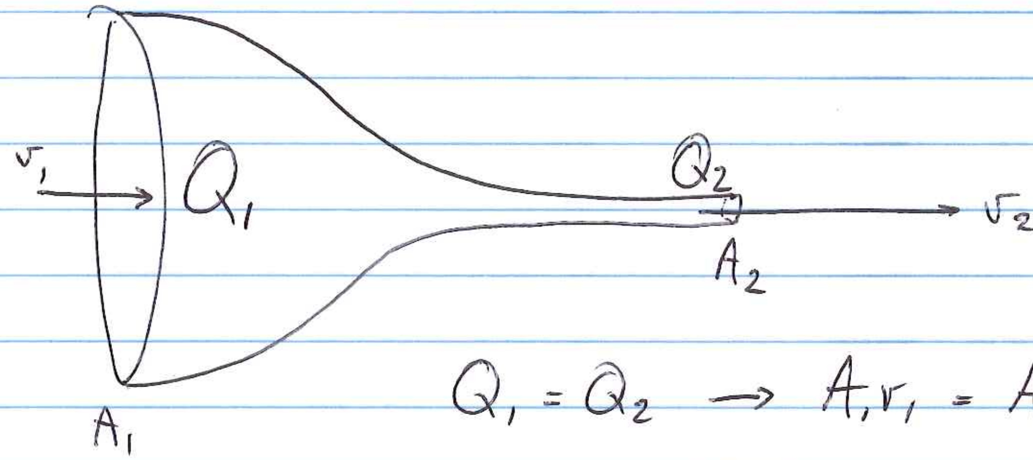
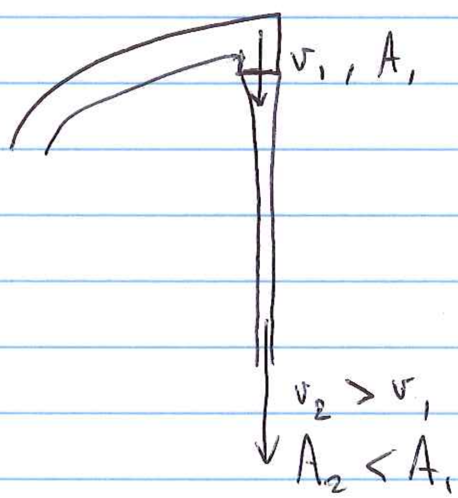
* Continuity equation



$$Q_1 = Q_2 \longrightarrow A_1 v_1 = A_2 v_2$$

* Faucet



$$Q_1 = v_1 A_1$$

$$Q_2 = v_2 A_2$$

* Artery with blockage

$$A_1 = \pi r_1^2 \quad A_2 = \pi r_2^2 = \frac{1}{4}\pi r_1^2 = \frac{1}{4} A_1$$

$$r_2 = \frac{1}{2} r_1$$

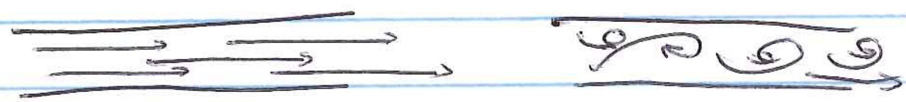
$$Q_1 = A_1 v_1 = A_2 v_2 = Q_2$$

$$v_2 = \frac{A_1}{A_2} v_1 = 4 v_1$$

* Doppler echocardiography

* How does pressure influence velocity?
  ———— velocity ———— pressure?

Assumptions: - incompressible fluids = liquids (ρ is constant)
- low viscosity
- flow is in the laminar regime
  → velocity is slow, no turbulence



Bernouilli's equation:

$$\boxed{P + \rho g h + \frac{1}{2}\rho v^2 = \text{constant}}$$

2 points: 1 and 2

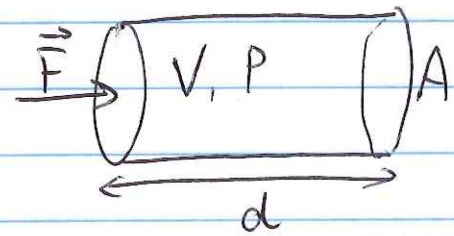
$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

