First Name-- **Date:November 15, 2014-**
Last Name--
Student ID Number-----------------------------

Cankaya University
Faculty of Engineering
Mechanical Engineering Department
ME 211 Thermodynamics I
Midterm Exam I
Closed Notes Closed Book
Fall 2014

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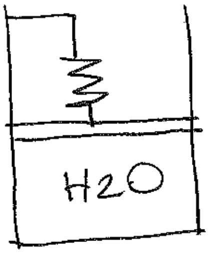
1) One kg of water that is initially at 90° C with a quality of 10 percent occupies a spring-loaded piston– cylinder device, such as that as shown in figure below . This device is now heated until the pressure rises to 700 kPa and the temperature is 240° C.
 Determine :
 a) The initial pressure
 b) the total work produced during this process, in kJ
 c) show the process on a p-v diagram with respect to saturation lines



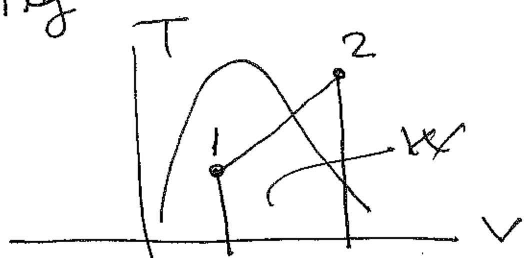
$m = 1\ kg$, $T_1 = 90°C$, $x_1 = 0.1$ | $P_1 = 0.7014\ bar$, $v_f = 1.036 \times 10^{-3}\ m^3/kg$, $v_g = 2.361\ m^3/kg$

$$v_1 = v_f + x_1 v_{fg} = 0.237\ m^3/kg$$

state-2; $P_2 = 700 kPa = 7\ bar$, $T_2 = 240°C$ | $P_2 = 7\ bar \rightarrow T_{SAT} = 165°C$

$T_2 > T_{SAT}$ superheated

$$\therefore v_2 = 0.3292\ m^3/kg$$

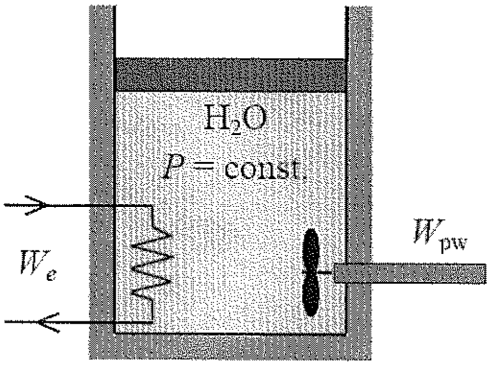


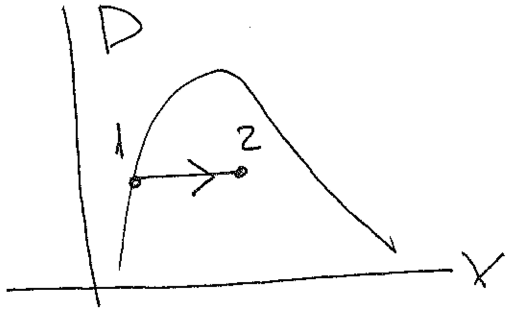
$$W = \frac{1}{2}(P_1 + P_2)(m)(v_2 - v_1)$$

$$= 0.5(0.7014 + 7)\,bar\left(10^5 \frac{N/m^2}{bar}\right)(0.3292 - 0.237)\frac{m^3}{kg}(1\ kg)$$

$$= 70982\ J$$

2) An insulated piston– cylinder device contains 5 L of saturated liquid water at a constant pressure of 200 kPa. Water is stirred by a paddle wheel while a current of 8 A flows for 45 min through a resistor placed in the water. If one- half of the liquid is evaporated during this constant-pressure process and the paddle- wheel work amounts to 400 kJ, determine the voltage of the source. Also, show the process on a p- v diagram with respect to saturation lines.





