AAE 519 Prof. Schneider, Fall 2013
Problem Set 1
Handed Out: Monday, 19 August
Due: Friday, 30 August (in Schneider's mailbox in ARMS)

Consider inviscid flow past a sharp double wedge whose axis is aligned parallel to the stream. The upstream and downstream included angles are the same (see Figure 1). The pressure on the leading surface can be determined from oblique shock theory, and the pressure on the trailing surface can be determined from the Prandtl-Meyer expansion at the corner. Analyze this flow using perfect gas assumptions with $\gamma = 1.4$. Consider two half-angles for the wedge, 1.5 and 6 degrees (in other words, the flow on each side is turned by 1.5 or 6 degrees). Consider Mach numbers ranging from 2 to 30. Using both of the following analysis techniques, determine the shock angle, the surface Mach numbers and pressure coefficients on the leading and trailing surfaces, and the inviscid drag coefficient.

1. Full perfect gas theory, with no simplifying assumptions.

2. The hypersonic approximations to the above. The accuracy depends on which assumptions you make when you make these approximations; it depends on which terms you include and which terms you neglect. You may wish to try various approaches and see how well they work. In particular, you may want to consider approximating the oblique shock relations via expressions that are different from those shown in Fig. 2.2 of Anderson HHTG (1st or 2nd edition).

Plot the results vs. Mach number for each half angle. Compare the hypersonic approximation to the full theory. Does the approximation improve at higher Mach number? How do the results depend on the approximations that you choose to make? Is either set of results Mach-number independent at high Mach number? Can you scale the results to make them obey hypersonic Mach-number independence? How does the drag depend on Mach number? What happens to the afterbody pressure as the Mach number rises? Discuss your results.

Note: Equation 2.39 as printed on p. 46 of Anderson's hypersonics book (second edition) has a typo in it. The printing on p. 48 is correct.

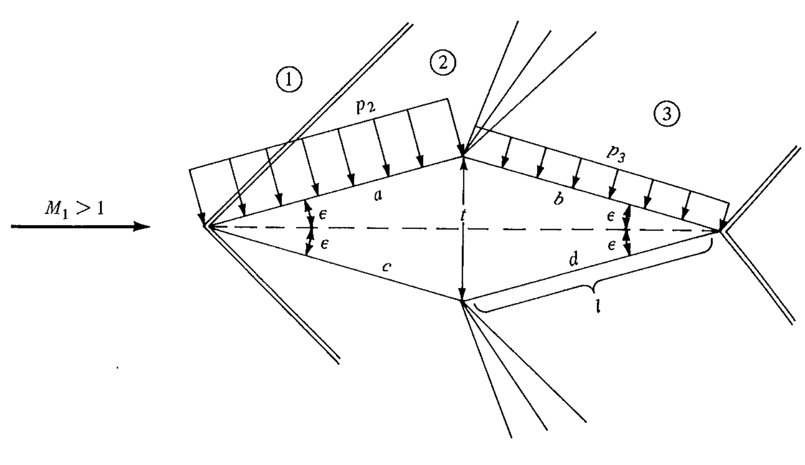

Figure 1: Double-Wedge Geometry (from Anderson, Fundamentals, 4e)