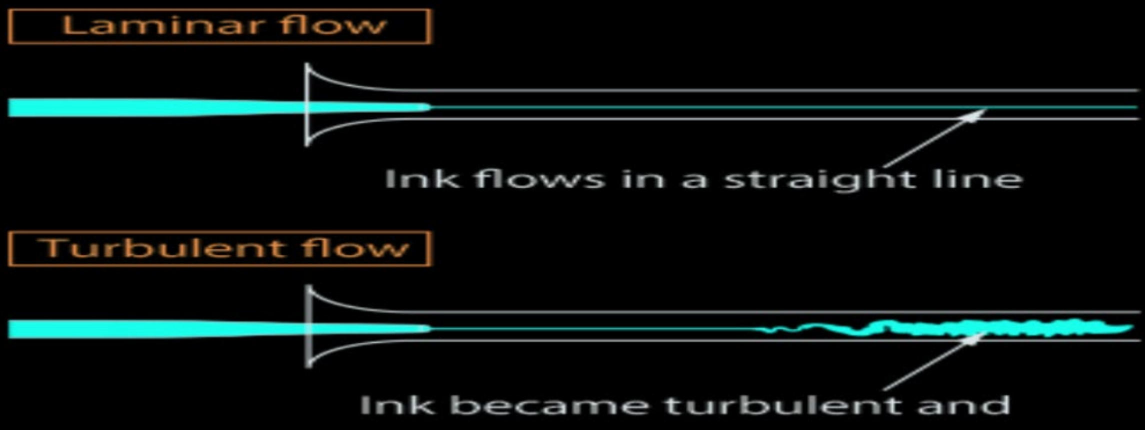
A fluid's motion has two types

- **Laminar flow**
- **Turbulent flow**

We can know the difference between these using
**the Reynold's experiment**

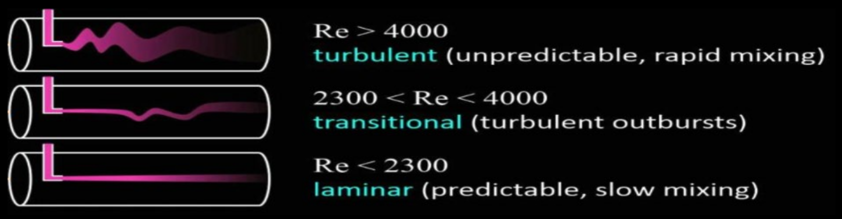



The path of the fluid is called a **streamline**

In laminar, the streamline is straight
In turbulent, it is unpredictable

We can know the flow's characteristics can be determined using
**Reynold's number (Re)**

$$\mathrm{Re} = \frac{\rho v_{gvg} D}{\mu}$$




**Laminar flow:**
It consist of smooth highly ordered streamlines, their velocity is constant at any point of the fluid
**Turbulent flow:**
Velocity fluctuations distort the paths and they lead to tiny whirlpool regions called **EDDY CURRENTS**

The law of conservation of mass & energy can be described using the model of an **ideal fluid**

- Is non viscous (meaning there is no Internal friction)
- Is incompressible (density is constant)
- Motion is steady, irrotational, and one dimensional

**Volume flow rate ($R_v$)**

Here is this pipe with fluid moving across, to get the volume here, you have to get the

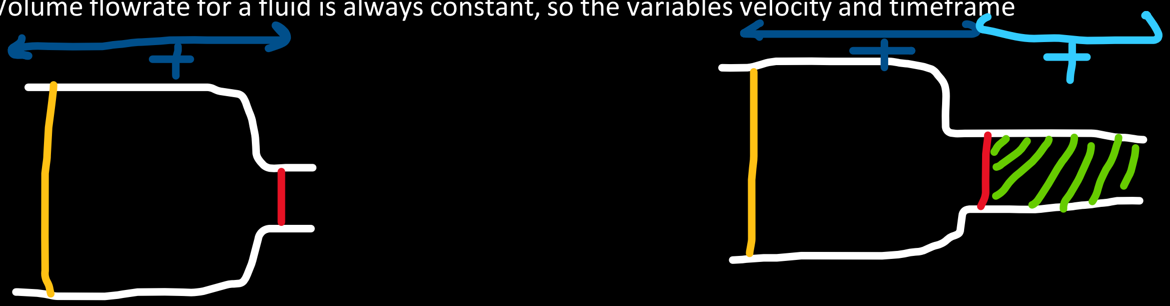
- Area
- Length -> because we are moving, it is calculated by multiplying **velocity & time**

$$R_v = \frac{V}{\Delta t}$$

- V -> VELOCITY OF FLUID
- Δt -> change in time

The SI unit of it is liters/sec or $m^3/s$

Volume flowrate for a fluid is always constant, so the variables velocity and timeframe

