AEE 343 Compressible Flow
Problem Set 3
Due Date: 2/26/2015

Problem 1

A supersonic wind tunnel is designed to produce flow in the test section at Mach 2.4 and standard atmospheric conditions. Assuming isentropic flow, calculate:

(a) The exit-to-throat area ratio of the nozzle.
(b) Reservoir pressure (in atm) and temperature (in ^{o}R).

Problem 2

Air flows steadily and isentropically from standard atmospheric conditions (P_0 = 14.7 psia, ρ_0 = 2.38 x 10^{-3} slug/ft^3, T_0 = 519^{o}R) to a receiver pipe through a *converging* duct. The cross section area of the throat of the converging duct is 0.05 ft^2. Determine the mass flow rate through the duct if the receiver pressure is (a) 10 psia, (b) 5 psia. Sketch the temperature-entropy diagrams for situations (a) and (b).

Problem 3

An ideal gas enters subsonically and flows isentropically through a choked converging-diverging duct having a circular cross section area A that varies with axial distance x from the throat according to the formula

$$A(x) = 0.1 + x^2$$

where A is in ft^2 and x is in ft. Note that the throat is located at x = 0. For this flow situation, sketch the side view of the duct and graph the variation of Mach number, pressure ratio p/P_0, and temperature ratio T/T_0 through the duct from x = -1 ft to x = +1 ft.

Problem 4

Carry out the same calculation as in problem 3 but for Helium, where γ = 1.66.

Problem 5:

Consider a convergent-divergent nozzle with an exit-to-throat area ratio of 1.53. The reservoir pressure is 1 atm. Assume isentropic flow, except for possibility of normal shock wave inside the nozzle, calculate the exit Mach number when exit pressure p_e is

(a) 0.94 atm (b) 0.886 atm (c) 0.75 atm (d) 0.154 atm.