M E 417 Thermodynamics II
Midterm Examination
October 2003, 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 that 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] Air at $p_o = 300\ kPa$ and $T_o = 500\ K$ flows through a converging-diverging nozzle into a large receiving vessel (tank). The area at the throat of the nozzle is $A_t = 1\ cm^2$, and the area at the exit plane is $A_e = 3\ cm^2$. Assume constant specific heats with $k = 1.4$. If the mass flow rate is $\dot{m} = 195.2\ kg/h$, what is the maximum value of the pressure at the exit. Explain the rationale for your calculation.

2. [25 marks] Consider the same nozzle as in question 1 but for different flow conditions with a normal shock wave standing in the exit plane. If the exit pressure (just downstream of the shock wave) is $125\ kPa$, calculate the stagnation pressure upstream of the shock wave.

3. [45 marks] The processes in each cylinder of an IC engine are modelled by an *air standard Diesel cycle* with a cutoff ratio of 2.5. At the beginning of the compression stroke, the flow properties are: $p_1 = 95\ kPa$, $T_1 = 22\ ^oC$ and $V_1 = 3.2\ L$. At the end of the compression stroke, the temperature is $T_2 = 850\ K$.

   a) Sketch the cycle on a $p - v$ diagram and fix the state points.
   b) Calculate the compression ratio.
   c) Calculate the net work developed per cycle (kJ), and the thermal efficiency.
   d) Comment on how the air standard efficiency relates to the actual or indicator efficiency calculated from performance data measured in the laboratory. Explain the reason for any discrepancies.

THE END