

Last Name: _____ First Name: _____ Thermo no. _____

**ME 200 Thermodynamics 1
Fall 2017 – Exam 2**

Circle your instructor's last name

Division 1: Naik

Division 2: Sojka

Division 3: Wassgren

Division 4: Goldenstein

Division 6: Braun

Division 7: Buckius

Division 8: Meyer

INSTRUCTIONS

- 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.**
- **Do not write on the back of any page** because it will not be scanned so will not be graded. If you need extra paper raise your hand and a proctor will supply it.

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.

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1. [20 points] Circle all (and only all) correct answers.

(a) Can a constant mass of an ideal gas be compressed in an insulated piston-cylinder device using an isothermal process? Ignore KE and PE changes. You must justify your answer with equation(s) to receive any credit on this problem.

Yes

No

(b) A constant mass of an ideal gas is heated from 300 K to 1000 K in a piston-cylinder device while maintaining the pressure constant either at 1 bar (Process A) or at 10 bar (Process B). Ignore KE and PE changes. Which of the following is true regarding heat transfer in the two processes? You must justify your answer with equation(s) to receive any credit on this problem.

$$Q_A = Q_B$$

$$Q_A < Q_B$$

$$Q_A > Q_B$$

Insufficient information

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Problem 1 (continued)

(c) Which of the following assumption(s) is (are) required to calculate the mass flow rate as: $\dot{m} = \rho AV$? No justification is required for the answer(s) on this problem.

Steady state

1-inlet, 1-exit

One-dimensional, uniform flow

No change in potential energy

(d) Which of the following assumption(s) is (are) required to obtain the relation for volume flow rate as: $A_1V_1 = A_2V_2$? You must justify your answer with equation(s) to receive any credit on this problem.

Steady state

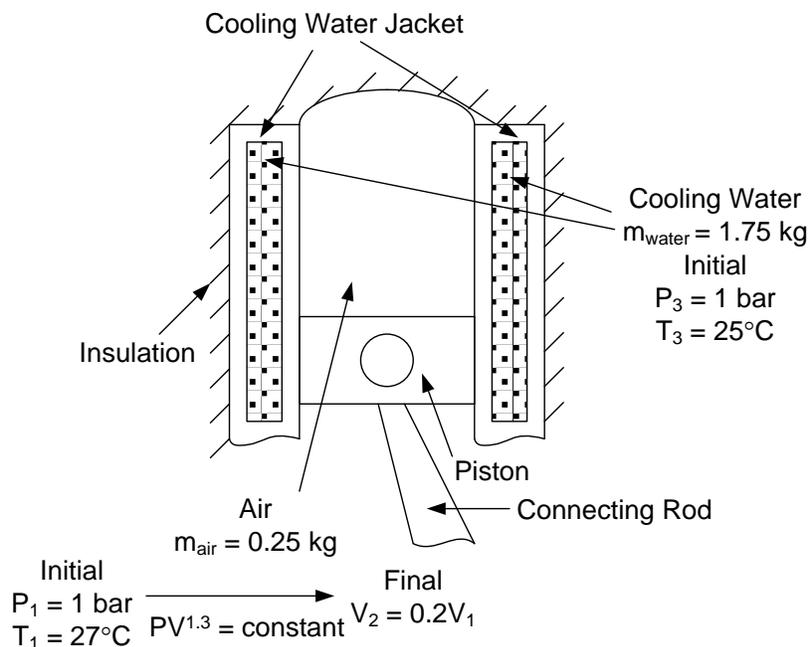
1-inlet, 1-exit

Incompressible

No change in potential energy

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2. [40 points] A piston-cylinder device contains 0.25 kg of air initially at temperature of 27°C and an absolute pressure of 1 bar (State 1). The air undergoes a compression process, where $PV^{1.3} = \text{constant}$, until the volume is 20% of the initial volume (State 2). The cylinder is fitted all around its outer wall with a cooling water jacket. The cooling water jacket contains 1.75 kg of liquid water. The water is initially at a temperature of 25°C and an absolute pressure of 1 bar (State 3) at the start of the air compression process. Heat transfer occurs only between air in the cylinder and water inside the cooling jacket since the water jacket is perfectly insulated on the outside.



Molecular weight of air: 28.97 kg/kmol

Specific heat of liquid water: 4.18 kJ/kg-K

Use the closest value in ideal gas table; do not interpolate.

- Determine the boundary work (kJ) for air during the compression process.
- What is the temperature change ($^\circ\text{C}$) of water during the compression process?

Identify appropriate system or systems 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.

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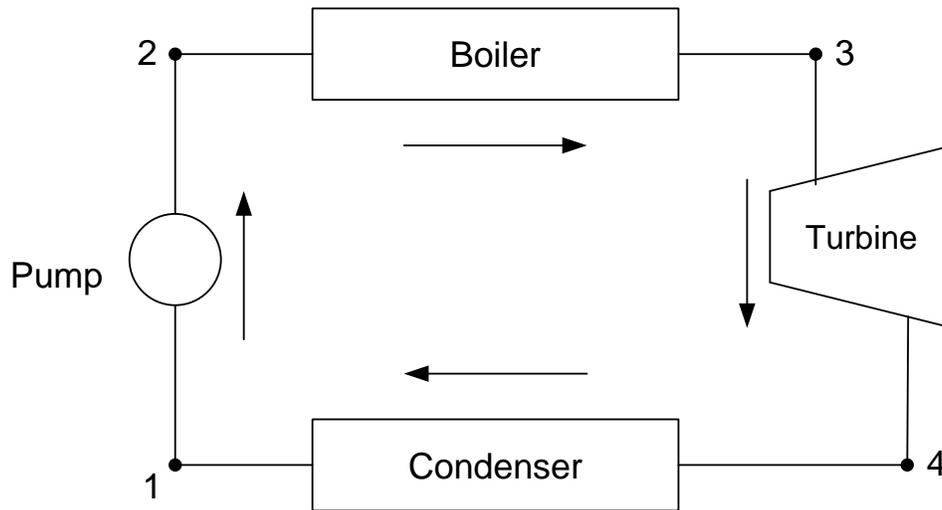
Extra Space for Problem 2

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Extra Space for Problem 2

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3. [40 points] A solar-powered steam power plant uses the sun's radiation to boil water. At peak operating conditions, the rate of radiation heat transfer into the boiler is 420 MW. The working fluid is water/steam, with data at each state provided in the table below; all the pressure values are absolute.



State	P, bar	T, °C	u, kJ/kg	h, kJ/kg	v, m ³ /kg
1	0.0123	10	42.0	42.0	0.00100
2	40	10	41.9	45.9	0.000998
3	40	600	3280	3670	0.0988
4	0.0123	10	2150	2270	95.7

- Calculate the steam mass flow rate (kg/s) through the boiler
- Find the net power (MW) produced by the power plant.
- Determine thermal efficiency (%) of the power plant.
- Show the cycle on P- v diagram relative to the vapor dome and the relevant lines of constant temperature. Label the axes and four states and indicate the process directions with arrows. Critical temperature and pressure of water are 374°C and 221 bar, respectively. Saturated liquid water exits the condenser/enters the pump at State 1. Note that T_{sat} at 40 bar is 250.4°C.

Identify appropriate system or systems 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.

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Extra Space for Problem 3

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Extra Space for Problem 3