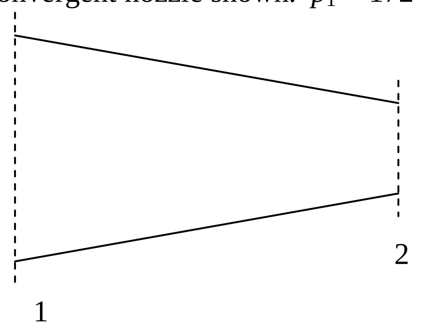
UUM 622B Advanced Problems in Compressible Flow

Assignment #2 **February 15, 2002**

1] Check on ability to apply "basic" governing equations! 2 kg/s of air flow through the convergent nozzle shown. p_1 = 172 kPa, T_1 = 350 K, A_1 = 0.1 m^2, p_2 = 101.3 kPa and T_2 = 330 K. Determine whether the flow between the inlet and the exit is isentropic. What is the force acting on the inner walls of the nozzle?



2] The Rankine-Hugoniot equation relates the density ratio to the pressure ratio and is given by

$$\frac{\rho_2}{\rho_1} = \frac{(\gamma - 1) + (\gamma + 1)\dfrac{p_2}{p_1}}{(\gamma + 1) + (\gamma - 1)\dfrac{p_2}{p_1}}$$

Starting with the governing equations for 1-D flow, derive the above. Also, show that the change in the internal energy across the shock is given by

$$e_2 - e_1 = \frac{p_1 + p_2}{2}\left(\frac{1}{\rho_1} - \frac{1}{\rho_2}\right)$$

3] Air flows through a convergent-divergent duct with an inlet area of 5 cm^2 and an exit area of 3.8 cm^2. At the inlet section the air velocity is 100 m/s, the pressure is 680 kPa and the temperature is 60 °C. Find the mass flow rate through the nozzle and, assuming isentropic flow, the pressure and the velocity at the exit section.

4] Air is expanded isentropically from a reservoir in which the pressure is 1000 kPa and the temperature is 30 °C until the pressure has dropped to 25 kPa. A normal shock wave occurs at this point. Find the static pressure, the static temperature, the air velocity and the stagnation pressure after the shock wave.

5] A normal shock wave propagates down a constant-area tube containing stagnant air at a temperature of 300 K. Find the velocity of the shock wave if the air behind the wave is accelerated to Mach number of 1.2.