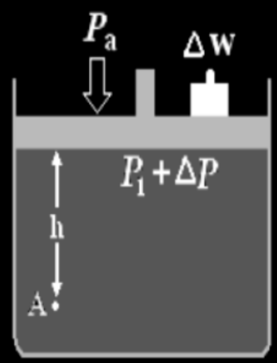


Re = Re
A > A
V < V

## Pascal's principle

When pressure is applied to an **incompressible** liquid enclosed in a container, it is transmitted to all parts of the liquid as well as the walls of the container

imagine a container of liquid with a piston on top




- **Pressure immediately underneath the piston**
  - $P_{surface} = P_{atm}$ + Pressure due to the weight of the piston
- Pressure at point **A** at depth **h** inside the liquid
  - $P_A = P_{surface} + \rho gh$
- Pressure at point **A** at depth **h** inside the liquid
  - $P_A = P_{surface} + \rho gh$

## Hydraulic press & lift (applications of pascal principle)

It is a mechanism that helps lift heavy stuff, when the pressure is equal at the two sides

when the smaller press gets a force applied to it, the bigger press will face a higher force in the opposite direction of the smaller force

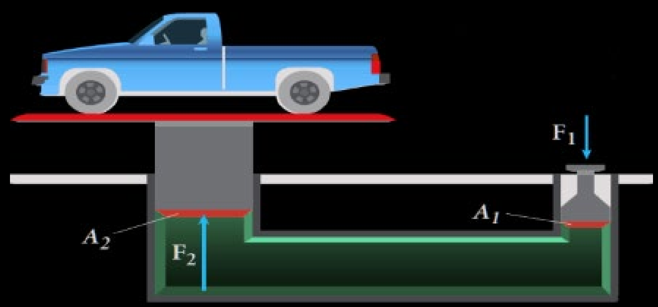
Let's imagine the large hole as $P = F_{big} / A_{big}$

And the small hole as $P = F_{small} / A_{small}$

And because the pressure is equal

$$\frac{F_S}{A_S} = \frac{F_b}{A_b}$$

If a small force is applied on the small piston, larger force is generated from the large piston




## Mechanical advantage of hydraulic lift

❖ **According to the law of conservation of energy:**

The work done on the small piston = the work gained from the large piston.

$$(\textbf{Work})_{in} = (\textbf{Work})_{out}$$

$$f\, y_1 = F\, y_2$$

As: $y_1$ is the distance moved by small piston.

$y_2$ is the distance moved by large piston.

$$\boxed{\therefore \eta = \frac{F}{f} = \frac{A}{a} = \frac{R^2}{r^2} = \frac{y_1}{y_2}}$$

**Mass Flow Rate ($R_m$)**
$R_m = pVA$

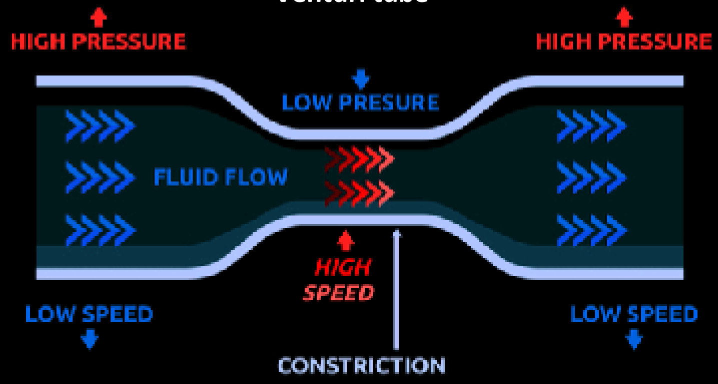
Where
- P = density of fluid
- V = velocity of liquid
- A = area of cross section

Its SI units are Kg/s

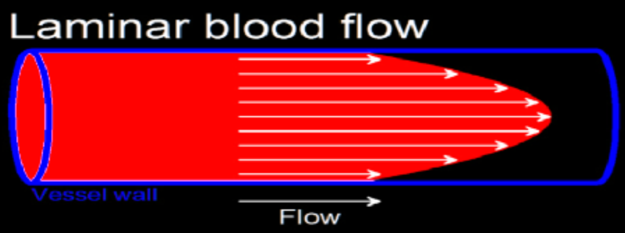
The relation between mass and volume flow rates
$\mathbf{R_m = p\,R_V}$

