HW (Oblique Shock and Expansion waves)

Due: 21/2/1392

1- Pictured in Figure 1 is the air inlet to a jet aircraft. The plane is operating at 50,000 ft, where the the pressure is 243 psfa and the temperature is 392°R. Assume that the flight speed is $M_0 = 2.5$.

(a) What are the conditions of the air (temperature, pressure, and entropy change) just after it passes through the normal shock?

(b) If the single 15° wedge is replaced by a double wedge of 7° and 8° (see Figure 2), determine the conditions of the air after it enters the diffuser.

(c) Compare the losses for parts (a) and (b).

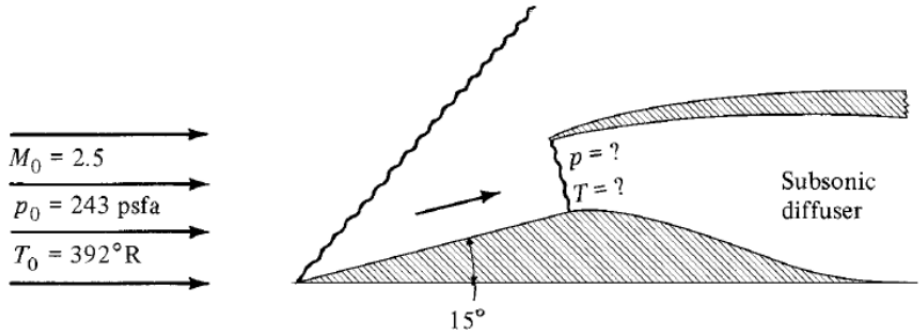


Fig. 1

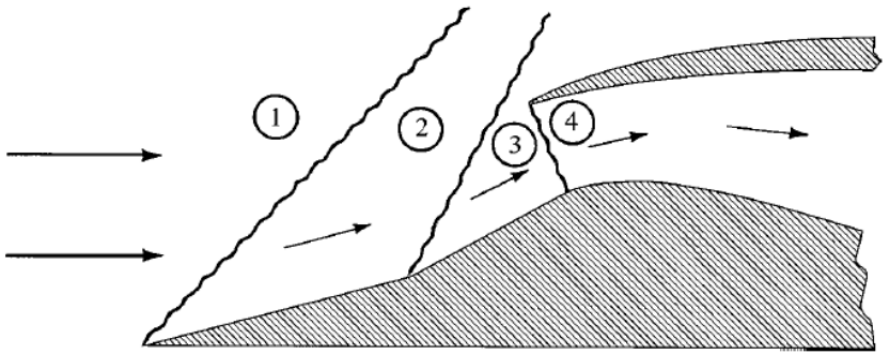
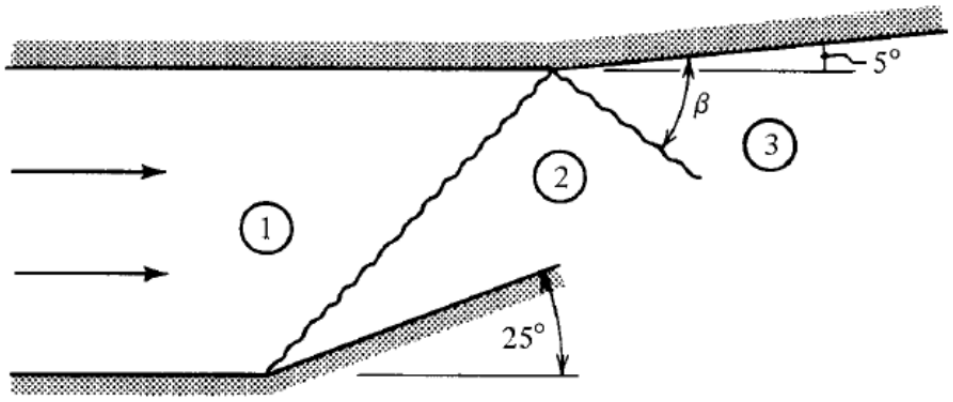


Fig. 2

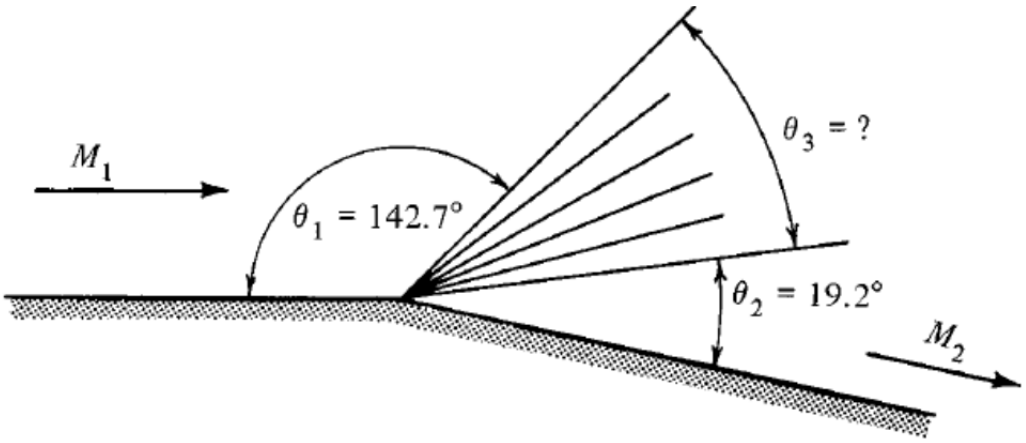
2- A uniform flow of air has a Mach number of 3.3. The bottom of the duct is bent upward at a 25° angle. At the point where the shock intersects the upper wall, the boundary is bent 5° upward as shown in Figure below. Assume that the flow is supersonic throughout the system. Compute M_3, p_3/p_1, T_3/T_1, and β



