Typical Control Mass Problem Chart 2
(Not complete material coverage)

State \( \mathbf{1} \)

- Normally 3 variables are needed to fully determine it.

- 2 known intensive variables
  
  (May get away with \( T \) only in some approximations, eg, when using saturated values as an approximation for compressed liquids.)

- Tables, eg B.1.1-B.1.4:
  - \( pv \) or \( Tv \) diagrams;
  - \( v = v_f + x (v_g - v_f) \)
  - and similar for \( u, h, \) and \( s \).

- Ideal gas (applicable?)
  - \( pv = RT \) (4 forms)
  - Tables A5-A8 for \( u, h, s \).

- Make do with the formulae for differences in intensive variables listed below under “Process”?

- Remaining intensive variables \( p, T, v, (x), u, h, s \).

- Amount of material:
  - \( v = V/m \)
  - \( u = U/m \)
  - \( h = H/m \)
  - \( s = S/m \)

Process

\textbf{C1:} Type of process \( (V = C, \ p = C, \ p \ \text{linear in} \ V, \ p V^n = C, \ T = C, \ 1 Q_2 = 0, \ \text{reversible}) \)

\textbf{C2:} Mass:
\[ m_1 ( + m_{\text{added}} ) = m_2 \]

Energy:
\[ E_2 - E_1 = 1 Q_2 - 1 W_2 \quad (E = U + KE? + PE?) \]

\textbf{C3:} \[ 1 W_2 = 0 \]
\[ 1 Q_2 = |0 \ \text{and} \ S_2 = S_1] \]
\[ T(S_2 - S_1) \]
\[ 1 S_2.\text{gen} = \Delta S_{\text{net}} = S_2 - S_1 - \frac{1 Q_2}{T_{\text{surr}}} \]

For ideal gases:
\[ u_2 - u_1 = \int_1^2 C_v \ dT \approx C_{v,\text{ave}} (T_2 - T_1) \quad h_2 - h_1 = \int_1^2 C_p \ dT \approx C_{p,\text{ave}} (T_2 - T_1) \]
\[ s_2 - s_1 = s^0_f(T_2) - s^0_f(T_1) - R \ln \left( \frac{p_2}{p_1} \right) \approx C_{p,\text{ave}} \ln \left( \frac{T_2}{T_1} \right) - R \ln \left( \frac{p_2}{p_1} \right) = \ldots \]

Polytropic:
\[ \frac{p_2}{p_1} = \left( \frac{v_1}{v_2} \right)^n = \left( \frac{T_2}{T_1} \right)^{n-1} \]

- Isentropic and \( k \) constant:
  - \( n = 1 \)
  - \( n = k \) ?

For solids and compressed liquids, \textit{by approximation}, best at constant pressure:
\[ 1 Q_2 = m \int_1^2 C_{(p)} \ dT \approx m C_{(p),\text{ave}} (T_2 - T_1) \quad s_2 - s_1 \approx C_{(p),\text{ave}} \ln \left( \frac{T_2}{T_1} \right) \]

State \( \mathbf{2} \)

- Same procedures as state \( \mathbf{1} \)