AE339: High-speed aerodynamics
Tutorial 3

1. Air having an initial Mach number $M_1 = 2.0$ is deflected through an angle $\delta = 15^0$ by a frictionless surface. Assuming that a weak shock wave occurs, calculate (i) the downstream Mach number, (iii) pressure ratio and (iii) temperature ratio.

2. Air at a Mach number of 2.0 expands a sharp convex corner. While expanding around the corner, the flow has deflected away by an angle of 10^0. If the initial pressure and temperature of air are 100 kPa and 300 K, find the final pressure, temperature and Mach number of air, assuming isentropic expansion.

3. Derive the following relation for oblique shocks in a perfect gas

$$V_{n1}V_{n2} = a^{*^2} - \frac{\gamma - 1}{\gamma + 1}V_t^2$$

   where V_{n1},V_{n2} represent the normal components of velocity up and downstream of the oblique shock, V_t represents the tangential component and $*$ represents the critical condition.

4. Air at a pressure of $40kPa$ and -30^0C flows at Mach 3 down a wide duct. The upper wall of the duct turns sharply through an angle of 5^0 leading to the formation of an oblique shock wave.
   (a) Find the Mach number, temperature and pressure behind this shock wave.
   This shock wave strikes the lower wall of the duct exactly at a point where the lower wall turns away from the flow through an angle of 2^0.
   (b) Find the Mach number, pressure and temperature behind the reflected wave.