\times5)cm^3} = \boxed{2.0\,g/cm^3}$

$\rho_B = \frac{100g}{(5\times5\times2)cm^3} = \boxed{2.0\,g/cm^3}$

$\rho_C = \frac{50g}{(1\times5\times5)cm^3} = \boxed{2.0\,g/cm^3}$

$\boxed{\rho_A = \rho_B = \rho_C}$

$\boxed{\text{SAME}}$



Example:
What is the mass of air in a living room with dimensions 4.0 m x 6.0 m x 2.5 m?

$\rho = \frac{m}{V}$; $m = \rho \cdot V = \left(\frac{1.2\,kg}{m^3}\right)(4.0\times6.0\times2.5)m^3$

$\boxed{m = 72\,kg}$

If the living room was converted into a swimming pool what would the mass be of the same swimming pool filled with BLOOD!? ***Mr. Lawson did you just go there!?***

$m = \rho V = 1060\frac{kg}{m^3}(4.0\times6.0\times2.5)m^3$

$\boxed{m = 63{,}600\,kg \text{ of BLOOD...}}$

Some other interesting Densities…

Entity	ρ (kg/m³)
Interstellar medium	1×10^{-19}
The Earth	5,515
The inner core of the Earth	13,000
The core of the Sun	33,000–160,000
Super-massive black hole	9×10^{5}
White dwarf star	2.1×10^{9}
Atomic nuclei	2.3×10^{17}
Neutron star	1×10^{18}
Stellar-mass black hole	1×10^{18}

Example:
How large would a white dwarf star be if it has the same mass as planet Earth?

$V_{Earth} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(6.38\times10^6 m)^3 = 1.09\times10^{21} m^3$ ← Earth!

$V = \frac{M_{earth}}{\rho_{WDS}} = \frac{5.98\times10^{24} kg}{2.1\times10^9 kg/m^3} = 2.85\times10^{15} m^3$ ← White Dwarf Star

Example:
What is denser an atomic nuclei or neutron star? *What does this suggest?*
Neutron Star! This suggest atomic nuclei must be squished together!

Pressure: a ratio of the Force exerted vs. the Area it is exert on.

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

Where: p = pressure (Pa) → Pascals
F = Force (N)
A = Area (m²)

We will mostly use Pascals and atm
(1 atm = the weight of 1 atmosphere)

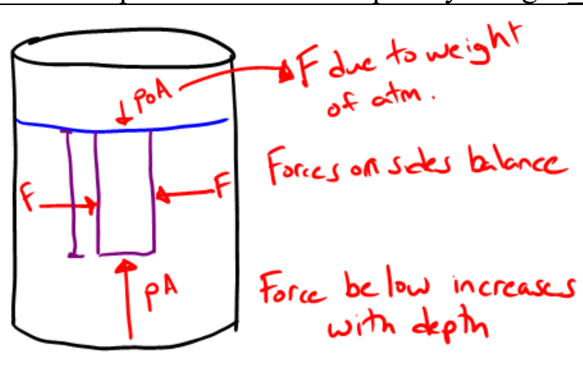
Did you know…? 99% of the mass of the atmosphere is below 30 km? I know right... either did I!

TABLE 10–2 Conversion Factors Between Different Units of Pressure

In Terms of 1 Pa = 1 N/m²	1 atm in Different Units
1 atm = 1.013×10^5 N/m² = 1.013×10^5 Pa = 101.3 kPa	1 atm = 1.013×10^5 N/m²
1 bar = 1.000×10^5 N/m²	1 atm = 1.013 bar
1 dyne/cm² = 0.1 N/m²	1 atm = 1.013×10^6 dyne/cm²
1 lb/in.² = 6.90×10^3 N/m²	1 atm = 14.7 lb/in.²
1 lb/ft² = 47.9 N/m²	1 atm = 2.12×10^3 lb/ft²
1 cm-Hg = 1.33×10^3 N/m²	1 atm = 76 cm-Hg
1 mm-Hg = 133 N/m²	1 atm = 760 mm-Hg
1 torr = 133 N/m²	1 atm = 760 torr
1 mm-H_2O (4°C) = 9.81 N/m²	1 atm = 1.03×10^4 mm-H_2O (4°C)

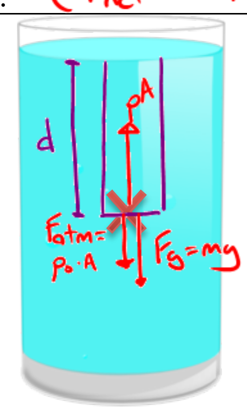
Hydrostatic Pressure: The **pressure** exerted by a fluid at equilibrium at a given point within the fluid.

