MAE 113
Fundamentals of Propulsion, Winter 2008
Midterm 1

Duration: 1 hour and 20 min.
Closed books; closed notes.
Maximum credit points possible: **115**

Problem 1(50%)

An **ideal** ramjet is traveling at Mach 3 at 4572m standard altitude (the external static temperature is 258.4K, and the external static pressure is 57.1kPa; $c_p = 1.005 kJ/kg \cdot K$; $\gamma = 1.4$; $R = 287.1 J/kg \cdot K$). The heating value of the fuel is 46,520kJ/kg. Air flow through the engine at 45.35 kg/s. The combustor exit total temperature is 1944K.
Find (a) The temperature at its front stagnation point (b) The combustor exit total pressure (c) The fuel-air ratio (d) The thrust specific fuel consumption.

Problem 2(50%)

Air flows steadily and isentropically through a variable-area duct. At section 1, $A_1 = 20 cm^2$, $P_1 = 300 kPa$, $\rho_1 = 1.75 kg/m^3$, and $M_1 = 0.25$. At section 2, the area is exactly the same, but the flow is much faster. Compute (a) The Mach number, velocity and temperature at section 2. (b) The mass flow rate (c) Is there a sonic throat between sections 1 and 2? If so, find its area. $\left(\gamma = 1.4; R = 287.1 J/kg \cdot K\right)$

Problem 3 (Bonus=+15%)

A calorically perfect gas expands adiabatically in steady flow from a pressure of 6MPa, a temperature of 3000K, and a velocity of 200m/s to a final pressure of 0.101MPa. $c_p = 2.494 kJ/kg \cdot K$; $\gamma = 1.2$

(a) For any adiabatic expansion from the same initial conditions to the same final pressure, is it possible for the final temperature to be as low as 450K?
(b) If no work is done on or by the gas during the process of expansion to the final pressure of 0.101MPa, what is the maximum possible final velocity? In this case, how high would the final temperature be?