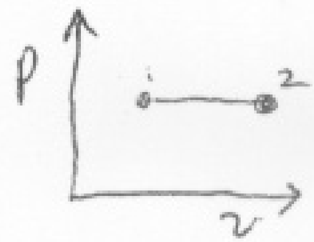
MAE223 Problem Set #7 4-7-99

3.30 Refigerant R-134a $p_1 = p_2$, $T_1 = -18.8°C$, $T_2 = 20°C$

Sat. vapor @ 1



assume process is reversible and adiabatic

$w = \int p\,dv = p\Delta v$ $v_1 = 0.1395\ m^3/kg$ (A-11)

$v_2 = 0.1652$ (A-12)

$p_1 = p_2 = 1.4$ bar

$\Rightarrow \boxed{w = 3.598\ kJ/kg}$

5.30 The greatest possible efficiency of a power cycle is that of a Carnot cycle operating between the same two temperature reservoirs.

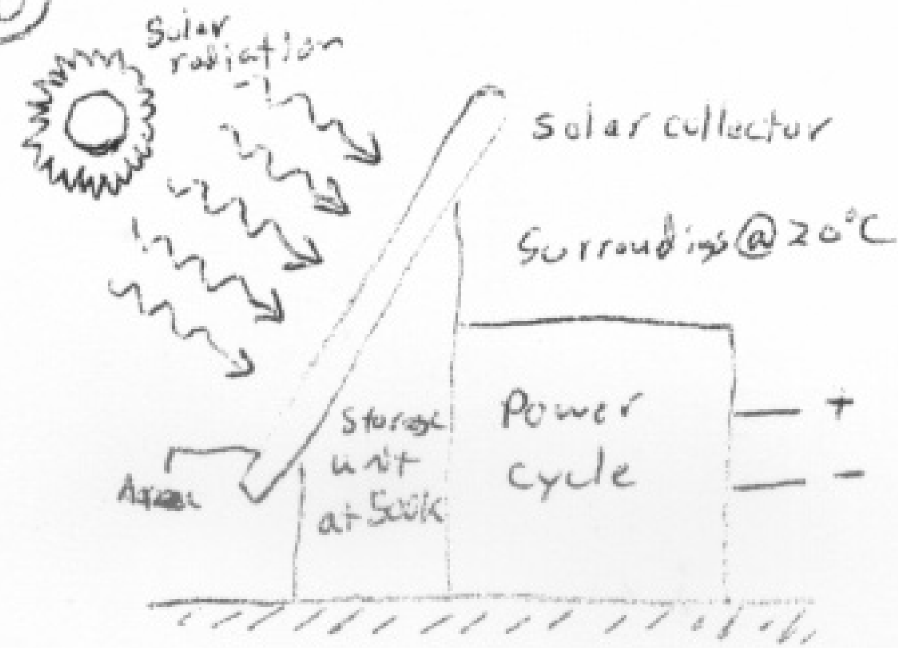
$$\eta_{th,carnot} = 1 - \frac{T_L}{T_H} = 1 - \frac{300}{500} = 40\%$$

$\boxed{\text{a) } 45\%\text{: impossible}}$

$\boxed{\text{b) } 40\%\text{: possible, but highly unlikely}}$

$\boxed{\text{c) } 35\%\text{: possible}}$

5.38



$\dot{Q}_{in} = 0.315\ \text{kW/m}^2$

$\dot{W}_{out} = 570\ \text{kW}$

To get minimum area, assume power cycle has the efficiency of a carnot engine,

$$\eta_{max} = 1 - \frac{293}{500} = 41.4\%$$

$$\eta = \frac{\dot{W}_{out}}{\dot{Q}_{in}} \Rightarrow A = \frac{570}{(0.414)(0.315)}$$

$$\Rightarrow \boxed{A = 4{,}371\ \text{m}^2}$$

5.54 $T_H = 68°F$, $T_C = 35°F$ $\dot{Q}_{out} = 30{,}000$ Btu/h

Actual cost/day: $(1\,hp)\left(\frac{1\,kW}{1.341\,hp}\right)\left(\frac{24\,h}{day}\right)\left(\frac{0.08\,\$}{kWh}\right)$

$\boxed{\text{Actual cost} = \$1.43/\text{day}}$

The minimum cost would occur if the heat pump had the efficiency of a carnot engine.

$$\frac{Q_{out}}{\dot{W}} = \frac{T_H}{T_H - T_C} = \frac{528°R}{528 - 495°R} = 16 = \frac{30{,}000\text{ Btu/h}}{\dot{W}}$$

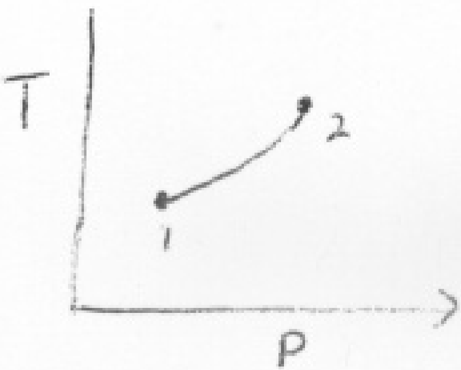
$\Rightarrow \dot{W} = 1{,}875$ Btu/h

min. cost $= (1{,}875\text{ Btu/h})\left(\frac{1\,kW}{3413\text{ Btu/h}}\right)\left(\frac{24\,h}{day}\right)\left(\frac{0.08\,\$}{kWh}\right)$

$\Rightarrow \boxed{\text{Min. cost} = \$1.05/\text{day}}$

6.20

Methane (CH_4)



$p_1 = 1\,\text{bar},\ T_1 = 298\,K,\ p_2 = 2\,\text{bar},\ T_2 = T$

Assuming the process is adiabatic, and the methane acts like an ideal gas.

$$\text{Eq. 6.23: } s_2 - s_1 = \int_{T_1}^{T_2} \frac{c_p}{T}\,dT - \frac{\bar{R}}{M} \ln \frac{p_2}{p_1}$$

$$s_2 - s_1 = \int_{T_1}^{T_2} \frac{c_p}{T}\,dT - 0.3593\ \text{kJ/kg}\cdot K$$

$$\bar{c}_p = \bar{R}\left[\alpha + \beta T + \gamma T^2 + \delta T^3 + \epsilon T^4\right] \qquad (A\text{-}21)$$

$$s_2 - s_1 = \frac{\bar{R}}{M} \int_{T_1}^{T_2} \left(\frac{\alpha}{T} + \beta + \gamma T + \delta T^2 + \epsilon T^3\right) dT - 0.3593$$

$$\boxed{s_2 - s_1 = 0.519\left[2.401\left(\ln \frac{T}{298}\right) + 8.735(10^{-3}) + -6.607(10^{-6})(T - 298) + 2.002(10^{-9})(T^2 - 298^2)\right] - 0.3593}$$