CIRCLE ONE:  Mayhew 4th  Mayhew 5th  Mech 4th  Mech 5th

For this exam you may use:
- One side of an 8-1/2 x 11 sheet for notes
- Tables in appendix of text
- Calculator
- Laptop

ES 202
Examination 1
January 8, 2010

<table>
<thead>
<tr>
<th>Problem</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>/55</td>
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<tr>
<td>2</td>
<td>/25</td>
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<td>3</td>
<td>/10</td>
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</tbody>
</table>

Show all work for credit
and
turn in your notes sheet
Problem 1 (55 pts) Consider the following three processes using Air:

1-2 Isentropic DIFFUSER
2-3 Constant-pressure COMBUSTOR
3-4 Isentropic NOZZLE

a. (5 pts) Sketch the processes on the T-s diagram.

b. (15 pts) Find the pressure (kPa) at the diffuser exit

c. (20 pts) Find the velocity (m/s) at the nozzle exit.

d. (10 pts) For $T_{\text{boundary}} = 2000$ K, find the specific entropy (kJ/kg-K) generated by the combustor.

e. (5 pts) Find the maximum possible thermal efficiency for any power cycle operating between 1750 K and 250 K.
Problem 2 (25 pts)

R-134a provides power through a turbine. The inlet and outlet information is indicated on the figure at the right. The inlet mass flow rate is 5 kg/s, and the turbine has an isentropic efficiency of 90%.

(a) Determine the power output from the turbine.
(b) Determine the outlet R-134a enthalpy and temperature.
(c) Sketch the process on a T-s diagram.

\[ P_1 = 1.2 \text{ MPa} \]
\[ T_1 = 60 \degree \text{C} \]
\[ \dot{m}_1 = 5 \text{ kg/s} \]
\[ \eta_{\text{turbine}} = 90 \% \]

\[ P_2 = 400 \text{ kPa} \]
Problem 3 (10 pts)

ARGON gas at 17 MPa cannot be treated as an ideal gas because the compressibility factor, Z, is 0.65 for the measured temperature.

(a) At what temperature is the ARGON?

(b) If a gas is treated as an ideal gas, what value of Z would be used?

Problem 4 (10 pts)

A saturated mixture of a substance is held in a sealed, rigid container. Initially, \( T_1 = 50 \, ^\circ\text{C} \) and \( v_1 = 0.001 \, \text{m}^3/\text{kg} \). The substance is heated until it is all liquid or all vapor. A related T-v diagram is shown at the right.

(a) Show the process on the T-v diagram.

(b) Did the substance contain liquid or vapor at the end of the process? Explain.

(c) Did the pressure of the substance increase, decrease, or stay the same during the process? Explain.