UUM 622B Advanced Problems in Compressible Flow

Assignment #1 **February 8, 2002**

1] In class we just wrote down the mass conservation, momentum, and energy equations. Now derive them, in integral form, starting from scratch (i.e., draw a control volume and look at what goes in and out, what goes on at the surfaces, and what goes on inside!). Second, starting with the full equations in integral form, extract the governing equations for steady, adiabatic 1-D and quasi 1-D flow. Third, obtain the momentum and energy equations in the form $dp = -\rho u du$ and $dh = -u du$, respectively.

2] Carbon dioxide flows through a constant area duct. At the inlet to the duct, the velocity is 120 m/s and the temperature and pressure are 200 °C and 700 kPa, respectively. Heat is added to the flow in the duct and at the exit of the duct the velocity is 240 m/s and the temperature is 450 °C. Find the amount of heat being added to the carbon dioxide per unit mass of gas and the mass flow rate through the duct per unit cross-sectional area of the duct at inlet. Assume that for carbon dioxide γ=1.3.

3] A very weak pressure wave, i.e., a sound wave, across which the pressure rise is 30 Pa moves through air which has a temperature of 30 °C and a pressure of 101 kPa. Find the density change, the temperature change and the velocity change across this wave.

4] Calculate the speed of sound at 288 K in hydrogen, helium and nitrogen. Under what conditions will the speed of sound in hydrogen be equal to that in helium?