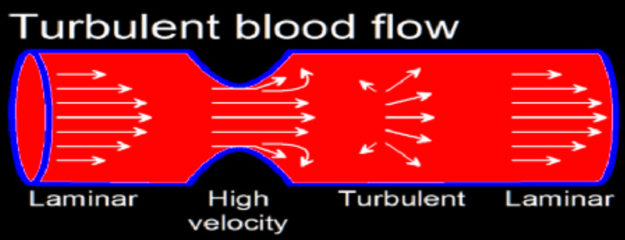
**Continuity Equation**
It states that the mass flowrate is constant at any cross section of the pipe, basically the same we said for the volume flowrate

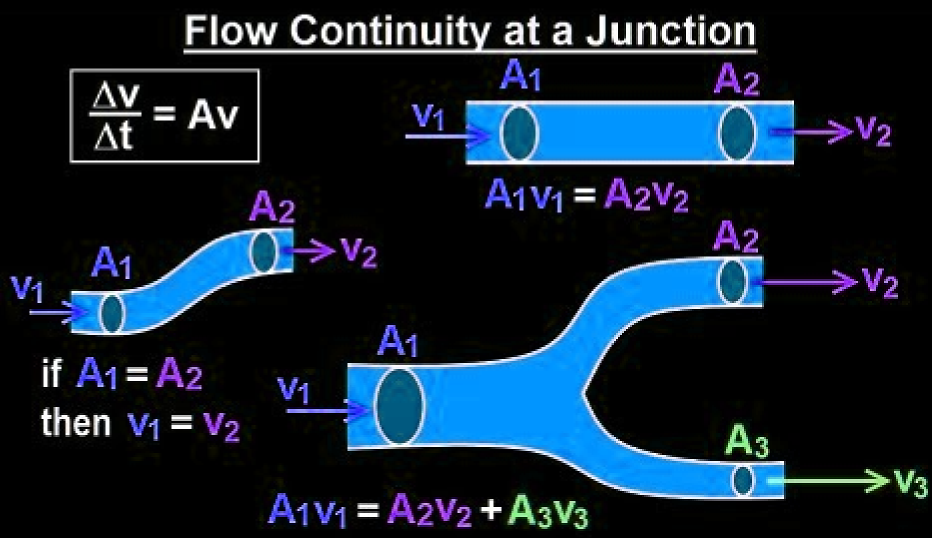
**Venturi tube**




**Some phenomena on continuity equation**



## Bernoulli's principle

It says that if the **velocity** of a fluid particle **increases** as it travels along a horizontal streamline, the **pressure decreases**, and vice versa

**The law of conservation of energy in a system states that**

Total mechanical energy = potential energy + kinetic energy

**Work** is the energy required to move something against a force
**Fluid kinetic energy** an expression of the fact that a moving object can do **work** on anything it hits
**pressure** in fluids can be seen as a **measure of energy per unit volume** or **energy density**

**The (d)** here is the displacement

$$P = \frac{Force}{Area} = \frac{F}{A} = \frac{F \cdot d}{A \cdot d} = \frac{W}{V} = \frac{Energy}{Volume}$$

**pressure volume work**

Defining work by constant pressure as (work = pressure times volume)

