COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
M E 417.3 Thermodynamics II
Final Examination
December 1999; *D.J. Bergstrom*

TIME: 3 hours

Provide specific and complete answers to the following questions. State the major assumptions, and identify the state points. Use a process diagram where appropriate. Reference all tables which are used. This is a closed book exam; the student is only allowed to use the property tables in the text, and can refer to his/her assignment solutions as well as a formula sheet. A generic formula sheet is attached to the exam.

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25 1. Air enters the compressor of an ideal gas turbine at $100\ kPa, 300\ K$ with a volumetric flow rate of $5\ m^3/s$. The compressor pressure ratio is 10. For a turbine inlet temperature of $1600\ K$, use air standard analysis to determine:

a) The net power developed.

b) The thermal efficiency.

Include a sketch of the cycle on a $T-s$ diagram.

10 2. For the turbine considered in question (1), let the isentropic efficiency be $\eta_t = 0.85$. Evaluate the second-law efficiency of the turbine, and comment on the significance of your answer.

30 3. One kmol of CO_2 initially at temperature $T_1 = 400K$ and pressure $p_1 = 1\,atm$ is heated at constant pressure until a final state is attained consisting of an equilibrium mixture of CO_2, CO, O_2.

a) If the amount of CO_2 in the equilibrium mixture is $0.422\ kmol$, determine the final temperature, T_2.

b) Calculate the work and heat transfers.

30 4. Consider a rocket nozzle with a throat diameter of $d_t = 10\ mm$. Solid propellant fuel supplies a gas at $800\,K$ and $1\ MPa$. For the gas, use: $k = 1.2$ and $R = 0.189\,kJ/kg \cdot K$.

a) For choked flow, determine the mass flow rate.

b) If the nozzle is designed to smoothly accelerate the gas to supersonic flow at the exit, determine the correct exit diameter. At an elevation of $600\,m$, assume an ambient pressure of $94.4\,kPa$.

c) For a normal shock wave standing at a location where the diameter is $d = 12\ mm$, determine the temperature change across the shock wave.

5 5. Explain the concept of "matching the source and use temperatures" as it applies to the energy supplied from a thermal generating plant.

The End