We can determine the pressure within a liquid by using a FBD. ($F_{net} = 0$!)



$pA = p_oA + mg$

$p = p_o + \rho g d$



$$p = p_o + \rho g d$$

Where:
p = Absolute Pressure (Pa)
p_o = Atmospheric Pressure (Pa)
ρ = Fluid Density (kg/m³)
g = gravity
d = Depth from surface

Example:

A submarine cruises in the ocean at a depth of 300. m. What is the pressure at this depth? Give your answer in ***both*** Pascal's and atmospheres.

$p = p_0 + \rho_{sw} g d$

$p = (1.013\times10^5) + (1030)(9.8)(300)$

$\boxed{p = 3.13\times10^6\ Pa}$

$p = 3.13\times10^6\ Pa \times \frac{1\,atm}{1.013\times10^5\ Pa} = \boxed{30.9\,atm}$

Example:

A fresh water research submarine has a circular 20. cm diameter window that is 8.0 cm thick. The manufacturer says the window can withstand forces 1.0 x 10^6 N. What is the submarine's maximum safe depth at sea? The pressure inside the submarine is 1.0 atm.

$p = \frac{F}{A} = \frac{1.0\times10^6\ N}{\pi (0.10)^2} = 3.18\times10^7\ Pa$

$p = p_0 + \rho g h$

$d = \frac{p - p_0}{\rho_w g} = \frac{(3.18\times10^7 - 1.013\times10^5)}{(1000)(9.8)}$

$\boxed{d = 3.14\times10^3\ m \text{ or } 3.14\ km}$

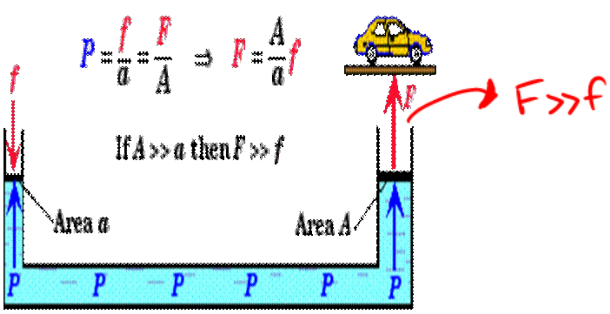
Gauge Pressure is used when fluids exist in a closed system, like bike/car tires.

Gauge Pressure = Absolute Pressure – Atmospheric Pressure = $p - p_0$

Pascal's Principle….

When force is applied to a confined fluid, the change in pressure is transmitted equally to all parts of the fluid. (Egg!!!)

This principle is used in hydraulic (*a liquid moving in a confined space under pressure*) lifts….



Example:

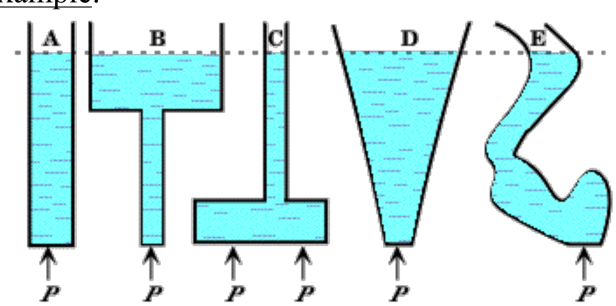
A barber raises his customer's chair by applying a force of 150 N to a hydraulic piston of area 0.010 m^2. If the chair is attached to a piston of area 0.10 m^2, how massive a customer can the chair raise? Assume the chair itself has a mass of 5 kg.

