Mechanical Engineering Department V.P. Carey
University of California at Berkeley Fall 2020

Midterm 1. Extended Analysis Problems

NAME: ____

Read this before downloading the test and sign below to acknowledge the instructions. This signed first page must be submitted with your solutions.

Failure to sign and submit this will result in loss of 5 points in addition to deductions for not following instructions.

1. You are on your honor **not** to consult with classmates or other individuals regarding solution of the problems on this midterm, and **not** to post solution information on the internet.

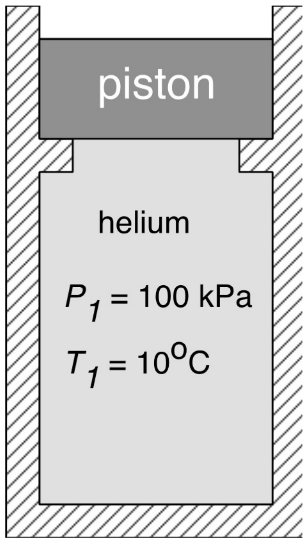
2. To get full credit you must:
(a) indicate what the equations you use represent, and why they apply
(b) if terms in the full governing equations are neglected, indicate why
(c) indicate any idealizations about processes
(d) indicate how properties are evaluated (indicate table number if relevant)
(e) indicate units on properties and final answer

Failure to adhere to these instructions (a)-(e) will result in loss of up to 20% of points for the problem.

I acknowledge the instructions above. Signature: _________________________________

Unless you have received information about a special time window, once you start, you will have 100 minutes to complete this portion of the exam, (including scanning and uploading) and your work must be submitted by **midnight Pacific time, Friday October 2, 2020**. Be sure to allow time at the end to scan and upload your work.

Problem 1. (30 pts.)



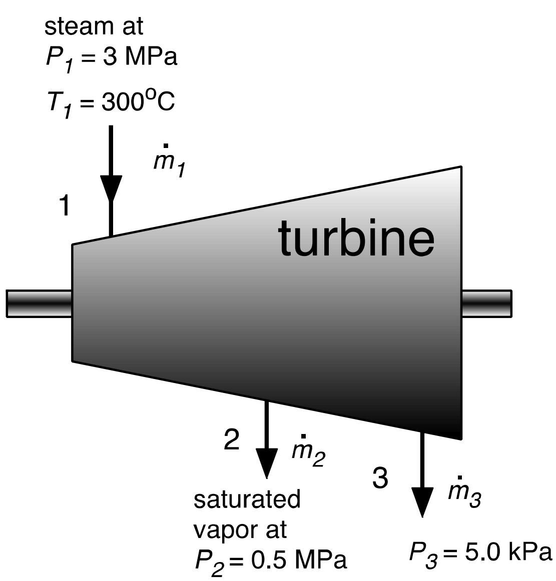
As shown at left, a piston and cylinder device whose piston is resting on a stop contains 0.5 kg of helium gas, initially at 100 kPa and 10°C. The mass of the piston and the effect of the atmospheric pressure acting on the piston are such that a pressure of 500 kPa is required to raise the piston off the stop.

(a) How much energy must be transferred by heat to the helium (Q_{12}) before the piston starts rising? Treat helium as an ideal gas with constant specific heats.
(c_v = 3.116 kJ/kgK, c_p = 5.193 kJ/kgK).

(b) Determine the resulting change in entropy for the helium system for the process 1→2 in part (a)

(c) If the heat input to the helium comes from a surrounding isothermal reservoir at 2000 K, what is the entropy change of the reservoir? Should the entropy decrease of the reservoir equal the entropy increase of the system for the process 1→2? Justify your answer using thermodynamic principles.

Problem 2 .(50 pts.)



A well-insulated (adiabatic) turbine operating at steady state with steady inlet and exit conditions is shown schematically above. Bulk kinetic and potential energy effects are negligible. Steam enters at state 1 at P_1 =3.0 MPa and T_1 = 300 °C at a flow rate $\dot{m}_1$ = 14.0 kg/s. Some steam is extracted part-way through the turbine at

the saturated vapor state for pressure P_2 = 0.5 MPa. The remaining part of the steam flow continues and exits at the end of the turbine at pressure P_3 = 5.0 kPa. The process from 1 to 2 is irreversible, and the process from 2 to 3 is reversible.

(a) Find the specific enthalpy values at states 1, 2 and 3.

(b) Plot points and add labels to indicate states 1, 2 and 3 on the *T*-*s* diagram to the right. For full credit you must plot the points in the correct locations.

(c) The total power output of the turbine is 11,800 kW. Determine the mass flow rates at the exits $\dot{m}_2$ and $\dot{m}_3$.

(d) Determine the total rate of entropy generation associated with the flow of steam through the turbine.