NAME:
AERO 360
Examination 1
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1. (20) Write the energy equation in *non-conservative form* for a fluid which is

   - one-dimensional
   - unsteady
   - compressible
   - inviscid
   - heat conducting via Fourier's Law
   - a calorically perfect ideal gas

2. (20) A gas obeys the following thermal state equation:

$$P = \rho RT\left(1 + b\rho^2\right)$$

   Find a general expression for the internal energy and sound speed of this gas.

3. (20) Calorically perfect ideal helium, $R = 2,077\ \frac{J}{kg\ K}, \gamma = \frac{5}{3}$ is at rest in a tube at $P = 100\ kPa, T = 150\ K$. A piston travelling at $250\ \frac{m}{s}$ drives a normal shock wave into the helium. Calculate the speed of the shock wave and the change in specific entropy.

4. (20) A large tank contains air at $P_o = 25\ psia$, $T_o = 60°F$. Air exits a small circular hole of radius $0.5\ in^2$ to the atmosphere at $P_{atm} = 14.7\ psia$. What is the mass flow rate? For air take $R = 1,717\ \frac{ft^2}{s^2\ °R}, \gamma = \frac{7}{5}$ and assume it is a calorically perfect ideal gas. One also has $g_c = 32.17\ \frac{ft\ lbm}{lbf\ s^2}$.

5. (20) Argon, $\gamma = \frac{5}{3}, R = 208.13\ \frac{J}{kg\ K}$ flows isentropically through a duct. At section 1, $P_1 = 75\ kPa, T_1 = 200\ K, u_1 = 400\ \frac{m}{s}, A_1 = 0.02\ m^2$. At section 2 downstream, the cross-sectional area has tripled. Find $\dot{m}$, M_2, and P_2.