$\frac{F_1}{A_1} = \frac{F_2}{A_2}$; $\frac{F_1}{A_1} = \frac{mg}{A_2}$

$m = \frac{A_2 F_1}{A_1 g} = \frac{(0.10\,m^2)(150\,N)}{(9.8\,m/s^2)(0.010\,m^2)} = 153\,kg$

Customer = 153 kg – 5 kg = $\boxed{148\,kg}$

Example:



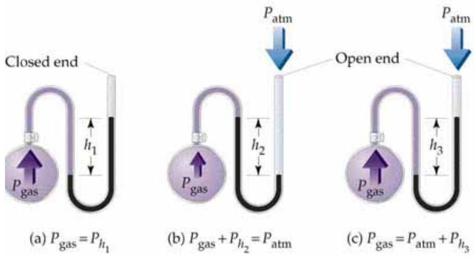
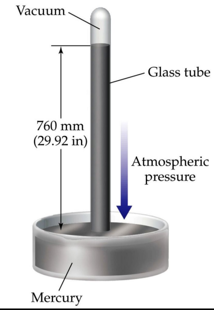
Which of the following is under the great pressure at point p?

$\boxed{\text{SAME}}$

Equal depth = Equal Pressure

shape is irrelevant!

Devices to measure gas pressure

<table>
<tr><th>Manometer</th><th>Barometer</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>U-shaped tube connected to <u>gas</u> at one end and <u>open to air</u> at the other
Tube is filled with a liquid (often <u>mercury</u>)
The liquid exists in <u>Static equilibrium</u>
(forces are <u>equal!</u>) P_o
$P_{gas} = 1atm + \rho gh$</td><td>The glass tube is filled with mercury inverted and placed on a dish of mercury
While some of the mercury <u>escapes</u> the tube, P_{atm} pushes <u>down</u> on the dish eventually creating <u>static equilibrium</u>.
$P_{atm} = \rho gh$</td></tr>
</table>

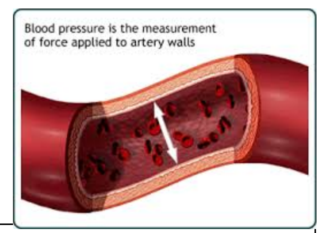
Blood Pressure – *Bio Connect…. I know… Eww*

On average, a human heart beats <u>75 times</u> in <u>1 min</u> (<u>1 beat/0.8 sec</u>)

The heart circulates blood to all parts of the body, allowing <u>nutrients</u> and <u>waste</u> to diffuse substances <u>in</u> and <u>out</u> of cells.

Arteries carry <u>nutrient rich</u> blood to cells due to the contraction of heart muscles causing arteries to become <u>pressurized</u>.

Blood pressure is measured using both…



Systolic: the <u>maximum</u> blood pressure Diastolic: <u>base</u> blood pressure

120/80

Example:

Postural hypotension is the occurrence of low (systolic) blood pressure when standing up too quickly from a reclined position, causing fatigue or lightheadedness. For most people, a systolic pressure of less than 90 mm Hg is considered low. If the blood pressure in your brain is 120 mm when you are lying down, what would it be (in mm Hg) when you stand up? Assume that your brain is 40 cm from your heart. Note: normally blood vessels contract and expand to keep your brain blood pressure stable when you change your posture.

$\boxed{1 \text{ mm Hg} = 133 \text{ Pa}}$

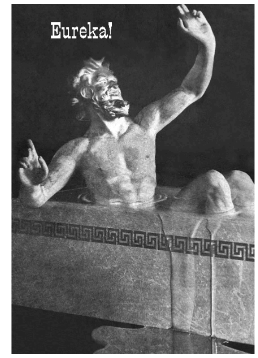
$\Delta P = \rho g \Delta h = (1060)(9.8)(0.40)$

$\Delta P = 4155.2 \text{ Pa}$

$\Delta P = 4155.2 \text{ Pa} \times \frac{1 \text{ mmHg}}{133 \text{ Pa}} = 31.2 \text{ mHg}$

