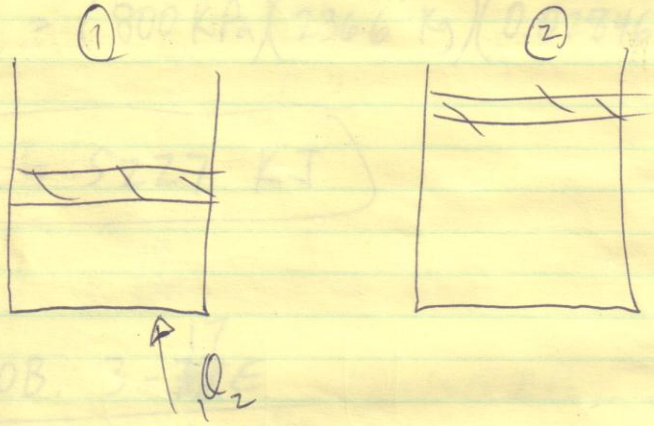
RETURN TO DR. THOMAS

HOMEWORK #3 SOLUTIONS 3-15, 3-17, 3-19, 3-20
3-22, 3-29, 3-31

PROB. 3-15



$V_1 = 200\ L$ SAT. LIQUID R-134a

$P_1 = 800\ kPa$

$P_2 = P_1 = 800\ kPa$

$T_2 = 50°C$

FIND WORK DONE

$v_1 = v_f = 0.0008454\ \frac{m^3}{kg}$

$v = \frac{V}{m}$, $m = \frac{V}{v} = \frac{(200\ L)\left(\frac{m^3}{1000\ L}\right)}{\left(0.0008454\ \frac{m^3}{kg}\right)} = 236.6\ kg$

$_1W_2 = \int_1^2 P\,dV = P_m(V_2 - V_1)$

PROB, 3-~~14~~15

AT $P_2 = 800\ KPa$, $T_2 = 50°C$,

$v_2 = 0.02846\ \frac{m^3}{kg}$

$${}_1W_2 = (800\ KPa)(236.6\ kg)(0.02846 - 0.0008454\ \tfrac{m^3}{kg})\left(\frac{KJ}{KPa/m^3}\right)$$

$${}_1W_2 = 5227\ KJ$$

PROB. 3-~~18~~17E

$m_T = 12\ LBM$ S.H.V. H_2O, $P_1 = 60\ PSIA$, $T_1 = 500°F$

$P_2 = 60\ PSIA$, $m_f = 0.7\, m_T$

FIND WORK

$${}_1W_2 = P_m(v_2 - v_1)$$

$v_1 = 9.399\ \frac{ft^3}{LBM}$

$m_g = 0.3\, m_T = (0.3)(12\ LBM) = 3.6$

$x = \frac{m_g}{m_T} = \frac{3.6}{12} = 0.3$ $\quad x_2 = \frac{m_g}{m_T} = 0.3$

$v_f = 0.017378\ \frac{ft^3}{LBM}$, $\quad v_g = 7.177\ \frac{ft^3}{LBM}$

PROB. 3-17

$$v_2 = (0.017378) + (0.3)(7.177 - 0.017378)$$

$$v_2 = 2.165 \frac{ft^3}{LBM}$$

$$_1W_2 = \left(60 \frac{LBF}{in^2}\right)\left(\frac{144 in^2}{ft^2}\right)(12\ LBM)\left(2.165 - 9.399 \frac{ft^3}{LBM}\right)$$

$$\boxed{_1W_2 = -7.5 \times 10^5\ FT\text{-}LBF}$$

PROB. 3-19

N_2, $T_1 = 300\ K$, $P_1 = 150\ KPa$, $V_1 = 0.2\ m^3$

$T_2 = T_1 = 300\ K$, $P_2 = 800\ KPa$

FIND WORK

$$_1W_2 = \int_1^2 P\,dV$$

$$PV = mRT$$

PV = CONSTANT

$$_1W_2 = P_1V_1 \ln \frac{V_2}{V_1}$$

~~$V_2 = \frac{mRT}{P_2}$~~

$$P_1V_1 = P_2V_2$$

$$\frac{V_2}{V_1} = \frac{P_1}{P_2}$$

PROB. 3-~~19~~ 19

$$_1W_2 = P_1 V_1 \ln \frac{P_1}{P_2}$$

$$= (150\ \text{KPa})(0.2\ m^3) \ln\left(\frac{150}{800}\right)$$

$$\boxed{_1W_2 = -50.2\ \text{KJ}}$$

PROB. 3-~~18~~ 20

$V_1 = 0.42\ m^3$, $V_2 = 0.12\ m^3$

$P = aV + b$, $a = -1200\ \frac{\text{KPa}}{m^3}$, $b = 600\ \text{KPa}$

FIND WORK DONE

$$_1W_2 = \int_1^2 P\,dV = \int_1^2 (aV + b)\,dV$$

$$_1W_2 = \left[\frac{a}{2}V^2 + bV\right]_1^2$$

$$= \left[\left(\frac{a}{2}V_2^2 + bV_2\right) - \left(\frac{a}{2}V_1^2 + bV_1\right)\right]$$

