ES 202 - Exam II Winter 2002-2003 Richards/Lui

Name:________________________________________ Campus Mail Box ____________

Circle One: Richards – 03 Richards – 04 Lui – 05 Lui - 06

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|---|---|---|
| Problem 1 | ( 32 ) | __________ |
| Problem 2 | ( 34 ) | __________ |
| Problem 3 | ( 34 ) | __________ |
| TOTAL | ( 100 ) | __________ |

**General Comments**

(1) Anytime you apply conservation or accounting principles in solving a problem, sketch and clearly identify the system you have selected. In addition, clearly indicate how your assumptions or given information simplifies the general equations. Numbered-symbols, e.g. $P_1$ ,in equations must make sense for the problem in question, i.e. they must match you figure and communicate information accurately.

(2) Guidelines – Open text book / closed notes; however, you may use the following
... your equation page (single side of 8-1/2 x 11 sheet of paper)
... unit conversion page provide with text
... your computer to run MAPLE assuming it is *not* communicating with any networks and you are not using any previously prepared worksheets, etc. **Use of EES is forbidden.**

(3) For maximum credit,
... solve problems symbolically first showing logic and reasoning for solution,
... substitute numbers into the equations clearly showing any required unit conversion factors
... then and only then crunch numbers on your calculator.
If I only have to punch your numbers into a calculator to get a correct answer (including units) you will receive full credit. **Don't make me guess what you are doing.**

(4) Watch the time and feel free to remove the staple and take the test apart so that you don't have to keep flipping pages around.

PLEASE REMOVE THE STAPLE AND USE EXTRA PAPER *INSTEAD* OF WRITING ON THE BACK OF PAGES AND THEN HAVING TO FLIP BACK AND FORTH TO FINISH THE PROBLEM. I'LL GLADLY RESTAPLE YOUR TEST! **If you remove the staple, *PLEASE* place your name on every page you turn in.**

**Length**

1 ft = 12 in = 0.3048 m = 1/3 yd

1 m = 100 cm = 1000 mm = 39.37 in = 3.2808 ft

1 mile = 5280 ft = 1609.3 m

**Mass**

1 kg = 1000 g = 2.2046 lbm

1 lbm = 16 oz = 0.45359 kg

1 slug = 32.174 lbm

**Temperature Values**

$(T/K) = (T/{}^oR) / 1.8$

$(T/K) = (T/{}^oC) + 273.15$

$(T/{}^oC) = [\,(T/{}^oF) - 32\,]/1.8$

$(T/{}^oR) = 1.8(T/K)$

$(T/{}^oR) = (T/{}^oF) + 459.67$

$(T/{}^oF) = 1.8(T/{}^oC) + 32$

**Temperature Differences**

$(\Delta T/{}^oR) = 1.8(\Delta T / K)$

$(\Delta T/{}^oR) = (\Delta T/{}^oF)$

$(\Delta T / K) = (\Delta T/{}^oC)$

**Volume**

1 m$^3$ = 1000 L = 10$^6$ cm$^3$ = 10$^6$ mL = 35.315 ft$^3$ = 264.17 gal

1 ft$^3$ = 1728 in$^3$ = 7.4805 gal = 0.028317 m$^3$

1 gal = 0.13368 ft$^3$ = 0.0037854 m$^3$

**Volumetric Flow Rate**

1 m$^3$/s = 35.315 ft$^3$/s = 264.17 gal/s

1 ft$^3$/s = 1.6990 m$^3$/min = 7.4805 gal/s = 448.83 gal/min

**Force**

1 N = 1 kg·m/s$^2$ = 0.22481 lbf

1 lbf = 1 slug·ft/s$^2$ = 32.174 lbm·ft/s$^2$ = 4.4482 N

**Pressure**

1 atm = 101.325 kPa = 1.01325 bar = 14.696 lbf/in$^2$

1 bar = 100 kPa = 10$^5$ Pa

1 Pa = 1 N/m$^2$ = 10$^{-3}$ kPa

1 lbf/in$^2$ = 6.8947 kPa = 6894.7 N/m$^2$

[lbf/in$^2$ often abbreviated as “psi” ]

**Energy**

1 J = 1 N·m

1 kJ = 1000 J = 737.56 ft·lbf = 0.94782 Btu

1 Btu = 1.0551 kJ = 778.17 ft·lbf

1 ft·lbf = 1.3558 J

**Energy Transfer Rate**

1 kW = 1 kJ/s = 737.56 ft·lbf/s = 1.3410 hp = 0.94782 Btu/s

1 Btu/s = 1.0551 kW = 1.4149 hp = 778.17 ft·lbf/s

1 hp = 550 ft·lbf/s = 0.74571 kW = 0.70679 Btu/s

**Specific Energy**

1 kJ/kg = 1000 m$^2$/s$^2$

1 Btu/lbm = 25037 ft$^2$/s$^2$

1 ft·lbf /lbm = 32.174 ft$^2$/s$^2$

**Problem 1** (32 points)

Complete the information in the table for refrigerant 134a (**R-134a).** Entries that require calculations are worth 4 points. Entries that only require a simple look up are worth 2 points.

For **phase**, indicate whether it is a compressed liquid (**CL**), saturated liquid (**SL**), saturated mixture (**SM**), saturated vapor (**SV**), or superheated vapor (**SHV**).

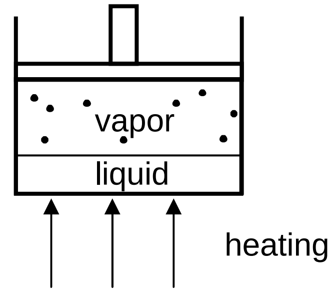
For **properties** and **quality**, provide a number or indicate it is not applicable (N/A).

| State | Phase | $T$ °C | $P$ MPa | $x$ | $\upsilon$ m³/kg | $h$ kJ/kg | $s$ kJ/(kg·K) |
|---|---|---|---|---|---|---|---|
| 1 | | 60 | | | | 172.71 | |
| 2 | | 60 | | | | | 0.9527 |
| 3 | | 60 | 0.8 | | | | |
| 4 | | 60 | 3.0 | | | | |
| 5 | SV | | 3.0 | | | | |

For answers that require calculations, show your work below as you feel necessary. ***Full credit* will be given if we only have to punch *your* numbers into a calculator.**

**Problem 2** (34 points)

A saturated mixture of water with an initial quality of 50%, a pressure of 100 kPa, and mass of 2 kilograms is contained in a piston cylinder device. During a constant pressure process, the water is heated to a temperature of 200$^{o}$C.




(a) Sketch the process on a *P-v* and a *T-v* diagram. Clearly label the initial state, final state, and the process line.

(b) Determine the *magnitude* and *direction* of the *work* and *heat transfer* for the process, in kJ.

**Problem 3** (34 points)

One way to provide air for cooling the passengers on an airliner is to expand high pressure air through an adiabatic, steady-state turbine as shown in the figure.

The inlet and outlet information is shown on the figure. The inlet volumetric flow rate is 0.2 $m^3/s$, and the turbine has an isentropic efficiency of 75%.

Assume air can be modeled as an ideal gas and use the *ideal gas tables*. **Do not interpolate—use closest values.**

(a) Sketch the process on a *T-s* diagram.

(b) Determine the power output from the turbine, in kW.

(c) Determine the outlet air temperature.