$P = 120 \text{ mmHg} - 31.2 \text{ mmHg} = \boxed{89 \text{ mmHg}}$

Fluids Notes
2 – Buoyant Force



The Story of Archimedes…

The story handed down through the generations is that Hiero, a king of the Greek city of Syracuse, gave a goldsmith a lump of gold and told him to make a royal crown. When the goldsmith brought the crown to the king, it weighed the same as the lump of gold Hiero had given to him. King Hiero began to ponder on the honesty of this craftsman. He was not certain, but he suspected that the goldsmith had kept some of the gold for himself and had mixed silver with the rest of it to make the crown heavy. That is when Hiero called Archimedes and asked him to discover the truth, but without melting the crown down.

Archimedes knew this would be a difficult problem to solve and wondered how to go about it. The answer came suddenly! One day as Archimedes was lowering himself into one of the public baths in the city, he noticed that some water flowed over the sides of the tub. It is said that he became so excited that he ran out of the bath house through the streets of Syracuse, yelling, "Eureka! Eureka!" In Greek it meant, "I found it! I found it!"

Archimedes then needed to make an experiment to prove this idea of his. First, he weighed the crown. Then, he took a lump of gold and of silver, each weighing the same as the crown. The silver lump was larger because silver is lighter than gold. It takes much more silver to weigh as much as the lump of gold.

He put each lump in a vessel. The vessels were filled to the rim with water. The larger amount of silver caused more water to overflow than the lump of gold did, although both weighed the same. Archimedes knew then that any solid material will push away an amount of water equal to its own bulkiness, or *volume*. If the crown were pure gold, it would have to push away, or *displace* the same amount of water as the lump of pure gold that weighed the same.

But the crown made **more** water overflow than the lump of gold had. Was the goldsmith honest or dishonest? He was dishonest. He had added silver to the crown to make it bulkier. The king found him guilty of stealing.

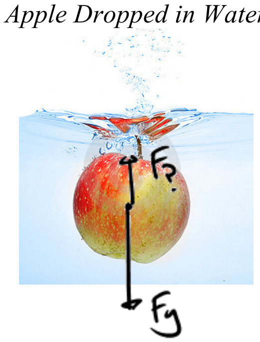
Archimedes continued experimenting and found that what he learned could be used as a rule. This rule could be used for things that could float as well as for things that sink. Any object that floats will displace its own *weight* of water. <u>Any object that sinks will displace an amount of water equal to its own *volume*</u>. *Volume is the amount of **space** an object takes up.*

What is weight? Weight tells how *heavy* something is. What is volume? Volume tells us how much *space* it takes up. Do a pound of butter and pound of marshmallows both weigh the same? Yes! But, if you make a pile from a pound of marshmallows, you discover that it takes up much more space, or *volume*.

Which apple falls faster…? Draw and FBD for each!

Apple Dropped in Air

Apple Dropped in Water

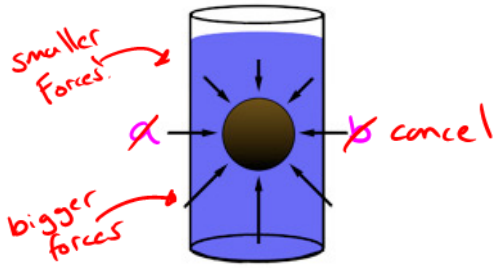
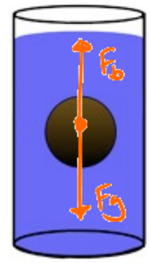


<u>Archimedes' Principle</u>: A fluid exerts an <u>upward force</u> on an object that is immersed in or floating in a <u>fluid</u>.

You've probably noticed this principle while <u>lifting yourself</u> (or yourself) in pools, lakes or oceans!

In fact the world record for bench-pressing 110 lbs is currently 36 reps! (***Highly Beatable!***)

That upward force is known as buoyant force (F_b) and due to the pressure difference at the top and bottom of an object in a fluid.

