**Exam I next Tuesday. Study guide up later today.**

- SSSF condition: steady state, steady flow.
  - Will look at this first.
  - \( \frac{dU}{dt} = 0 \)
  - \( \dot{m} = 0 \)
  - \( h_1 = h_2 = \dot{m} \)

- 1st law:
  - \( Q - W = m \left[ u_1 v_1 + \frac{1}{2} (V_1^2 - U_1^2) + g(z_2 - z_1) \right] \)

- Work from \( W \):
  - No "P'dV" contribution: Volume of CV is constant.
  - Two contributions to work:
    - Work associated with pushing the fluid through the CV.
    - Work associated with pushing the fluid through the CV.

- Working out problems w/ SSSF 1st law (or inlet, outlet)
  - Need to determine:
    - Is there heat transfer (adiabatic: \( Q = 0 \))
    - Is there work: \( W_{\text{CV}} \) will only appear for CVs that produce or consume work.
      - Turbine: produces work by dropping P.
      - Compressor: consumes work to increase P.
      - Pump: some things
        - Compressor: \( g_v \) (compressible)/static
        - Pump: \( g_v \) (incompressible)

- Volumetric flow rate:
  - \( V = \frac{m^3}{s} \)
  - \( A = \frac{1}{4} \pi D^2 \)
  - \( m^3/s = \frac{m}{s} \cdot m^2 \)

- \( \dot{m} = \rho A \dot{V} = \rho V \)
  - \( \frac{m}{s} = \frac{kg}{s} \)

- A stream in western North Carolina takes a 20-m³/s flow of water from the Nantahala river and ditches it into a trough through a 2 m-diameter pipe. The elevation drops from the inlet to the exit is 300 m.

- Calculates the mass averaged velocity through the pipe, and estimates the power output of the turbine, assuming negligible changes in KE and temperature of the flow.

- \( V = \frac{V}{A} = 10.5 \) m/s

- 1st law:
  - \( Q - W = \dot{m} \left( h_2 - h_1 + \frac{1}{2} (V_2^2 - U_1^2) + g(z_2 - z_1) \right) \)

- \( M = 30 \cdot 3.10^3 \text{ kg} / s \)

- \( h = \text{New value for liquid} \)
  - \( T = T_i \)

- \( V = \frac{V}{A} = 10.5 \text{ m/s} \)

- \( \text{cm typically neglect KE when velocity is less than } \approx 50 \text{ %} \)

- \( \frac{1}{2} V^2 \Rightarrow V = 30 \frac{m}{s} \)

- \( \frac{1}{2} V^2 = \frac{1}{2} (30 m/s)^2 = 450 \text{ m}^2 / s = 450 \text{ J} / kg \)

- \( 0.45 \text{ kg} / s \)

- \( W = \dot{m} \cdot g (z_2 - z_1) = \rho V g (z_2 - z_1) \)

- For hydrodynamic head: \( h_2 - h_1 = \text{Ideal output head} < \text{den.} \)

- Make sure only are correct.
  - \( Q' U'' = \frac{k_s}{m^3 / s} \cdot m / s = M = W = \frac{J}{s} \)

- 2. Air enters an adiabatic compressor at 300 K and 1 atm pressure, with a volumetric flow rate of 10 L/s. It exits at 600 K and 10 atm pressure. Calculate the power input to the compressor. State all assumptions.

- \( W = M (h_2 - h_1) \)
  - \( \text{Assume } Cp \text{ constant so } h_2 - h_1 \approx (Cp / M) (T_2 - T) \)
  - \( \dot{m} = \rho V = \rho_1 V_1 \)
  - \( V_1 = 10 \frac{L}{s} = 10 \cdot 10^{-3} \text{ m}^3 / s \)
  - \( \rho_1 = \frac{P_1}{RT_1} = \frac{1}{U_1} \)
5. A mass flow of 5 kg/s of saturated liquid water at 2 MPa enters a 5 cm diameter boiler pipe. The water exits at 3 MPa pressure. The rate of heat transfer to the water is 7500 kW.

(a) Neglecting KE at the exit, calculate the exit temperature and exit specific volume.

(b) Use the result in (a), along with the given mass flow and pipe diameter, calculate the exit velocity. Should KE be included at the exit?

(c) Using your result from (b) as an estimate of the exit velocity, recalculates the exit temperature.

\[ Q = \text{const} = \rho A \cdot \dot{V} = A = \text{const} \]

\[ \rho_1 \frac{V_1}{A} = \rho_2 \frac{V_2}{A} \]

\[ \frac{V_1}{A} = \frac{V_2}{A} \]

\[ Q = 7780 \text{ kW} \]

\[ a \text{ in } h_2 \text{ exit velocity} \]

\[ h_2 = h_1 + \frac{Q}{m} \]

\[ P_2 \text{ at } h_2 \text{ Ax shk 2} \rightarrow \text{exit } V_2 = \frac{1}{P_2} \]

\[ V_2 = \frac{m}{P_2 A} \]