AERO 360
Design Project
Prof. J. M. Powers

Given: A large supply of pure N_2 at $P_o = 10.0\ MPa$, $T_o = 225\ K$

Design: A converging-diverging nozzle with circular cross section for a thruster for an aerospace vehicle entering the atmosphere of another planet which happens to have a high ambient pressure relative to that of the earth.

Rank-Ordered Design Criteria:

1. $F_{thrust} = \frac{Your\ Social\ Security\ Number}{1 \times 10^8}\ kN$
2. shockless supersonic flow when $P_b = 2\ MPa$
3. no condensed N_2 in duct
4. $\left|\frac{dr}{dx}\right| < 0.15$ in the converging section
5. $\left|\frac{dr}{dx}\right| < 0.05$ in the diverging section
6. minimum duct length
7. minimum peak cross-sectional area

Milestones:

1. **April 13, 1995**, Preliminary design due. For a frictionless, isentropic, calorically perfect ideal gas model, give $A(x)$, $P(x)$, $T(x), M(x), P_o(x), T_o(x)$ under supersonic design conditions. For the same $A(x)$, show $P(x)$, $T(x)$, $M(x)$, $P_o(x)$, $T_o(x)$ if the back pressure were at subsonic design conditions. Calculate the thrust for both cases. (25%)
2. **May 2, 1995**, Final design due. Give $A(x)$, $P(x)$, $T(x)$, $M(x)$, $P_o(x)$, $T_o(x)$ under supersonic design conditions. Give $P(x)$ for the same $A(x)$ for a variety of back pressures ranging from $P_{supersonic\ design} < P_b < P_o$. For full credit include the effects of Darcy friction, normal shocks in duct, and non-ideality. I recommend a calorically perfect van der Waals state equation. (75%)

Both portions must be written as formal technical memoranda (written using LaTeX). Include a brief statement of the problem in your own words and a summary of your results. Number all figures and refer to each figure in the text. Your text should indicate if and how you met all design criteria. Include footnoted references if necessary. Detailed analysis should be included as you feel necessary. This should be relegated to appendices which can be done either in LaTeX or neatly handwritten.