ME 200 Thermodynamics 1
Fall 2018 – Exam 1

Circle your instructor’s last name

<table>
<thead>
<tr>
<th>Division 1 (7:30): Naik</th>
<th>Division 2 (9:30): Choi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division 3 (1:30): Wassgren</td>
<td>Division 4 (8:30): Holloway</td>
</tr>
<tr>
<td>Division 6 (11:30): Sojka</td>
<td>Division 7 (2:30): Vuppuluri</td>
</tr>
<tr>
<td>Division 8 (12:30): Buckius</td>
<td></td>
</tr>
</tbody>
</table>

Number of extra papers used if any

INSTRUCTIONS

- **Do not remove staples from any page.** If you use extra paper, attach it at the end of the exam with a paper clip and indicate above how many extra sheets were attached.
- **Do not write on the back of any page** because it will not be scanned so will not be graded.
- **This is a closed book and closed notes exam.** Equation sheets and all needed tables are provided.
- Significant credit for each problem is given if you identify your system and its boundary, draw the relevant energy flows on a diagram i.e. Energy Flow Diagram (EFD), start your analysis with the basic equations, list all relevant assumptions, and have appropriate units and use three significant figures. There is no need to re-write the given and find.
- Do not hesitate to ask if you do not comprehend a problem statement. For your own benefit, please write clearly and legibly. **You must show your work to receive credit for your answers.**

IMPORTANT NOTE

The use of PDAs, Blackberry-type devices, cell phones, laptop computers, smart watches or any other sources of communication (wireless or otherwise) is strictly prohibited during examinations. Doing so is cheating. If you bring a smart watch, cell phone, or other communication device to the examination, **it must be turned off** prior to the start of the exam, **placed in your backpack, and the backpack must be stored below your seat.** It shall be **reactivated only after you leave the examination room for the final time.** Otherwise it is a form of cheating and will be treated as such.

SECOND IMPORTANT NOTE

The only calculators allowed for use on this exam are those of the **TI-30X** series. No others.
1. [20 points]
Circle the correct answer (no partial credit) for (a) to (c). [2 points each]

(a) For a substance near saturation dome (on either side of it/under it), phase can always be determined knowing pressure and temperature. (True or False)

(b) For a substance near saturation dome (on either side of it/under it), phase can always be determined knowing pressure and specific volume. (True or False)

(c) At critical point, the specific internal energy of saturated liquid is equal to specific internal energy of saturated vapor. (True or False)

(d) A constant mass system, having negligible changes in KE and PE, is supplied with 20 kJ of work and heat transfer of 50 kJ occurs from the system to surroundings. Does the energy of the system (decrease or increase or remain the same)? Justify using an equation. [7 points]

(e) A closed, rigid tank contains a saturated liquid-vapor mixture \((v < v_{\text{critical}})\). When the tank is heated to a pressure below critical pressure, the possible final phase(s) is/are (saturated liquid-vapor mixture, saturated liquid, saturated vapor, compressed liquid, superheated vapor). Justify using a P-v diagram. [7 points]
2. [40 points] Water substance with an absolute pressure of 1 bar and a quality of 0.25 (State 1) is expanded in a closed piston-cylinder device along a path for which $Pv^{1.5} = \text{constant}$ until the absolute pressure drops to 0.5 bar (State 2).

(a) Find the final quality. Report your answer in %.
(b) Calculate the work per unit mass of water during the process. Report your answer in kJ/kg.
(c) Determine the heat transfer per unit mass of water during the process. Report your answer in kJ/kg.
(d) Show the process on a P-v diagram relative to the vapor dome and the lines of constant temperature for the two states. Label the axes, two states, and indicate the process direction with an arrow.

Identify the system, show mass/energy interactions (EFD), list any assumptions and basic equations, and provide your solution. There is no need to re-write the given and find.
Last Name: _______________ First Name: ____________ Thermo no. ______

Extra Space for Problem 2
Last Name:_______________ First Name: _____________ Thermo no. ______

Extra Space for Problem 2
3. [40 points] A piston-cylinder device contains air, stops, and a linear spring as shown in the figure below. Air initially occupies a volume of 0.5 m$^3$ at an absolute temperature of 1000 K (State 1) when the spring is touching the piston without exerting any force. Air is cooled until the piston hits the stops when the volume of air is 0.2 m$^3$ (State 2). Further cooling of air decreases the absolute temperature of air to 250 K (State 3). The mass of the piston is 20 kg, its cross-sectional area is 0.03 m$^2$, and the spring constant is 100 N/m.

![Diagram of piston-cylinder device with air, piston, and linear spring](image)

Molecular weight of air: 28.97 kg/kmol

(a) Draw a free body diagram for the piston showing appropriate forces at State 1 and calculate absolute pressure of air at State 1. Report your answer in kPa.
(b) Determine the displacement of the piston corresponding to the volume change from State 1 to State 2. Report your answer in m.
(c) Draw a free body diagram for the piston showing appropriate forces at State 2 and find absolute pressure of air at State 2. Report your answer in kPa.
(d) What is the absolute pressure of air at State 3? Report your answer in kPa.
(e) Show the two processes on P-V diagram. Label the axes and three states and indicate the two process directions with arrows.
(f) Find the boundary work for air in the cylinder from State 1 to State 2. Report your answer in kJ.

Identify the system on the sketch provided, show mass/energy interactions (EFD), list any assumptions and basic equations, and provide your solution. There is no need to re-write the given and find.
Last Name:________________ First Name: _____________ Thermo no. ______

Extra Space for Problem 3
Last Name:______________ First Name: _____________ Thermo no. _____

Extra Space for Problem 3
Last Name: _______________ First Name: _____________ Thermo no. ______

Extra Space for Problem 3