ECE309

INTRODUCTION TO THERMODYNAMICS & HEAT TRANSFER

16 June 2004

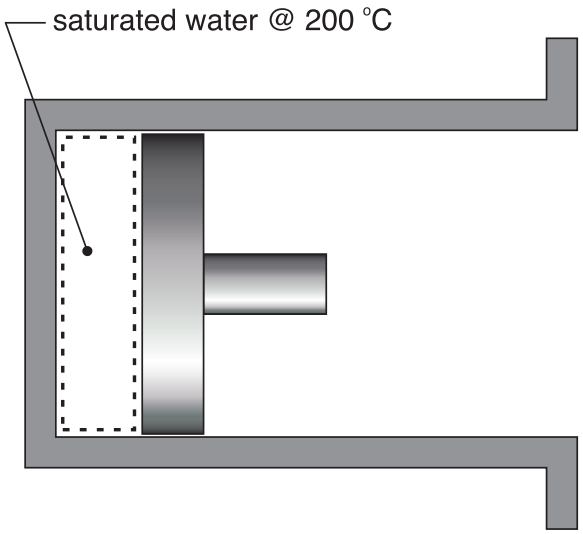
Midterm Examination R. Culham

- This is a 90 minute, closed-book examination.
- You are permitted to use one 8.5 in.$\times$ 11 in. crib sheet (one side only), Conversion Factors (inside cover of text) and the Property Tables and Figures from your text book.
- There are 4 questions to be answered. Read the questions very carefully.
- Clearly state all assumptions.
- It is your responsibility to write clearly and legibly.

Question 1 (20 marks)

Initially saturated water at $\mathbf{200}\ ^{\circ}\boldsymbol{C}$ is contained in a piston-cylinder device as shown below. The water is then heated isothermally until its volume is $\mathbf{100}$ times larger than its initial volume.

a) Determine the increase in energy $[\boldsymbol{kJ/kg}]$ of the water
b) Determine the work transfer $[\boldsymbol{kJ/kg}]$ and indicate whether it is into or out of the water.
c) Determine the heat transfer $[\boldsymbol{kJ/kg}]$ and indicate whether it is into or out the water.



Question 2 (20 marks)

Air at $40\ °C$ and $0.6\ MPa$ enters a $25\ mm$ diameter pipeline at a mass flow rate of $0.01\ kg/s$. The air flows through several valves and leaves the pipeline at a pressure of $110\ kPa$. The pipeline and the valves can be assumed to be adiabatic.

a) Determine the velocity of the air $[m/s]$ entering the pipeline.
b) Neglecting changes in kinetic energy, determine the exit state, i.e. T and v of air.
c) Based on your answer to part b), determine the exit velocity $[m/s]$ of the air.
d) Determine the exit state, T and v of the air if the change in kinetic energy is accounted for by assuming the exit velocity is the value found in part c). How much difference is there between your new state and the state found in part b)? What conclusion do you reach regarding the importance of including kinetic energy terms in your analysis?

Question 3 (15 marks)

Air is contained in a rigid, adiabatic $0.3\ m^3$ container at $20\ °C$ and $101.325\ kPa$. A paddle wheel sticking into the container then does $50\ kJ$ of work. Determine the entropy produced $[kJ/K]$.

Question 4 (20 marks)

One kilogram of superheated water vapour (steam) at $700\ °C$ and $2.0\ MPa$ is contained in an ejection tube behind a $50\ kg$ projectile that is initially held in place by a pin. The pin is then removed and the vapour pushes the projectile forward into the reference atmosphere at $T_{atm} = 20\ °C$ and $P_{atm} = 100\ kPa$. The process is adiabatic and occurs without friction.

a) Determine the expansion ratio V_2/V_1 necessary to obtain the maximum possible projectile velocity. Hint: a process with no irreversibilities.
b) Determine the maximum possible projectile velocity $[m/s]$.