Name: _________________________

ME 302          Quiz 3            SPRING 2009

2. 20 points total; 6 multiple choice/short answer problems; one long-answer problem; 20 minutes; points indicated in parentheses.
3. Show all work in problems that are not multiple choice; select only one answer for multiple choice problems.

Section 1 (15 pts): 13 Multiple choice/short answer problems. Select only one answer for multiple choice problems.

(1 pt) 1. If exit mass flow rate \( m_e \) < inlet mass flow rate \( m_i \), the mass in the control volume
   a) increases with time.
   b) decreases with time.
   c) remains the same with time.
   d) not enough information.

(1 pt) 2. Exit mass flow rate \( m_e \) in a duct is same as inlet mass flow rate \( m_i \) of water (constant density), and the inlet area is greater than exit area. Compared to the inlet speed, the exit speed is
   a) greater
   b) smaller
   c) same
   d) not enough information

(1 pt) 3. A closed adiabatic system undergoes a process, which involves no work interaction, the change in its energy is,
   (i) positive  (ii) negative
   (iii) zero   (iv) can not be determined from the given information

(1 pt) 4. A closed system undergoes a process which involves no energy transfer as work. The change in its energy,
   (i) is positive   (ii) is negative
   (iii) is zero     (iv) cannot be determined from the given information.
(1pt) 5 Write the first law of thermodynamics for a fixed mass system which is undergoing a cyclic process.

\[ Q - W = 0 \]

(2 pt) 6. Copy the energy equation shown in the problem below for a control volume and show which terms will you drop for an adiabatic, single entry single exit, steady state, device with no kinetic and potential energy change. Rewrite it in “per unit mass” form.

\[ \dot{Q} - \dot{W} = \sum \dot{m}_i \left( h + \frac{v^2}{2} + g_z \right)_{in} - \sum \dot{m}_o \left( h + \frac{v^2}{2} + g_z \right)_{out} + \frac{de}{dt} \]

\[ -\dot{w} = \dot{h} \text{ out} - \dot{h} \text{ in} \]
13 pts) Problem 1. In three parts.

**Part A (5 pts):** After returning from a Thanksgiving vacation, a man finds that his small house was chilly, at 50 °F. There is a refrigerator (100 W), a TV (100 W), a fan (100 W), and an electric heater (500 W) in the house; all these appliances were turned OFF while he was away. He decides to heat the house. Neglect heat given off by the man himself, and there is no thermostat in the house.

**Sketch** the variation of interior house temperature vs. time for three possible scenarios. Show all lines on the same graph starting at point A, and briefly justify your answer:

(a) Only the heater is ON; no loss to exterior

(b) All appliances are OFF, the heater is ON; 200 W loss to exterior

(c) All appliances are ON; the heater is OFF; 200 W loss to exterior

\[
\dot{Q} - \dot{W} = \frac{dE}{dt} = \frac{dU}{dt} + \frac{dT}{dt}
\]

(a) \( \frac{dT}{dt} \propto 0 - (-500) = 500 \)

(b) \( \frac{dT}{dt} \propto (-200) - (-500) = 300 \)

(c) \( \frac{dT}{dt} \propto (-200) - (-100 - 100 - 100) = 100 \)
(4 pts) (a) For an ideal gas, show that

Given: \( c_p = \left( \frac{\partial h}{\partial T} \right)_p \), \( c_v = \left( \frac{\partial u}{\partial T} \right)_v \), hint: start with definition of \( h \).

\[
h = u + pv
\]

\[
h(T) = u(T) + RT \quad \text{for ideal gas}
\]

\[
\frac{dh}{dT} = \frac{du}{dT} + R
\]

\[
\Rightarrow \quad c_p = c_v + R
\]

\[
\Rightarrow \quad c_p - c_v = R
\]

(4 pts) (c) The control volume mass flow and energy rate balance equations are given by

\[
\sum m_{\text{in}} - \sum m_{\text{out}} = \frac{dm}{dt}
\]

\[
Q - W = \sum m_{\text{out}}(h + \frac{V^2}{2} + g z)_{\text{out}} - \sum m_{\text{in}}(h + \frac{V^2}{2} + g z)_{\text{in}} + \frac{dE}{dt}
\]

In the table shown below, specify SI units (in column II) and give brief description (in column III) for terms 1, 4, 6, and 10

<table>
<thead>
<tr>
<th>Col. I Term #</th>
<th>Col.II Units</th>
<th>Col. III Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>kg/s</td>
<td>total mass flow rate entering the CV.</td>
</tr>
<tr>
<td>4</td>
<td>kW/s</td>
<td>rate of heat transfer into the CV.</td>
</tr>
<tr>
<td>6</td>
<td>kg/s</td>
<td>total mass flow rate leaving the C.V.</td>
</tr>
<tr>
<td>10</td>
<td>kg/s</td>
<td>total mass flow rate entering the C.V.</td>
</tr>
</tbody>
</table>