AEE 553 — Compressible Flow

Department of Mechanical and Aerospace Engineering

Homework 7

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Problem 1

(a) Calculate p_∞ and p_0 at the exit of the nozzle before the NS reaches it.

(b) Calculate p_∞ and p_0 at the exit of the nozzle after the shock passes and before the contact surface arrives.

(c) If you had a blunt wind-tunnel model at the exit plane of the nozzle, what p_0 would it feel at the blunted tip surface in the state-2 flow? Briefly justify your answer.

(d) How long will it take for the NS to reach the probe from the time the valve opens? Generally speaking, what does this mean for your test-section data if your instrumentation within it is triggered to start collecting data right when the valve opens?

(e) How much time elapses between the passage of the NS and of the contact surface?

(f) In actuality, given the values in the Normal-Shock part of the problem, the expansion wave would propagate downstream initially. So, for this expansion-wave part of the problem re-do the necessary calculations from above for $p_0 = 1000\,\text{kPa}$ and $T_0 = 500\,\text{K}$ and the back air at $p = 101\,\text{kPa}$ and $T_0 = 295\,\text{K}$.

(g) Use the method of characteristics to plot p/p_4 and T/T_4 as a function of time at the end wall of the driver tube. Do this for a few different number of characteristics. How many characteristics seems like enough?

(h) Plot the characteristics from the valve to the end wall and back.

(i) How long does it take for the head to get back to the location of the valve? If you approximated this time assuming a constant head speed equal to the local speed of sound (as done in the paper), would you expect it to be different than how you calculated if? If so would it be larger or smaller?

Problem 2

(a) Write out a detailed methodology for the solution of flow around an axisymmetric cone with a sharp nosetip.

(b) Plot shock half angle θ_s vs. cone half angle θ_c for $M_\infty = 1.25$, 2.0, 6.0, and 10.0

(c) Repeat part (b) but include results for a wedge with the same shock angles. Explain why you observe these differences between cones and wedges.

(d) Plot the Mach number at the cone surface, M_c, vs. cone half angle θ_c for $M_\infty =$ 1.25, 2.0, 6.0, and 10.0.

(e) Assuming an angle of attack of 0° and $\gamma = 1.4$, use the given flight data to recreate the Taylor-Maccoll plot from the left plot in Fig. 22.

(f) Describe how the Taylor-Maccoll code could be used to estimate the angle of attack of the flight vehicle.