M E 417 Thermodynamics II
Midterm Examination
October 2000, D.J. Bergstrom

TIME: 1 ½ hours

Provide complete answers to the following questions. State the major assumptions. Where applicable, sketch the process diagram and identify the state points. Reference all property tables which are used.

You are permitted to use the property tables in the appendices of the text, the conversion tables on the inside front cover, and your own problem solutions. A generic version of a formula sheet is also attached.

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1. [30 marks] Consider a water vapour power cycle. The turbine inlet pressure and temperature are 40 bars and 440°C, respectively. The reheat pressure is 5 bars, and the steam is reheated to a temperature of 360°C before entering the second stage turbine. The turbine efficiency is 85 percent.
   a) Determine the additional heat transfer $\dot{Q}/\dot{m}$ (per unit mass) required by the reheat process.
   b) Determine the work $\dot{W}/\dot{m}$ developed by the first stage turbine.
   c) Give two specific advantages of the use of reheat in a Rankine power cycle.

2. [55 marks] An Atkinson cycle can be created from an Otto cycle by extending the expansion stroke until the gas reaches the initial pressure, p_1. The cycle is then closed by a constant pressure heat rejection process. Consider an Atkinson cycle where the initial pressure and temperature are 100 kPa and 300 K, respectively. The constant volume heat addition is 1400 kJ/kg. Assume that the compression and power strokes are both isentropic, and use air standard analysis.
   a) Sketch the cycle on a p-v diagram.
   b) Determine the state points.
   c) Calculate the work (per unit mass).
   d) Calculate the thermal efficiency.
   e) Do you expect the thermal efficiency to be greater or less than that of an Otto cycle? Justify your answer.

3. [15 marks] Consider the differential relation: $du = T\,ds - p\,dv$
   a) Relate this equation to the classical statement of the first law.
   b) Simplify this relation for the case of an incompressible fluid.
   c) For an incompressible fluid with a constant specific heat, determine the change in entropy as a function of temperature.
   d) [Bonus] Use a Legendre transformation to obtain a differential expression for dh where $h(s, p)$.