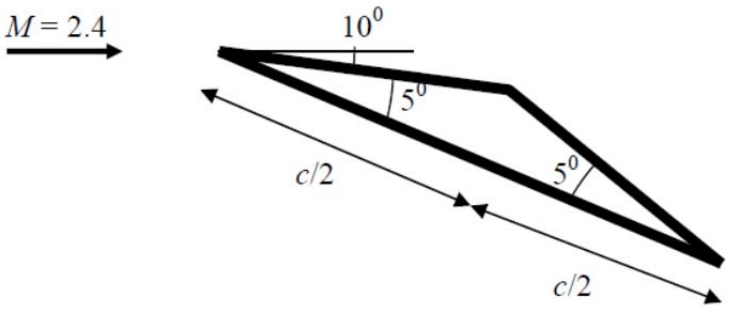
3- A Schleiren photo of the flow around a corner reveals the edges of the expansion fan to be indicated by the angles shown in Figure below. Assume that $\gamma = 1.4$.

(a) Determine the Mach number before and after the corner.

(b) Through what angle was the flow turned, and what is the angle of the expansion fan (θ_3)?

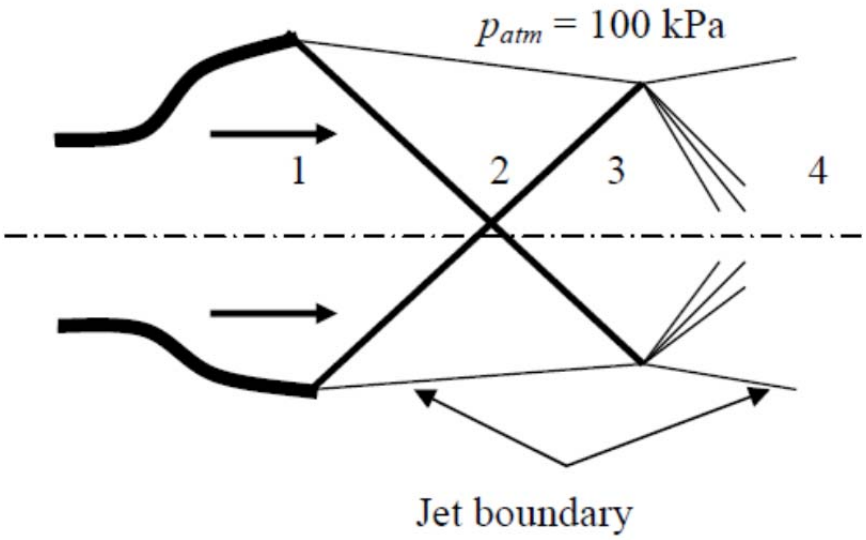


4- The two-dimensional airfoil is placed in an air stream with a Mach number of 2.4, as shown in the figure. If the angle of attack is 10 ⋅ , then determine the lift and the drag coefficients**. (Ans. 0.4931, 0.1352)**



5- An over-expanded converging-diverging nozzle has throat and exit cross-sectional areas of 0.001 m^2 and 0.002637 m^2, respectively, as shown in the figure. Air is supplied from a large reservoir, where the pressure and the temperature are 750 kPa and 500 K, respectively. The nozzle discharges to a back pressure of 100 kPa. Determine the Mach number, pressure, temperature and flow direction in regions 2, 3 and 4.

(Ans. 1.934, 100 kPa, 286.6 K, -13.610, 1.440, 202.3 kPa, 354 K, 00, 2.33, 100 kPa, 289.1 K, 13.720)



6- Two oblique shock waves, each making an angle of 300C with the uniform flow, intersect, as shown in the figure. The Mach number, the pressure and the temperature of the uniform flow are 2.5, 40 kPa and 240 K, respectively.

a) the pressure, temperature and Mach number after the incident shock wave,

b) the pressure, temperature and Mach number after the reflected shock wave and

c) the angle at which the reflected shock wave is inclined to the flow direction.

(Ans. a) 66.24 kPa, 278.2 K, 2.169; b) 104 kPa, 317.4 K, 1.874; c) 26.30)