$$= \frac{a}{2}\left(V_2^2 - V_1^2\right) + b\left(V_2 - V_1\right)$$

$$= \frac{(-1200\ \frac{\text{KPa}}{m^3})}{2}\left[(0.12\ m^3)^2 - (0.42\ m^3)^2\right]$$

$$+ (600\ \text{KPa})\left[(0.12\ m^3) - (0.42\ m^3)\right]$$

PROB. 3-20

$$_1W_2 = -82.8 \text{ KJ}$$

PROB. 3-22

$P_1 = 150$ KPa, $V_1 = 0.03\ m^3$

$V_2 = 0.2\ m^3$, $n = 1.3$

$$_1W_2 = \frac{P_2V_2 - P_1V_1}{1-n}$$

$PV^n = C$

$P_1V_1^n = P_2V_2^n$

$$\left(\frac{V_2}{V_1}\right)^n = \frac{P_1}{P_2}$$

~~$\frac{V_2}{V_1} = \left(\frac{P_1}{P_2}\right)^{\frac{1}{n}}$~~

~~$V_2 = V_1\left(\frac{P_1}{P_2}\right)^{\frac{1}{n}} = (0.03\ m^3)(150$~~

$$P_2 = P_1\left(\frac{V_1}{V_2}\right)^n = (150 \text{ KPa})\left(\frac{0.03}{0.2}\right)^{1.3} = 12.73 \text{ KPa}$$

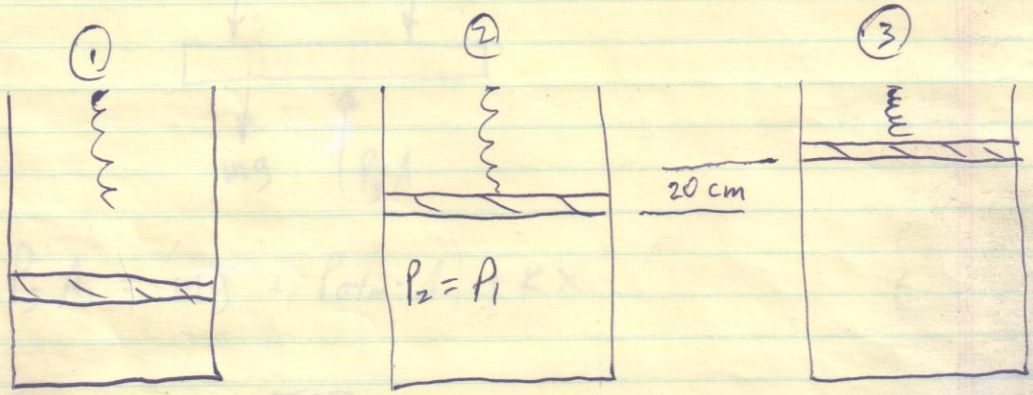
$$_1W_2 = \frac{(12.73 \text{ KPa})(0.2\ m^3) - (150)(0.03)}{1-1.3}$$

$$_1W_2 = 6.51 \text{ KJ}$$

PROB. 3-29

$m = 50\ Kg\ H_2O$, $P_1 = 150\ KPa$, $T_1 = 25°C$

$A = 0.1\ m^2$, $V_2 = 0.2\ m^3$



$K = 100\ \frac{KN}{m}$

a) FIND FINAL PRESSURE, TEMPERATURE

b) FIND WORK DONE

c) P-V DIAGRAM

a) $v_1 = v_f(T_{sat} = 25°C) = 0.001003\ \frac{m^3}{Kg}$

$V_1 = m v_1 = (50\ kg)(0.001003\ \frac{m^3}{kg}) = 0.05\ m^3$

$V_2 = 0.2\ m^3$

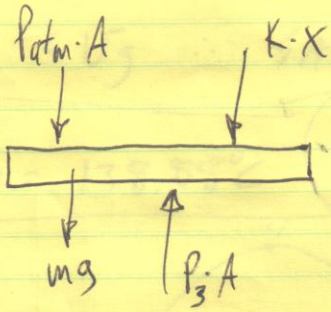
$V_3 = V_2 + xA = 0.2\ m^3 + (20\ cm)(\frac{m}{100\ cm})(0.1\ m^2)$