Conservation of energy. multiply by volume

$$PV + \underbrace{\rho V}_{m} g h + \frac{1}{2}\underbrace{\rho V}_{m} v^2 = \text{constant}$$

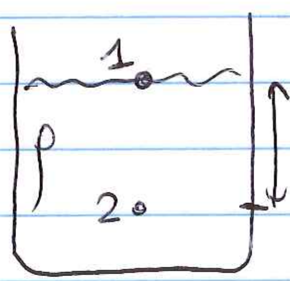
$$OE + \underbrace{mgh}_{PE} + \underbrace{\frac{1}{2}mv^2}_{KE} = \text{constant}$$

$$PV = \frac{F}{A} Ad = Fd = \text{work}$$



$$\boxed{P + \rho g h + \frac{1}{2}\rho v^2 = \text{constant}}$$

* special case : $v_1 = v_2 = 0$



$h_1, v_1 = 0, P_1 = 1\text{ atm}$

$\Delta h = h_1 - h_2$

$h_2, v_2 = 0, P_2$?

$$P_1 + \rho g h_1 = P_2 + \rho g h_2$$

$$P_2 = P_1 + \rho g (h_1 - h_2) = P_1 + \rho g \Delta h$$

* faucet : $P_1 = 1\text{ atm}$, $P_2 = 1\text{ atm}$

$P_1 = 1\text{ atm}, v_1, h_1$

Δh

$P_2 = 1\text{atm}, v_2 > v_1, h_2$

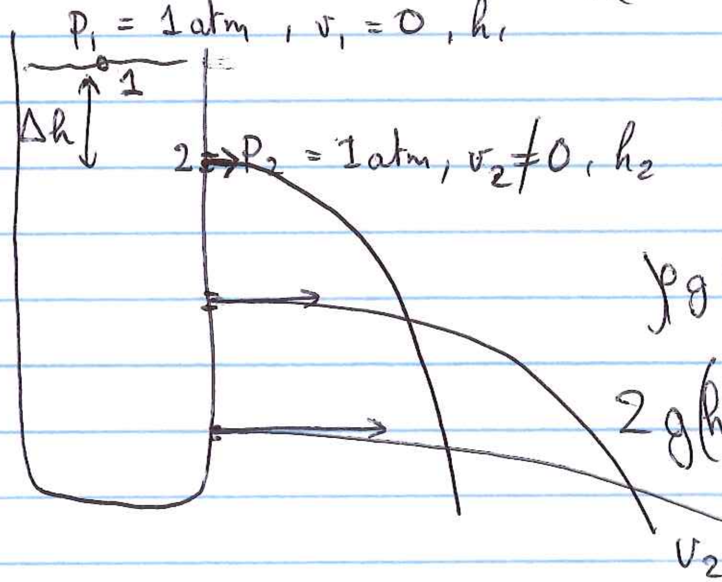
$$P + \rho g h + \frac{1}{2}\rho v^2 = \text{constant}$$

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

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

$$2 g h_1 + v_1^2 = 2 g h_2 + v_2^2$$

$$v_2^2 = v_1^2 + 2g(h_1 - h_2) = v_1^2 + 2g\,\Delta h$$



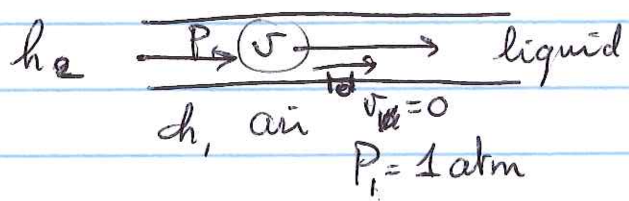
$$\cancel{P_1} + \rho g h_1 + \cancel{\frac{1}{2}\rho v_1^2} = \cancel{P_2} + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

