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Fluid Systems

Concepts

- Flow (q):
  - can be characterized via type:
    - flow of mass: q_m
    - flow of volume: q_v
- conservation of mass $\approx$ conservation of volume $\implies q_m = \rho q_v \implies \dot{m} = \dot{V}$
- $P_{gage} = P_{abs} - P_{atm}$
- Using the conservation laws,

$$\underbrace{\dot{m} = q_{mi} - q_{mo}}_{\substack{\rho\dot{V} = \rho q_{vi} - \rho q_{vo} \\ \downarrow \\ \dot{V} = q_{vi} - q_{vo}}} \implies \dot{m} = \frac{dm}{dt} = \frac{d}{dt}(\rho V) = \frac{d}{dt}(\rho A h) \ = ...$$

$$... \ = \ \rho A \, \frac{dh}{dt} = q_{mi}(t) - q_{mo}(t)$$

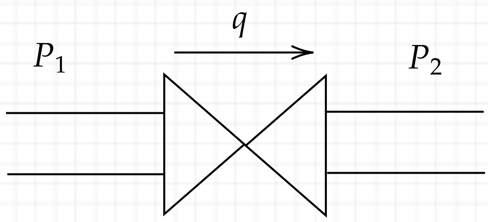
$$solving \ for \ h(t),$$

$$h(t) = h(0) + \frac{1}{\rho A} \cdot \int_0^t [q_{mi}(u) - q_{mo}(u)] \cdot du$$

- The pressure of points at the same level h are the same because pressure is a function of h.

Fluid Resistance

- When a fluid passes through a channel (eg. pipe), component (eg. valve), opening/orfice (eg. hole).



$$\therefore R = \frac{P_1 - P_2}{q} \Longrightarrow Rq = P_1 - P_2$$

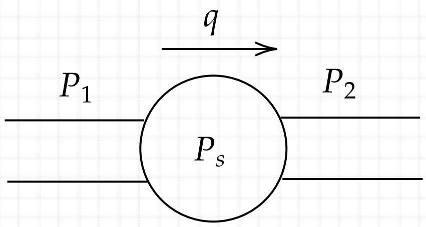
$$In\ Series\ \rightarrow R = \sum_{i}^{n} R_i\ ,\ n = 1, 2, 3,\ ...$$

$$In\ Parallel\ \rightarrow \frac{1}{R} = \sum_{i}^{n} \frac{1}{R_i}\ ,\ n = 1, 2, 3,\ ...$$

- In general, $P_1 > P_2$ when passing through a channel/component/opening/orfice

<u>Pump Models</u>

- A Pump increases pressued, called a 'pressure source'.



- In general, $P_2 > P_1$ when passing through a pump

The Equation of Motion (EOM) for the overall fluid system is in the following form:

$$m = \rho A\dot{h} = q_{in} - q_{out}$$