$V_3 = 0.22\ m^3$

$v_3 = \frac{V_3}{m} = \frac{0.22\ m^3}{50\ kg} = 0.0044\ \frac{m^3}{kg}$

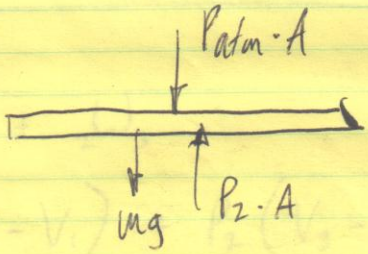
PROB. 3-29

STATE 3 : FBD



$$P_3 A = (mg + P_{atm} \cdot A) + KX$$

STATE 2: FBD



$$P_2 \cdot A = (mg + P_{atm} \cdot A)$$

$$P_3 \cdot A = P_2 \cdot A + KX$$

$$P_3 = P_2 + \frac{KX}{A}$$

$$P_3 = (150\ kPa) + \frac{\left(100\ \frac{kN}{m}\right)(0.2\ m)}{(0.1\ m^2)}$$

$$\boxed{P_3 = 350\ kPa}$$

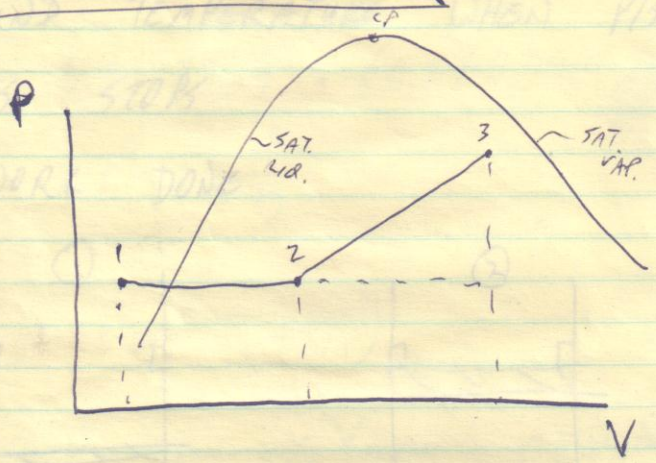
PROB. 3-~~29~~

AT $P_{sat} = 350$ kPa, $v_f = 0.001079$, $v_g = 0.5243 \frac{m^3}{kg}$

$v_f < v_3 < v_g$ ∴ SAT. MIX.

$$T_3 = T_{sat} = 138.88°C$$

b)



$$_1W_3 = {}_1W_2 + {}_2W_3$$

$$= P_1(V_2 - V_1) + P_2(V_3 - V_2) + \frac{1}{2}(V_3 - V_2)(P_3 - P_2)$$

$$= P_1(V_2 - V_1) + \frac{1}{2}(P_2 + P_3)(V_3 - V_2)$$

$$_1W_3 = (150\ kPa)(0.2 - 0.05\ m^3) + \frac{1}{2}(150 + 350\ kPa)(0.22 - 0.2\ m^3)$$

$$_1W_3 = 27.5\ kJ$$

OR $\quad _1W_3 = P_1(V_2 - V_1) + \frac{1}{2}kX^2$

PROB. 3-31

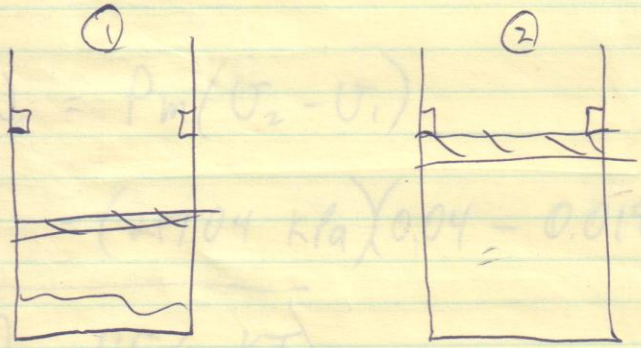
$m = 10\ kg$ R-134a

STATE 1 : $m_f = 8\ kg$, $T_1 = -8°C$

$V_2 = 400\ L$

a) FIND TEMPERATURE WHEN PISTON FIRST HITS STOPS

b) WORK DONE



a) $v_2 = \frac{V_2}{m_T} = \frac{(400\ L)}{(10\ kg)} \cdot \left(\frac{m^3}{1000\ L}\right) = 0.04\ \frac{m^3}{kg}$

$P_2 = P_1$ (CONSTANT PRESSURE PROCESS)

$P_1 = P_{sat}(T_{sat} = -8°C) = 0.21704\ MPa$

$P_2 = 217.04\ KPa$

FOR $P_{sat} = 217.04$, $v_f = 0.0007569$, $v_g = 0.0919\ \frac{m^3}{kg}$

$v_f < v_2 < v_g$ ∴ STILL SATURATED

PROB. 3-~~46~~ 31

$$T_2 = -8°C$$

b) FIND ${}_1W_2$: FIND $v_1 = v_f + x_1 v_{fg}$

$$x_1 = \frac{2}{10} = 0.2$$

$$v_1 = 0.0007569 + (0.2)(0.0919 - 0.0007569)$$

$$v_1 = 0.01899 \frac{m^3}{kg}$$

$${}_1W_2 = P_m(v_2 - v_1)$$

$$= (277.04\ kPa)(0.04 - 0.01899 \frac{m^3}{kg})(10\ kg)$$

$${}_1W_2 = 45.6\ kJ$$