$$w = -\rho \Delta \mathbf{v}$$

Where

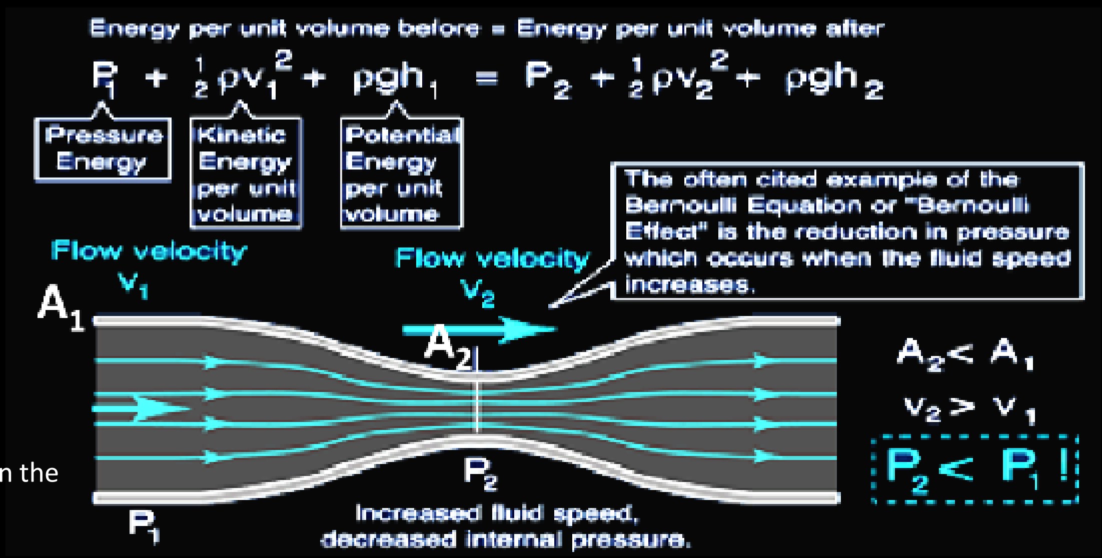
- p -> density
- ΔV -> change in volume (old vol – new vol)
- The negative sign is needed so that a COMPRESSION (decrease in volume) corresponds to work being done TO the system increase in pressure).

Unit:

1 joule (J) = 1 liter . Atm

By applying the principle of conservation of energy to the fluid we shall show that these quantities are related by

**Bernoulli's equation**




**Work-kinetic energy theorem**

states that the work done by the net force on a body is equal to the change in kinetic energy

$W_{net} = \Delta K_E$

$W_{net} = \frac{1}{2} M\left(v_f^2 - v_i^2\right)$

We can replace mass with density (p) and change in volume (ΔV)
NOTE : we choose change in volume instead of volume because the fluid changes volumes when it enters at the input and leaves on the output in a small time interval of Δt

$W_{net} = \frac{1}{2}\rho \Delta V\left(v_f^2 - v_i^2\right)$

There is something called gravitional work, here it is

$W_{net} = -\rho g \Delta V\left(y_f - y_i\right)$

$$W = W_g + W_p = \Delta K.$$

$$-\rho g \cancel{\Delta V}(y_2 - y_1) - \cancel{\Delta V}(p_2 - p_1) = \tfrac{1}{2}\rho \cancel{\Delta V}(v_2^2 - v_1^2).$$

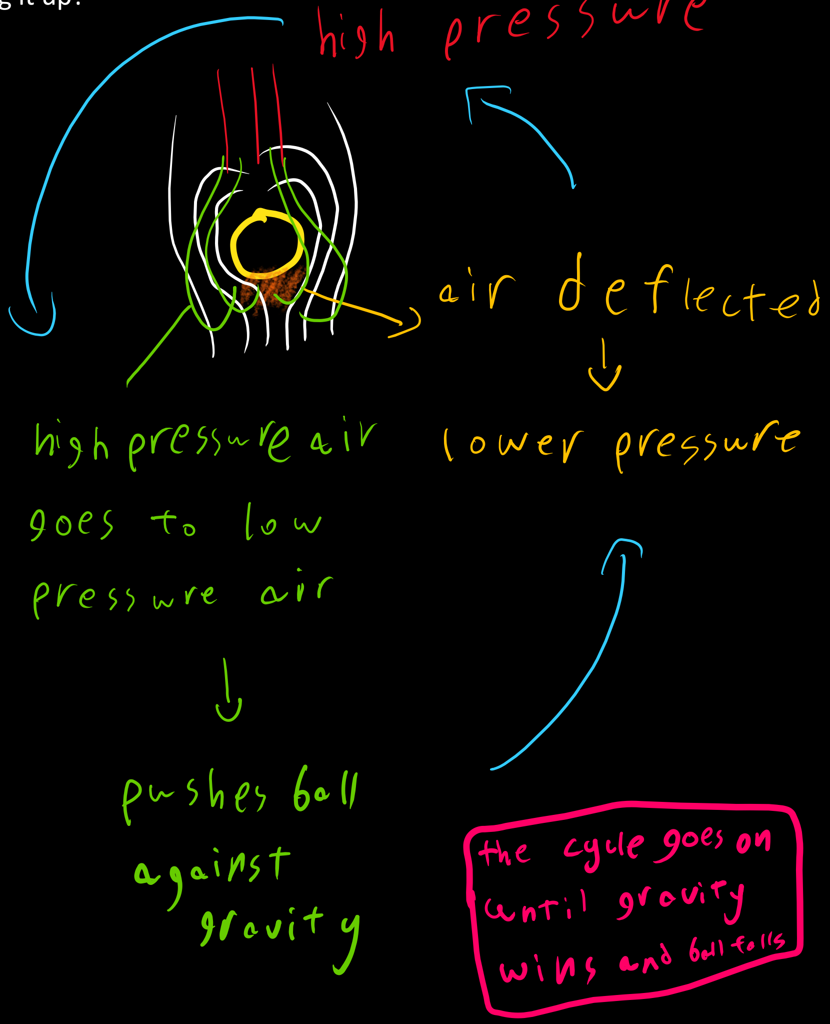
$$p_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2.$$