Forces due to pressure of Fluid	*FBD*
	

We can derive F_b from the pressure differential at the Top and Bottom of an object in water.

$$F_b = m_f g = \rho_f V g$$

$$F_b = F_{bottom} - F_{top} = P_{bottom} A - P_{top} A$$

$$F_b = (P_o + \rho_f g d_{bottom})A - (P_o + \rho_f g d_{top})A$$

$$F_b = \rho_f g (d_{bottom} - d_{top})A = \rho_f g h_{object} A$$

$$F_b = \rho_f g V$$

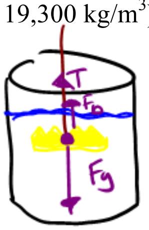
$$\boxed{F_b = m_f g = \rho_f g V}$$

Where:

F_b = Force buoyant (N)
ρ_f = Density of the fluid!!
V = Volume of the displaced fluid
g = gravity

Example:

A crown weighing 8.30 N is suspended underwater from a string. The tension in the string is measured to be 7.81 N. Is the crown pure gold? (Density of gold = 19,300 kg/m^3)



$F_{net} = 0 =$

$F_g = F_b + T$

$F_b = F_g - T = (8.30 - 7.81) = 0.49\text{ N}$

Remember $V_{object} = V_{fluid\ displaced}$!!

$F_b = \rho_w g V_o$

$V_o = \dfrac{F_b}{\rho_w g} = \dfrac{0.49}{(1000)(9.8)} = 5.0\times10^{-5}\text{ m}^3$

$\rho_{crown} = m/v$ and $m = \dfrac{F_g}{g}$

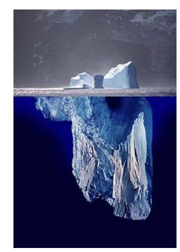
$\rho_{crown} = \dfrac{F_g}{g \cdot V} = \dfrac{(8.30)}{(5.0\times10^{-5})(9.8)}$

$= \boxed{17000\text{ kg/m}^3}$

No...

Example:

An iceberg floating in seawater is extremely dangerous because much of the ice is below the surface. The hidden ice can damage a ship (remember the Titanic?) that is still a considerable distance from the visible ice. What fraction of the iceberg lies below the water level? (ρ_{ice} = 917 kg/m^3)



$F_{net} = 0$

$\therefore F_b = F_g$

$\rho_f \cancel{g} V_f = \rho_o V_o \cancel{g}$

$\rho_f V_f = \rho_o V_o$

$\dfrac{V_f}{V_o} = \dfrac{\rho_o}{\rho_f} = 0.89$

$\therefore$ 89% of the object is below water

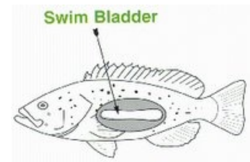
Floating objects that are not fully immersed are at static equilibrium.

$$F_b = F_g$$

$$\rho_f V_f \cancel{g} = \rho_o V_o \cancel{g}$$

$$V_f = V_o \frac{\rho_o}{\rho_f}$$

Swim Bladders



Fish have built-in mechanisms that allow them to move up and down and side to side in their environment.

Most fish rise and sink in the water the same way a hot air balloon rises and sinks in the air.

Most fish have an expandable sac; much like a human lung that allows it to increase or decrease the volume of water it displaces without changing it's mass appreciably.

This allows it to sink or float.

Float or Sink?

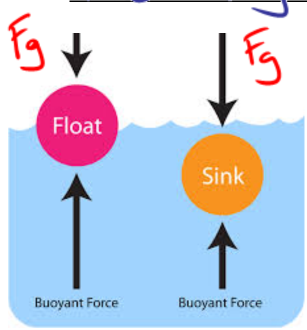
Determine if an object floats or sinks we must compare…. Force Gravity (F_g) with Force Buoyant (F_b).

$$F_g \ vs. \ F_b$$

$$m_{object} g \ vs \ \rho_f V_f g$$

$$\rho_o \cancel{V_o} \cancel{g} \ vs \ \rho_f \cancel{V_f} \cancel{g}$$

$$\boxed{\rho_o \ vs \ \rho_f}$$



If the object is more dense than water it will sink.

If the object is less dense than water it will float.

