ID NUMBER________________

Unified Engineering
Thermodynamics & Propulsion Quiz 1

Spring 2007
Z. S. Spakovszky

Calculators are allowed, no books or notes.

One cheat sheet allowed, written on the front and the back with your personal notes.

All problems count the same.

- Put your ID number on each page of the exam.
- Do all work for each problem on the pages provided.
- Show intermediate results. Partial credit will be given, but only when the intermediate results and explanations are clear.
- Explain your work – don't just write equations.
- Please be neat. It will be easier to identify correct or partially correct responses when the response is neat.
- Show appropriate units with your final answers.
- Underline your final answers.

Exam Scoring

1. (33%)	
2. (33%)	
3. (34%)	
Total (out of 100%)	

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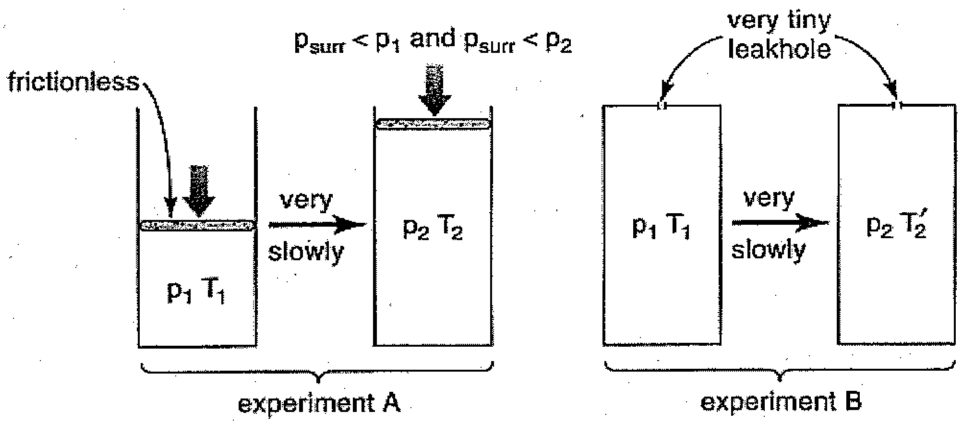
1. The sketches below show two ideal experiments, both done in perfectly insulated containers. In the experiment on the left, the container lid is moved **very slowly.** In the experiment on the right, the hole is small enough so that the gas leaks out **very slowly**. In both experiments the initial pressure p_1 decreases to p_2.



a) What is the thermodynamic process that the gas undergoes in each of the two experiments? Is the specific entropy of the gas **inside** the container the same in both cases? Why or why not?

b) Is $T_2' > T_2$, or $T_2' < T_2$, or $T_2' = T_2$? Discuss how you came to this conclusion.

c) Is there a difference in the work received by any agency external to the gas? If so, describe it?

d) Is experiment A reversible? Why or why not? If irreversible, where is entropy generated?

e) Is experiment B reversible? Why or why not? If irreversible, where is entropy generated?

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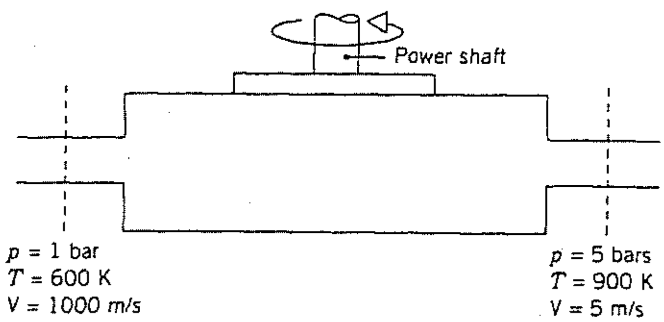
2. The following device operates at steady-state and is well insulated. Air enters at one location and exits at another with a mass flow rate of 10 kg/s. Assume air to be a perfect gas with cp=1004 J/kgK and $\gamma = 1.4$. Potential energy effects can be neglected.



a) Determine the direction of the air flow. (*Hint: it might be useful to initially assume directions of the different energy fluxes and then to check for consistency.*)

b) Draw the process in an *h-s* diagram and label all states (both static and stagnation).

c) Find the shaft power in kW. Indicate the specific shaft power in the *h-s* diagram.

d) What is the direction of the shaft power flow? Indicate this in your drawing of the device.

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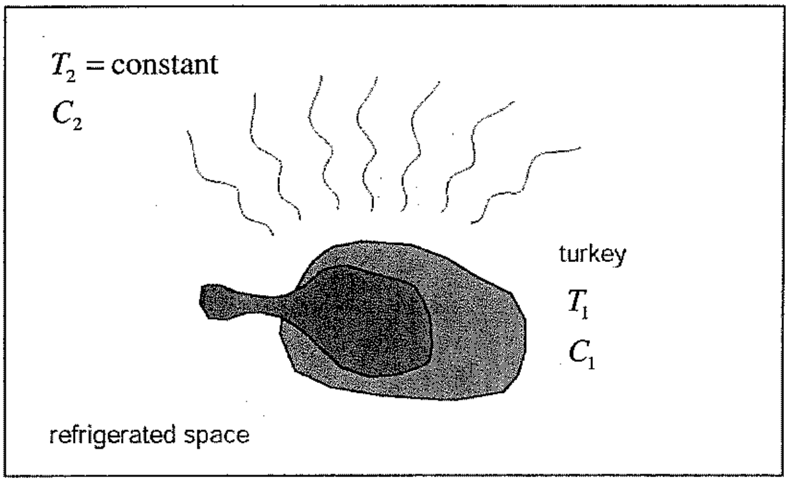
3. After a dinner party, a warm turkey is placed into a refrigerated space. The temperature of the refrigerated space is kept constant by a Carnot refrigerator. After a long period of time, the turkey and the refrigerated space reach thermal equilibrium. The turkey and the air in the refrigerated space have specific heat capacities C_1 and C_2, and the initial temperatures are T_1 and T_2 respectively.



a) What is the final temperature of the overall system (turkey and the refrigerated space) when thermal equilibrium is reached?

b) What is the change in entropy of the turkey?

c) What is the change in entropy of the refrigerated space?

d) How much entropy does the Carnot refrigerator's cooling system pump out of the refrigerated space, i.e. what is the change in entropy of the rest of the universe?

e) How much entropy is generated in the cooling process?

f) Indicate where and discuss how the entropy is generated. A sentence or two is expected.

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