$\not{Q}^{\,0} - W = m(u_2 - u_1)$

$\not{Q}^{\,0} - [W_e + W_{pw} + W_b] = m(u_2 - u_1)$

$+W_{pw} + W_e - W_b = m(u_2 - u_1)$

$W_b = \int_1^2 p\,dV = p(V_2 - V_1) = mp(v_2 - v_1)$

$+W_{pw} + W_e = m(h_2 - h_1)$

$+W_{pw} + VI\Delta t = m(h_2 - h_1)$

$VI\Delta t + 400 = 4.71(1605.5 - 504.7)$

$VI\Delta t = 4784.76$

$V = \frac{4784.76}{(8A)(45)(60)} \; \frac{1000\,V.A}{1\,kJ/s}$

$= 221.5$ Volt

$P_1 = 2$ bar, $x_1 = 0$ → $h_1 = h_f = 504.7\ \frac{kJ}{kg}$

$v_1 = v_f = 1.0605 \times 10^{-3}\ \frac{m^3}{kg}$

$P_2 = 2$ bar, $x_2 = 0.5$ →

$h_2 = h_f + x_2 h_{fg}$

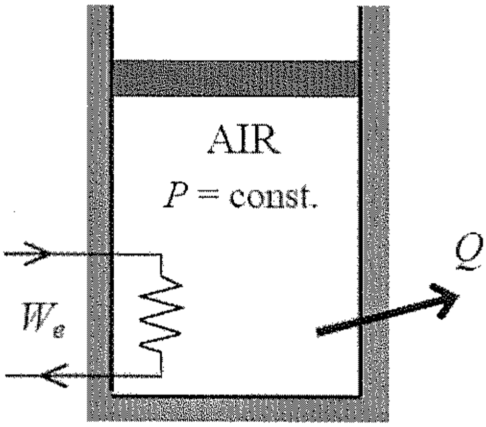
$= 504.7 + 0.5)(2201.9)$

$= 1605.65\ \frac{kJ}{kg}$

$m = \frac{V}{v_1} = \frac{0.005}{1.0605 \times 10^{-3}}$

$= 4.71$ kg

3) A mass of 15 kg of air in a piston– cylinder device is heated from 27° C to 77° C by passing current through a resistance heater inside the cylinder. The pressure inside the cylinder is held constant at 300 kPa during the process, and 845 kJ of work is done on the air by passing current through resistor. Determine the heat transfer during the process.



$$Q - W = m(u_2 - u_1)$$

$$Q - (W_e + W_b) = m(u_2 - u_1)$$

$$Q - W_e - W_b = m(u_2 - u_1)$$

$$W_b = \int_1^2 P\,dV = mP(v_2 - v_1)$$

$$Q - W_e = m(h_2 - h_1)$$

$T_1 = 27°C = 300\,K$ $\quad h_1 = 300{,}19$ kJ/kg

$T_2 = 77°C = 350\,K$ $\quad h_2 = 350.49$ kJ/kg

$$Q - (-845) = (15)(350{,}49 - 300{,}19)$$

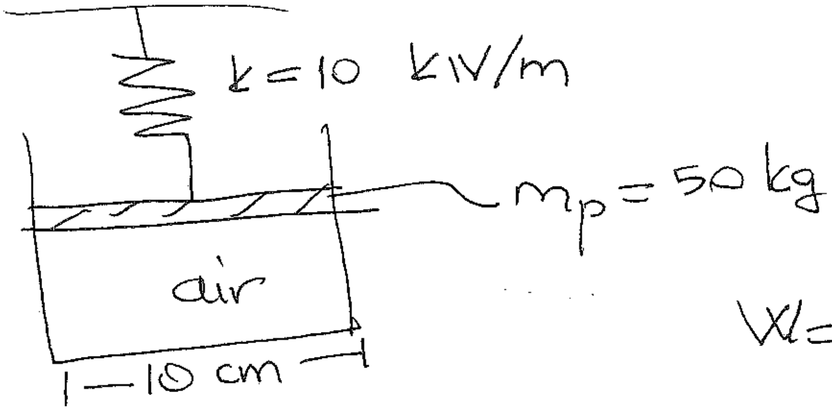
$$Q + 845 = 754.5$$

$$Q = -90.5\text{ kJ}$$

4) A rigid tank contains 10 kg of air at 350 kPa and 27° C. The air is now heated until its pressure doubles. Deter-mine (a) the volume of the tank and (b) the amount of heat transfer using air tables.

Extra Credit: If you do this problem you will get 10 points.

Consider the air in a piston cylinder assembly. Initially the spring touching the piston but exerting no force. The atmospheric pressure is 100 kPa. The air is heated until the spring is compressed 50 mm. Find the work done by the air on the frictionless piston.



$\Delta x = 50$ mm

$W = W_b + W_s$

$$P_1 A = P_{atm} A + mg$$

$$P_1 = P_{atm} + \frac{mg}{A} = 100\,000 + \frac{(50)(9.81)}{\frac{\pi (0.1)^2}{4}}$$

$$= 162.45 \text{ kPa}$$

$$W_b = \int_1^2 p\, dV = p\,(V_2 - V_1) = pA(\Delta x)$$

$$= \left(162.45 \frac{kN}{m^2}\right)(\pi)(0.05)^2 (0.05)\left(\frac{1000 N.m}{kN}\right)$$

$$= 63.8 \text{ kJ}$$

$$W_s = \frac{k}{2}\Delta x^2 = \frac{10\,000 N/m}{2}(0.05)^2 = 12.5 \text{ kJ}$$

$$W = 63.80 + 12.5 \approx 76.3 \text{ kJ}$$