Example:
A ferryboat is 4.0 m wide and 6.0 m long. When a truck pulls onto it, the boat sinks 4.00 cm in the water. What is the weight of the truck?

$F_{net} = 0$

$F_g = F_b = \rho_f V_f g$

$F_g = (1000\,kg/m^3)(4.0 \times 6.0 \times 0.0400)m^3(9.8\,m/s^2)$

$\boxed{F_g = 9.4 \times 10^3\,N}$

Example:
An empty rubber balloon has a mass of 0.0120 kg. The balloon is filled with helium at 0°C, 1 atm pressure. The filled balloon has a radius of 0.500 m and is perfectly spherical. What is the magnitude of the buoyant force acting on the balloon?

$F_b = \rho_f V_f g = (1.2)(\frac{4}{3}\pi(0.500)^3)(9.8)$

$\boxed{F_b = 6.16\,N \text{ up}}$

What is the magnitude of the net force acting on the balloon?

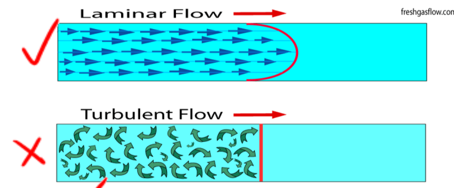
$F_{net} = F_b - F_{g\,ballon} - F_{g\,helium}$

$F_{net} = 6.16N - (0.0120)(9.8) - (0.179)(\frac{4}{3}\pi(0.500)^3)(9.8)$

$\boxed{F_{net} = 5.12\,N}$

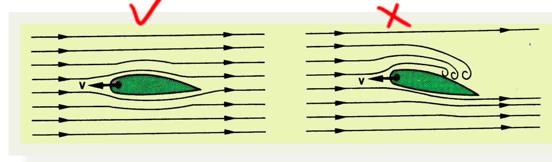
Fluids Notes

3 – Hydrodynamics



So far we have only dealt with fluids at rest (Hydrostatics).

Now we will address fluids in motion (Hydrodynamics)



Before we do so we must made 3 assumptions

- Fluids are incompressible. this assumption applies to gases
- Laminar flow; Fluids flow is steady and therefore it's flow rate is CONSTANT.
- Fluid flow is non-viscous (the higher the viscosity the more resistant to flow Ex: honey, tar, lava)

Flow Rate (*f*): flow rate of fluid that passes a particular point in a given time.

$$f = \frac{V}{t} = \frac{A \cdot d}{t} = Av$$

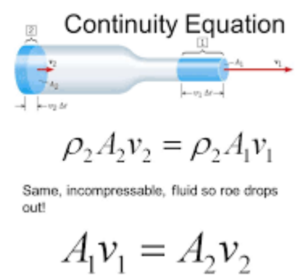
Where: V = volume (L or m^3)
A = cross-sectional area of the pipe (m^2)
v = velocity of the fluid (m/s)

Equation of Continuity: flow rate is constant at ALL points in a closed tube

Since V_1 of a fluid entering one part of a tube or pipe much be matched by an equal V_2 of the same fluid at another part of a tube or pipe.

~~Flows~~ fluids flow faster at the narrower parts of the tube/pipe and narrow at the wider parts of the tube.

This is really just a statement of the **Law of Conservation of MASS…**



Example:
The radius of the aorta is about 1.0 cm and the blood flowing through it has a speed of about 30. cm/s. Calculate the average speed of the blood in the capillaries given the total cross section of all the capillaries is about 2000. cm^2.

$$A_1 v_1 = A_2 v_2$$

$$v_2 = \frac{A_1 v_1}{A_2} = \frac{(30\,cm/s)(\pi(1.0\,cm)^2)}{2000\,cm^2}$$

$$\boxed{v_2 = 0.047\,cm/s}$$

Example:
A garden hose has an inside diameter of 16 mm. The hose can fill a 10. L bucket in 20. s. What is the speed of water out of the end of the hose?

r = 0.008 m

$$A_1 v_1 = A_2 v_2 = \frac{V_2}{t}$$ Volume!

