ME 200 Spring 2007  
Exam 1  
Wednesday February 14

- You may use only your own book, your own notes (this includes course instructor notes you have written on) and any quizzes you were given in class.
- You may not use any additional material, such as another persons notes, other books, technical papers, solution manuals, old exams, anyone else’s homework, etc.
- You must turn off all communications devices before starting this exam, place them under your seat out of sight, and leave them off until you exit the examination room.
- You must place all materials, other than your calculator, pencil, eraser, book/note, and this exam under your seat and not move them until you leave the exam hall for the last time this evening. Recall that this includes any communications devices.
- You must interpolate when necessary. You will not obtain full credit if you choose “the closest answer.”
- You must follow the problem solution format to obtain full credit.

Name: _____________________________  Thermo No: __007__ (1 pt)

CIRCLE YOUR DIVISION

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<td>Div. 2 (1030)</td>
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1. **(All parts worth 6 pts)** Carbon monoxide gas (CO, MW=28.0) with a mass of 0.050 kg is contained in a piston-cylinder assembly initially at 1.20 bars and 0.040 m$^3$. The gas is maintained at a constant temperature of 50°C while being stirred by a paddle-wheel subject to a torque of 10 N·m for 90 revolutions. At the end of the stirring process the volume is 0.020 m$^3$.

(a) Describe in one short sentence the system you are considering; draw its boundary on the equipment sketch provided above.

(b) Determine the paddle-wheel work. **Report your answer in kJ.**

(c) Determine the heat transfer. **Report your answer in kJ, and indicate the direction of heat transfer on the equipment sketch above.**

(d) Plot the process on the p-V diagram provided below, clearly indicating the initial and final states, as well as the path of the process.

\[ W_{\text{paddle}} = \int p \, dV \]

\[ W = W_{\text{rev}} + W_{\text{paddle}} \]

\[ W = \int p \, dV \]

\[ W = \int p \, dV = n \left[ \frac{RT}{V} \right] dV = nRT \ln \frac{V_f}{V_i} \]

\[ W = 0.05 \times 8.314 \times (273+50) \ln (\frac{1}{2}) \]

\[ W = -3.32 \text{ kJ} \]

\[ Q = W_{\text{rev}} + W_{\text{paddle}} = -1.811 - 3.32 \]

\[ Q = -8.98 \text{ kJ} \]
2. (Parts a, b, and d worth 9 pts; part c worth 18 pts) A piston cylinder assembly contains water initially as a saturated vapor at 60 psia. The fluid is first heated at constant pressure to 600 F, and then cooled at constant volume to 10 psia.

(a) Denote the system boundary on the sketch at right.

(b) Sketch the two processes on the p-V diagram below, relative to the saturation lines.

(c) Determine the work, heat transfer, and internal energy change for the first process. **Report your answer in Btu/lbm.**

(d) Determine the internal energy change for the second process. **Report your answer in Btu/lbm.**

\[ Q \rightarrow W = \Delta E = \Delta U + \Delta (\text{KE}) + \Delta (\text{PE}) \]

\[ W_{12} = \int_{V_1}^{V_2} PDV = \int_{V_1}^{V_2} \text{PCVDV} \]

\[ V_1 = 7.1766 \text{ ft}^3/\text{lbm} \]

\[ V_2 = 10.425 \text{ ft}^3/\text{lbm} \]

\[ W_{12} = 65 \text{ Btu/lbm} \left( \frac{10.425 - 7.1766}{1\text{ ft}^3/\text{lbm}} \right) \text{Btu/lbm} = 355.1 \text{ Btu/lbm} \]

\[
\Delta U_{12} = \frac{1}{2} M \left( V_2 - V_1 \right) \left( U_3 - U_2 \left( \frac{V_3}{V_2} \right) \right) = \frac{1}{2} \cdot 1 \cdot \left( 10.425 - 7.1766 \right) \left( 10.425 - 7.1766 \right) \left( U_3 - U_2 \left( \frac{V_3}{V_2} \right) \right)
\]

\[ U_3 = 0.271 \left( 10.425 \right) + \left( 1 - 0.271 \right) 616.22 = 468 \text{ Btu/lbm} \]

\[ \Delta U_{12} = \frac{1}{2} \cdot 1 \cdot 3.25 \cdot \left( 10.425 - 7.1766 \right) \left( U_3 - U_2 \left( \frac{V_3}{V_2} \right) \right) = -50 \text{ Btu/lbm} \]
3. **(All parts worth 6 pts)** Water initially exists at 500 psia with an enthalpy of 1357 Btu/lbm. For the three separate processes described below, use tables to find the properties requested. If a calculation is necessary in order to determine a property value, the calculation **must be shown** to receive credit.

(a) The initial fluid (State 1) is cooled in a rigid tank until the pressure reaches 250 psia (State 2).

State 1: $T_1 = \text{700°F}$  $u_1 = \text{1736.4 Btu/lbm}$

State 2: $T_2 = \text{97°F}$

(b) The initial fluid (State 1) is heated in a rigid tank until the pressure reaches 600 psia (State 3).

State 3: $T_3 = \text{500°F}$

(c) The initial fluid (State 1) is cooled at constant pressure until the temperature reaches 300 F (State 4).

(d) On the p-V diagram shown at right, locate all four states (1-4), as well as the three processes that connect them (a-c).

(e) Oxygen (O$_2$, MW=32) at 1.1 bars and 300 K is heated in a rigid tank until its temperature reaches 500 K. Determine the internal energy change. **Report your answer in kJ/kg.**

$$\Delta u = \left( 1004 - 605 \right) \text{k}J/\text{kg}$$

$$\boxed{\Delta u = 157 \text{k}J/\text{kg}}$$