$$p + \tfrac{1}{2}\rho v^2 + \rho g y = \text{a constant} \quad \text{(Bernoulli's equation).}$$

- **A major prediction of Bernoulli's equation emerges if we take y to be a constant (y = 0) so that the fluid does not change elevation as it flows.**

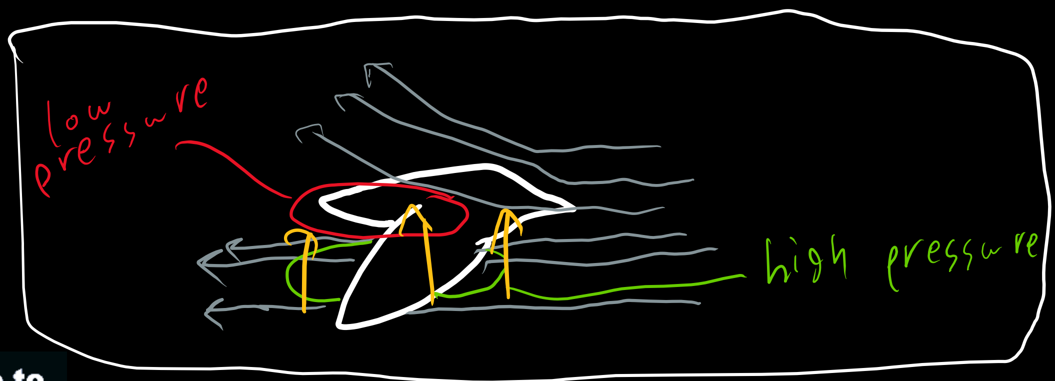
$$p_1 + \tfrac{1}{2}\rho v_1^2 = p_2 + \tfrac{1}{2}\rho v_2^2,$$

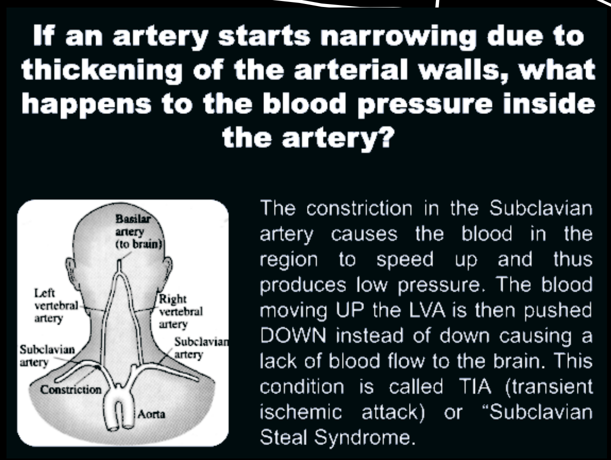
Imagine a tennis ball with an air blower below it, you would see that the ball seems standing
but why, is it because of the air blower pushing it up?
Well, NO!

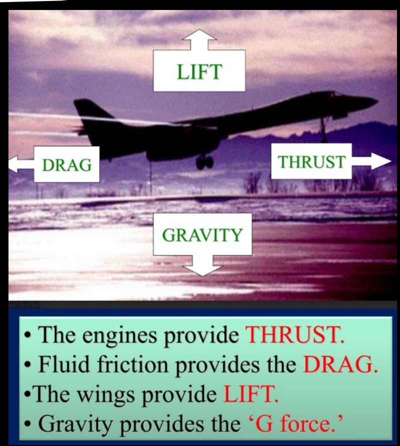



This fluid curve like effect is called **coanda effect**
The air pressure below the ball is equal to the **G force "down force"**

**HOW AERODYNAMIC SHAPES WORK (WINGS)**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