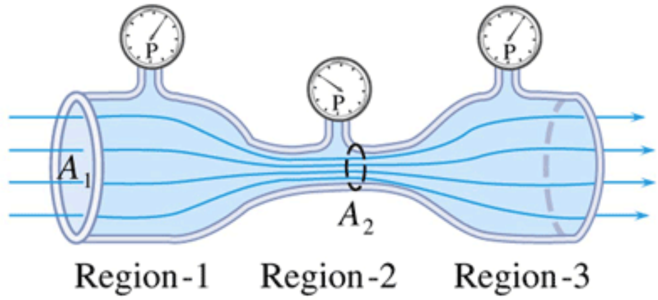
$$v_1 = \frac{V_2}{t A_1} = \frac{0.010\,m^3}{(20\,s)(\pi(0.008\,m)^2)} = \boxed{2.5\,m/s}$$

What diameter nozzle would cause the water to exit with a speed 4 times greater than the speed inside the hose?

$\boxed{8\,mm}$ → half the diameter to increase speed by ×4

Continuity describes a moving fluid but NOT WHY the fluids moves…

Venturi Meter



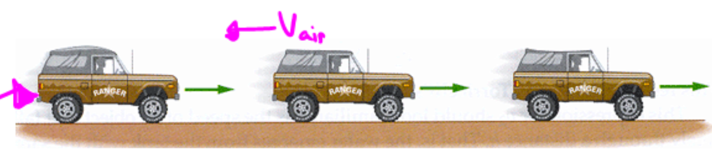
Which area(s) have the highest pressure? Region 1 Region 2 Region 3

Energy due to pressure gets converted into energy due to velocity (Kinetic energy)

The higher the velocity the lower the pressure ... this is stated in Bernoulli's Equation…

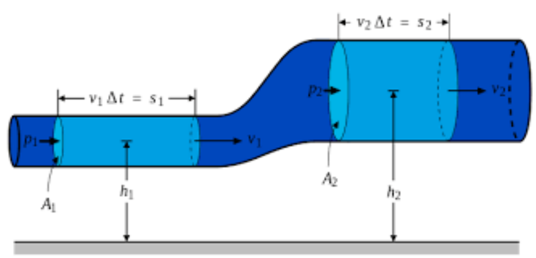
Example:
A small ranger vehicle has a soft, ragtop roof. When the car is at rest the roof is flat. When the car is cruising at highway speeds with its windows rolled up, does the roof

a. bow upward
b. remain flat
c. bow downward?



Bernoulli's Equation… A Statement of the **Law of Conservation of** Energy

Law of Conservation of Energy: Energy can neither be created nor destroyed in a pipe/tube.



Derivation…

$$W_1 + E_{k1} + E_{p1} = W_2 + E_{k2} + E_{p2}$$

$$Fd_1 + \frac{1}{2}mv_1^{\ 2} + mgh_1 = Fd_2 + \frac{1}{2}mv_2^{\ 2} + mgh_2 \ (divide\ all\ by\ V!)$$

$$\frac{Fd_1}{V} + \frac{\frac{1}{2}mv_1^{\ 2}}{V} + \frac{mgh_1}{V} = \frac{Fd_2}{V} + \frac{\frac{1}{2}mv_2^{\ 2}}{V} + \frac{mgh_2}{V}$$

$$\boxed{p_1 + \frac{1}{2}\rho v_1^{\ 2} + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^{\ 2} + \rho g h_2}$$

Bernoulli's Equation

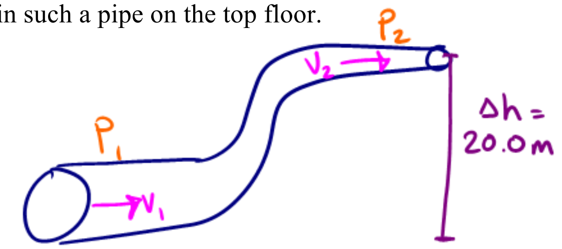
$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

Where:

P = pressure (Pa)
ρ = density of the fluid
v = velocity
g = gravity
h = height above the ground

Example:

Water at a pressure of 385035 Pa at street level flows into an office building at a speed of 0.60 m/s through a pipe 5.0 cm in diameter. The pipes taper down to 2.6 cm in diameter by the top floor, 20.0 m above. Calculate the flow velocity and the pressure in such a pipe on the top floor.



$$A_1 v_1 = A_2 v_2$$

$$V_2 = \frac{A_1 v_1}{A_2} = \frac{\cancel{\pi}(0.025)^2(0.60)}{\cancel{\pi}(0.013)} = \boxed{2.2\ m/s}$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \cancel{\rho g h_1}^{\,0} = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

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

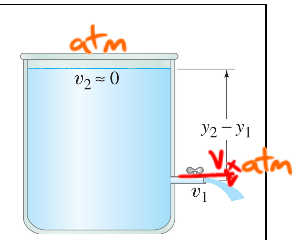
$$P_2 = 385035 + 0.5(1000)(0.60)^2 - 0.5(1000)(2.2)^2 - (1000)(9.8)(20)$$

$$\underline{P_2 = 186795\ Pa}$$

$$\boxed{P_2 = 1.9 \times 10^5\ Pa}$$

Example:

A very large storage tank, open to the atmosphere at the top and filled with water, develops a very small hole in its side at a point 9.2 m below the water level. If this hole is 2.0 m above the ground, how far (measured horizontally) from the base of the tank does the water strike the ground?



$$\underbrace{\cancel{P_1}^{\,0} + \frac{1}{2}\rho v_1^2 + \rho g h_1 = \cancel{P_2}}_{\text{both at 1 atm}} + \frac{1}{2}\cancel{\rho v_2^2}^{\,0} + \rho g h_2$$

$$\frac{1}{2}\cancel{\rho} v_1^2 + \cancel{\rho} g h_1 = \cancel{\rho} g h_2$$

$$\frac{1}{2} v_1^2 = g h_2 - g h_1$$

$$V = \sqrt{2g(h_2 - h_1)}$$ ⟶ Torricelli's Theorem

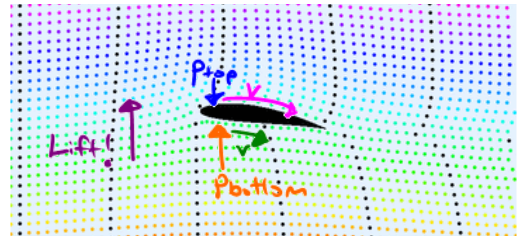
$$V = \sqrt{2(9.8)(9.2)} = 13.4\ m/s \rightarrow V_x$$

$$d_y = \cancel{V_{y0} t}^{\,0} + \frac{1}{2} a t^2$$

$$t = \sqrt{\frac{2 d_y}{a}} = \sqrt{\frac{2(-2.0)}{-9.8}} = 0.639 s$$

$$d_x = V_x \cdot t = (13.4\ m/s) \cdot (0.639 s) = \boxed{8.56 m}$$

Application: Airplanes generate lift!



Bernoulli discovered that a faster moving fluid has exerts less pressure than a slower moving fluid.

The air (fluid) moving of the top of the wing encounters an obstacle that it must go around and therefore its speed increases and its pressure drops. The difference in pressure between the bottom and top of the wing results in more pressure at the bottom, thus pushing the wing upwards into the sky. This is lift!!!.

Example:

What is the lift (in Newtons) due to Bernoulli's Principle on a wing of area 80.0 m^2 if the air passes over the top and bottom surfaces at speeds of 340. m/s and 290. m/s, respectively?

Find Δp!

top bottom difference in h ~ 0m

$$p_1 + \frac{1}{2}\rho v_1^2 + \cancel{\rho g h_1} = p_2 + \frac{1}{2}\rho v_2^2 + \cancel{\rho g h_2}$$

$$\frac{1}{2}\rho(v_1^2 - v_2^2) = p_2 - p_1 = \Delta p$$

$$\Delta p = 0.5(1.2)(340^2 - 290^2) = 189{,}000 \text{ Pa}$$

$$F = \Delta p \cdot A = (189{,}000)(80.0) = \boxed{1.51\times10^6 \text{ N of lift! [up]}}$$