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

$$2g(h_1 - h_2) = v_2^2$$

$$v_2 = \sqrt{2g\,\Delta h}$$

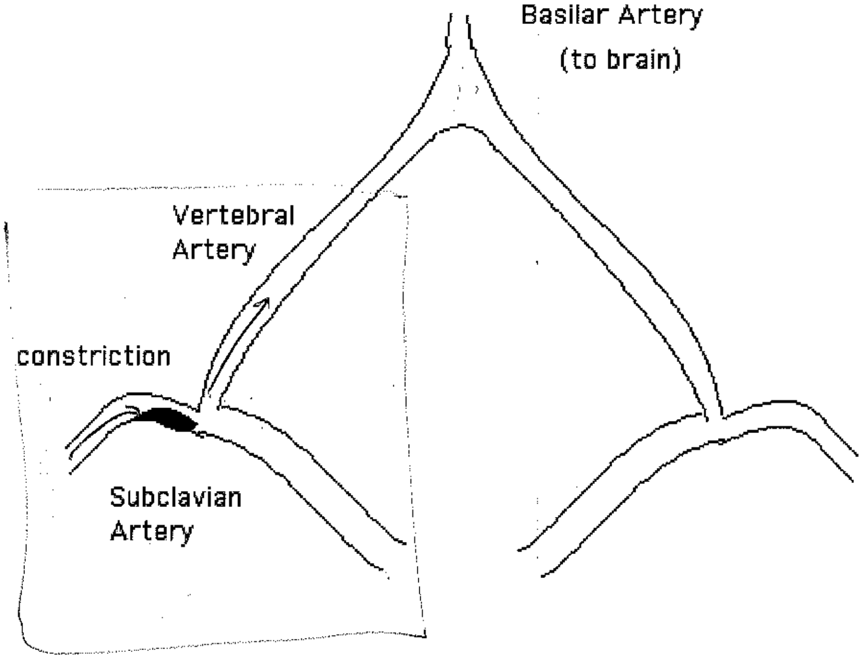
* Venturi effect : pressure will decrease when velocity increases



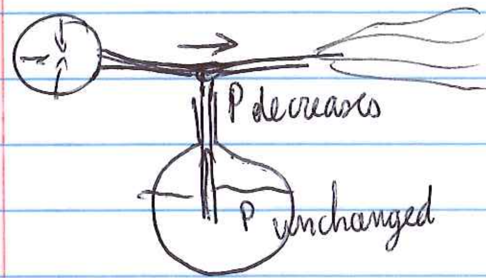
$$\underbrace{P_1 + \cancel{\frac{1}{2}\rho v_1^2}}_{\text{air at hole}} = \underbrace{P_2 + \frac{1}{2}\rho v_2^2}_{\text{inside the pipe}} \qquad v_1 = 0$$

$$1\,\text{atm} = P_{atm} = P_2 + \frac{1}{2}\rho v_2^2$$

$$P_2 = \underline{P_{atm}} - \frac{1}{2}\rho v^2$$



Basilar Artery
(to brain)
Vertebral
Artery
constriction
Subclavian
Artery

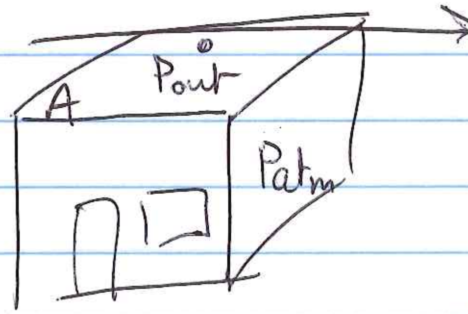


* Transient ischemic attack

obstruction in subclavian artery → increase velocity

→ pressure decreases

* Hurricanes



v_{wind} large

$$P_{out} = P_{atm} - \frac{1}{2}\rho v_{wind}^2$$

$$\begin{aligned} F_{lift} &= F_{out} - F_{atm} \\ &= P_{out}A - P_{atm}A \\ &= (P_{out} - P_{atm})A \\ &= \frac{1}{2}\rho v_{wind}^2 A \end{aligned}$$

$v_{wind} = 30\,m/s$

$(100\,km/h)$

$A = 15m \times 15m$

$$F_{lift} = \frac{1}{2}(1.29\,kg/m^3)(30\,m/s)^2(15\,m)^2$$

$$F_{lift} = 1.3 \times 10^5\,N$$