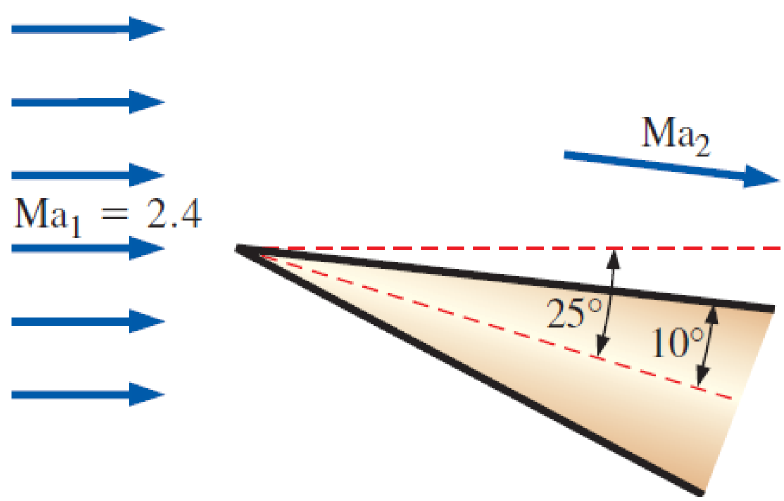
SPC 407

Sheet 7

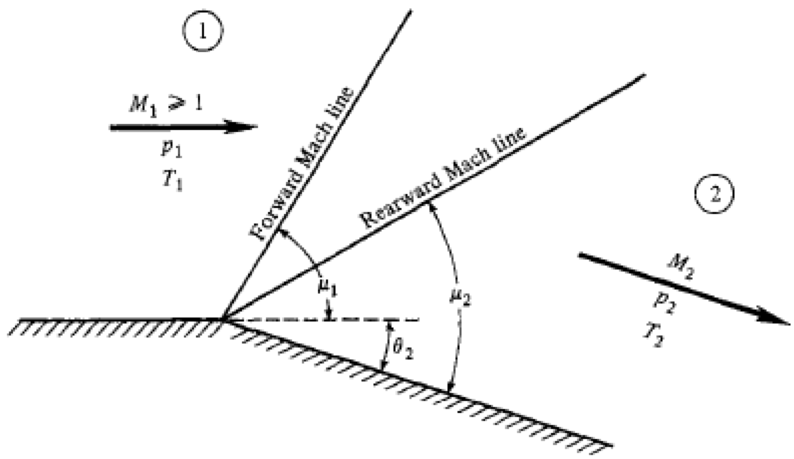
Compressible Flow – Expansion Waves

1. Are the isentropic relations of ideal gases applicable for flows across (a) normal shock waves, (b) oblique shock waves, and (c) Prandtl–Meyer expansion waves?
2. Air flowing at 32 kPa, 240 K, and $Ma_1 = 3.6$ is forced to undergo an expansion turn of 15°. Determine the Mach number, pressure, and temperature of air after the expansion.
3. For a given Prandtl-Meyer expansion, the upstream Mach number is 3 and the pressure ratio across the wave is $p_2/p_1 = 0.4$. Calculate the angles of the forward and rearward Mach lines of the expansion fan relative to the free-stream direction.
4. Consider the supersonic flow of air at upstream conditions of 70 kPa and 260 K and a Mach number of 2.4 over a two-dimensional wedge of half-angle 108. If the axis of the wedge is tilted 258 with respect to the upstream air flow, determine the downstream Mach number, pressure, and temperature above the wedge.



5. Reconsider Prob. 4. Determine the downstream Mach number, pressure, and temperature below the wedge for a strong oblique shock for an upstream Mach number of 5.

6. A uniform supersonic stream with $M_1 = 1.5$, $p_1 = 17001b/ft2$, and $T_1 = 460°$ R encounters an expansion comer (see Fig.) which deflects the stream by an angle $\theta_2 = 20°$. Calculate M_2, p_2, T_2, p_{02}, T_{o2}, and the angles the forward and rearward Mach lines make with respect to the upstream flow direction.



7. Consider a supersonic flow with an upstream Mach number of 4 and pressure of 1 atm. This flow is first expanded around an expansion comer with $\theta = 15°$, and then compressed through a compression comer with equal angle $\theta = 15°$ so that it is returned to its original upstream direction. Calculate the Mach number and pressure downstream of the compression comer.
8. Consider the arrangement shown in Fig. A 15° half-angle diamond wedge airfoil is in a supersonic flow at zero angle of attack. A Pitot tube is inserted into the flow at the location shown in Fig. The pressure measured by the Pitot tube is 2.596 atm. At point a on the backface, the pressure is 0.1 atm. Calculate the free-stream Mach number M_1.