Circle your division:

7:30 Gore  10:30 Frankel  1:30 Sojka  3:30 Kim  4:30 Clark

**Instructions:** This is a closed book/note exam. You may use a calculator. You must start from the most basic form of the equations and simplify accordingly to receive full credit. Show all your work! Keep your eyes on your own paper. If you are caught cheating you will get a zero for the exam and your name will be turned over to the Dean of Students.

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>TOTAL POSSIBLE</th>
<th>YOUR SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>
1. Answer the following questions true or false.

a. A closed system always contains the same matter; there is no transfer of matter across its boundary  
   \[ Q = 0 \]
   True

b. The volume of a closed system can change  
   False

c. When a closed system undergoes a process between two specific states, the change in temperature between the end states is independent of the details of the process  
   False

d. A refrigerant at an absolute pressure of 0.8 atm is at gage pressure of 0.2 atm \( \bar{P}_{abs} = \bar{P}_{g} + \bar{P}_{l} \)  
   False

e. Temperature is the property that is the same for each of two systems when they are in thermal equilibrium  
   True

f. A temperature change of 85 K is equal to a temperature change of 188 C  
   False

g. A temperature change of 188 C is equal to a temperature change of 370 F  
   True

h. A control volume is a special type of closed system that does not interact in any way with its surroundings  
   False
2. A vertical frictionless piston-cylinder assembly (shown in cutaway below) contains initially 0.025 kg of water at 10°C and 150 kPa. The cylinder is fitted with stationary stops, which limit the travel of the piston to a total of 0.10 m. The piston has an area of 0.05 m² and is weighted so that it maintains a constant pressure of 150 kPa on the water until the piston reaches the stops. Heat is transferred to the steam until the temperature reaches 150°C.
   a. Show the processes on a P-v diagram. (9 points)
   b. Find the temperature in Celsius of the steam when the piston first reaches the stops. (9 points)
   c. Find the pressure in bars of the steam when the temperature reaches 150°C. (9 points)
   d. Determine the magnitude of the total heat transfer required in kJ. (9 points)
3. The figure below shows an insulated tank of 0.266 m³ internal volume with a fixed thin membrane. One side of the tank is empty (vacuum). The other side is filled with 2 kg of steam at 3 MPa and the steam volume is 0.17 m³. The steam causes the shaft of a shaft-work machine (as shown in the figure below) to spin until it reaches a state of saturated vapor. At this point the membrane ruptures and the shaft stops spinning. Clearly identify your thermodynamic system.

   a. Find the pressure in bars at the time of rupturing the membrane. (9 points)
   b. Calculate the work interaction with the shaft-work machine in kJ. (9 points)
   c. Find the specific internal energy at the state after breaking of the membrane and filling of the vacuum. (10 points)
   d. Show the two expansion processes on a P-V diagram. (10 points)