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

DISCLAIMER

This practice exam is only for practice. The actual exam may not have a format similar to the problems included in this practice exam.

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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: $\dot{m} = \rho A V$? 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: $A_1 V_1 = A_2 V_2$? 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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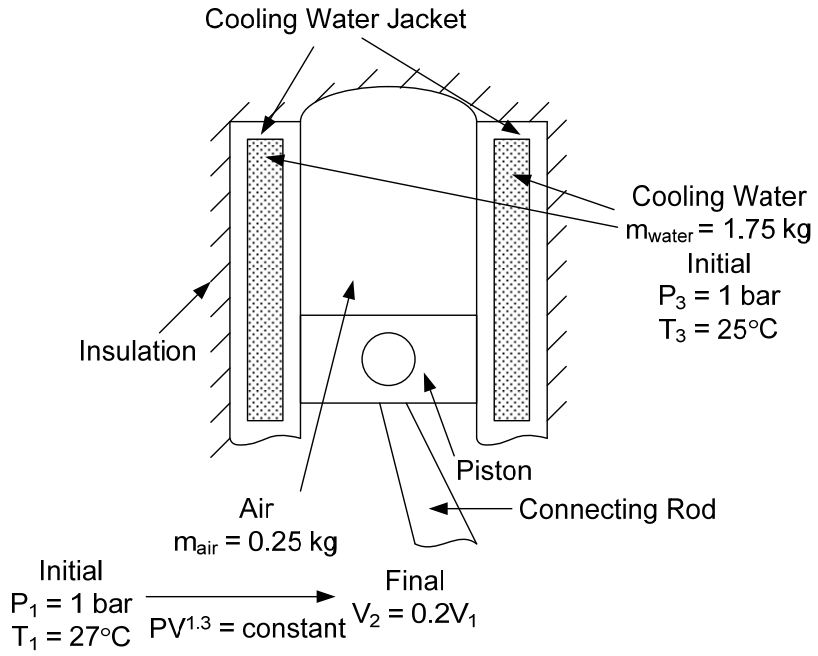
2. [40 points] A piston-cylinder device contains 0.25 kg of air initially at a temperature of 27°C and an absolute pressure of 1 bar (State 1). The air undergoes a compression process, where $PV^{1.3}$ = constant, until the volume is 20% of the initial volume (State 2). The cylinder is fitted with a cooling water jacket all around its outer wall. 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 its 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.

(a) Determine the boundary work (kJ) for air during the compression process.
(b) What is the temperature change (°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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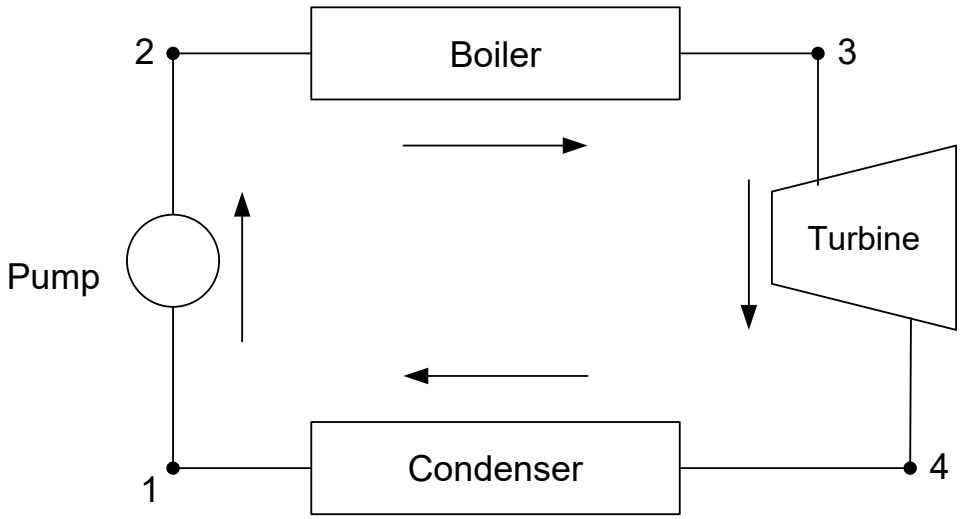
3. [40 points] A solar-powered steam power plant uses the sun's radiation to boil water. At peak operating conditions, the rate of radiation heat transfer into the boiler is 420 MW. The working fluid is water/steam, with data at each state provided in the table below; all the pressure values are absolute.



State	P, bar	T, °C	u, kJ/kg	h, kJ/kg	ν, 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

(a) Calculate the steam mass flow rate (kg/s) through the boiler
(b) Find the net power (MW) produced by the power plant.
(c) Determine thermal efficiency (%) of the power plant.
(d) Show the cycle on P-ν 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.

Selected Answers

1(a) No

1(b) $Q_A = Q_B$

2(a) W_{12} = -44.5 kJ

2(b) 1.38°C

3(a) 115.9 kg/s

3(b) 161.8 MW

3(c) 38.5%