Exam II: week from Thursday
- review sheet posted early next week.
- will cover through HW 9
- Entropy: applications to closed & open systems.
- Entropy: a property of substances.
- tables: H₂O, R₁₃₄₅
- or in codes
- Ideal gases: use either tables or simple formulas.

Want to find $W_{rev}$ for process.
- can approach problem 2 ways
  1. Mechanical/heat engine approach:
     reversible HE: $\eta_{rev} = 1 - \frac{T_i}{T_H}$
     apply on a differential basis: $dW_{rev} = \eta_{rev} dQ_H$
     or $W_{rev} = \int dW_{rev} = \int (1 - \frac{T_i}{T_H}) dQ_H$
  2. Entropic approach: want to consider a hypothetical reversible process.

Consider this: process goes from 1 $\rightarrow$ 2
Net change in entropy
  = entropy change of system
  + entropy change of environment.

= $m(s_2 - s_1) - \frac{Q_{1-2}}{T_o} = S_{gen}$; $S_{gen}$ of process.

2nd law: $S_{gen} \geq 0$

$Q_{1-2}$: heat transfer to/from system during process.
$Q_{1-2}$ negative: heat flows from system to environment.
$Q_{1-2}$ negative $Q_{1-2}$ implies environment entropy increases.

$W_{rev}$ is work from environment.

$$\text{system} \rightarrow Q \rightarrow \text{environment} \rightarrow T_o$$

Diagram:
- System
- $Q_{1-2}$
- Environment
- $T_o$ (thermal reservoir)
- 1st law: $Q_{1-2} - W_{rev} = m(u_2 - u_1)$

How much work could have been derived?
- $W_{rev}$ is from environment.
- $Q_{1-2}$ goes to environment.

Need to relate $dQ_H$ to $T_H$

Coffee cup: $Q_H = M \cdot C \cdot \Delta T$

$Q_H = M \cdot dT_H$

$\rightarrow$ mechanical approach is difficult to apply.

Entropic approach: want to consider a hypothetical reversible process.

$S_{gen} \geq 0$
process is reversible
1st law: \( Q - W_{nw} = M(u_2 - u_1) \)
2nd law: \( S_{eq} = S = M (s_2 - s_1) - \frac{Q}{T_0} = 0 \)
\( \Rightarrow 0 \times 2^{nd} \text{ law} : Q = M T_0 (s_2 - s_1) \)
\( \Rightarrow 0 \times 1^{st} \text{ law} : W_{nw} = M [(u_1 - T_0 s_1) - (u_2 - T_0 s_2)] \)

\[ \text{Willard Gibbs: American physicist: late 19th century} \]
1st law on a differential basis:
\( dq - dw = du \)
\( dq - dw = du \)
\( \Rightarrow \) say we have a reversible process:
\( du = P \, dq \) and \( dq = T \, ds \)
\( \Rightarrow \)

\[ \frac{ds}{dt} = \frac{du}{T} - \frac{P \, dp}{T} \]
\( ds = C_p \, \frac{dT}{T} - R \, \frac{dp}{p} \)
integrate:
\( S_2 - S_1 = \left( C_p \frac{dT}{T} - R \frac{p_2}{p_1} \right) \)
\( = S^0(T_2) - S^0(T_1) - R \ln \frac{p_2}{p_1} \)

\[ \text{ideal gases: 'Gibbs' equation} \]

\[ TdS - PdV = du \] Gibbs Eq #1
\( \Rightarrow \) apply to any process (reversible or not):
\( dh = du + P \, dV - V \, dp \)
\( TdS + V \, dp = dh \) Gibbs #2
apply to IG: \( P_0 = RT \)
\( dh = C_p dT \)

\( \Delta S \) depends on \( T_2, T_1, \) and \( \frac{P_2}{P_1} \)
\( \text{constant } C_p \approx \text{ const.} \)
\( \int_{T_1}^{T_2} C_p \, \frac{dT}{T} = C_p \int_{T_1}^{T_2} \frac{T}{T} = C_p \ln \frac{T_2}{T_1} \)
and
\( S_2 - S_1 = C_p \ln \frac{T_2}{T_1} - R \ln \frac{p_2}{p_1} \)