

AE 6020 High-Speed Flow Assignment #3

Unless otherwise stated, use the ratio of specific heats, $\gamma = 1.4$. Pick enough points in the varying Mach ranges to give you a good indication of the characteristics of the flow.

1. Consider supersonic and hypersonic flow of air (with $\gamma = 1.4 = \text{constant}$) over a 20 deg half-angle wedge. Let θ denote the wedge half-angle, and β the shock-wave angle. Then, $\beta - \theta$ is a measure of the shock-layer thickness. Make a plot of $\beta - \theta$ vs the freestream Mach number, M_∞ , from $M_\infty = 2$ to 20. Make some comments as to what Mach number range results in a “thin” shock layer.

2. Using the exact shock relations with a constant planar deflection angle of 20 degrees, compute the pressure ratio (p_2/p_1), density ratio (ρ_2/ρ_1), temperature ratio (T_2/T_1) and velocity ratios (u_2/V_1 , v_2/V_1), for initial Mach numbers varying from 2 to 20. Compare* your results with the limiting hypersonic equation results. What do you hypothesize happens for finite Mach numbers greater than 20?

3. Using the exact Prandtl-Meyer expansion wave theory and a constant expansion corner of 20 degrees, compute the pressure ratio for initial Mach numbers varying from 2 to 20. Compare* your results with the limiting hypersonic equation results. What do you hypothesize happens for finite Mach numbers greater than 20?

4. For the following examples, show that using Newtonian theory the c_L and c_D can be computed as:

a) flat plate at an angle of incidence, α

$$c_l = 2 \sin^2 \alpha \cos \alpha$$

$$c_d = 2 \sin^3 \alpha$$

b) an infinite span circular cylinder with radius R (flow is incident along the infinite span)

$$c_l = 0$$

$$c_d = 4/3$$

* What does ‘Compare’ or ‘Discuss’ signify? These words indicate that the homework example is designed to make you think about the results. So, if possible, you should compute differences or percentage differences. You should think about the differences or similarities of the results with respect to hypersonic flows and write a short paragraph on your observations.