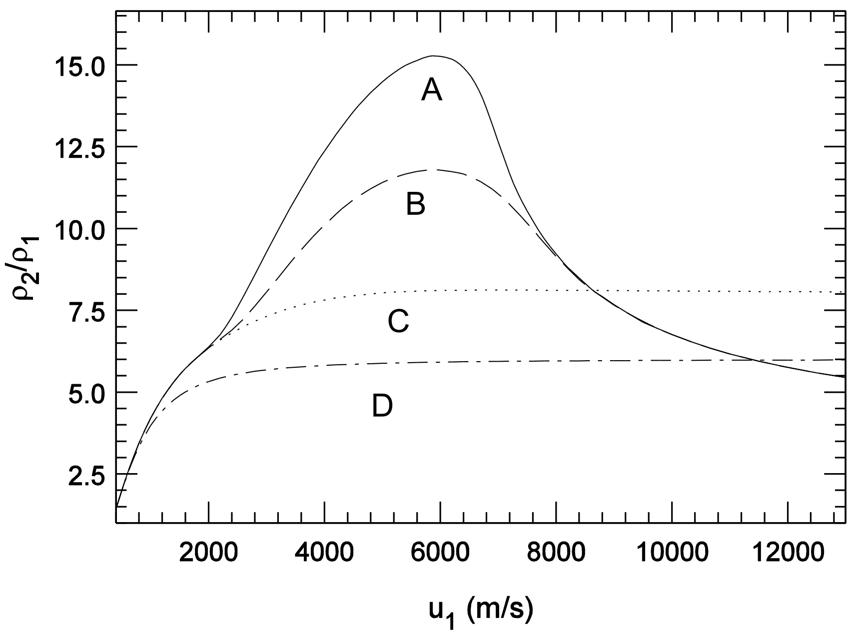
Equilibrium and Frozen Flows

• Homework solutions should be neat and logically presented, see format requirements (seitzman.gatech.edu/classes/ae6050/homeworkformat.html). Please note the requirement to draw some **implications** from the results of each problem. This could be implications for a practical device, a comparison of the results of different parts of a problem, a physical interpretation for an equation, etc.

• To receive credit, show ALL work in the format described above. If you use equations from the notes, the class textbook or another book, please cite the reference.

1. **Normal Shocks (based on former midterm problem)**

   The calculated density ratio across a normal shock, with the initial (oncoming) gas consisting of pure O_2 at 280 K, is shown in the figure below as a function of the oncoming gas velocity. The figure contains four curves, labeled A-D. Each curve is based on a different flow assumption: 1) equilibrium flow with the oncoming gas at a pressure of 1.0 atm, 2) cpg, 3) frozen chemistry but all other energy modes in equilibrium, and 4) equilibrium flow with an initial pressure of 0.01 atm.



   a) Determine which assumption is associated with which curve and explain your reasoning.

   b) At an oncoming velocity of 2400 m/s, which of these assumptions will result in the smallest speed of sound in the post-shock gases.

   c) At an oncoming velocity of 9000 m/s, which of these assumptions will result in the largest speed of sound in the post-shock gases?

2. **Supersonic Expansion**

Consider a (fictitious) diatomic gas of molecular weight 50.0 with a characteristic dissociation temperature of 50.0×10^3 K that is heated to a temperature of 4500. K and a pressure of 148 bar in a reservoir. Assume the gas can be treated as an ideal dissociating gas with a characteristic dissociation density of 1.50×10^5 kg/m^3, and with no electronic energy.

a) Estimate the degree of dissociation after the gas was heated.

b) Estimate the maximum velocity **and** the corresponding pressure that could be achieved if this hot, ideal dissociating gas was expanded isentropically from the reservoir through a CD nozzle to a temperature of 1750 K?

c) Estimate the velocity and corresponding temperature that would be achieved if the same hot gas was isentropically expanded to the **same** final pressure as in part b), **but** without a change in the hot gas composition during the expansion **and** assuming any vibrational energy modes were also frozen during the expansion.