Problems of Chapter 4 Part 2
(Shock reflection and shock-expansion theory)

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Relation between the units:

1 ft=0.3048m;1lb=0.454 kg; 1lb/ft^2=47.89N/m^2=47.89 Pa; 1^{o}R=5/9K

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4.6 A supersonic stream at $M_1 = 3.6$ flows past a compression comer with a deflection angle of 20^o. The incident shock wave is reflected from an opposite wall which is parallel to the upstream supersonic flow, as sketched in Fig. 4.18. Calculate the angle of the reflected shock relative to the straight wall.

4.7 An incident shock wave with wave angle= 30^o impinges on a straight wall. If the upstream properties are $M_1 = 2.8, p_1 = 1$ atm, and $T_1 = 300$ K, calculate the pressure, temperature, Mach number, and total pressure downstream of the reflected wave.

4.8 Consider a streamline with the properties $M_1 = 4.0$ and $p_1 = 1$ atm. Consider also the following two different shock structures encountered by such a streamline: (a) a single normal shock wave; and (b) an oblique shock wave with $\beta = 40^o$, followed by a normal shock. Calculate and compare the total pressure behind the shock structure of each (a) and (b) above. From this comparison, can you deduce a general principle concerning the efficiency of a single normal shock in relation to an oblique shock plus normal shock in decelerating a supersonic flow to subsonic speeds (which, for example, is the purpose of an inlet of a conventional jet engine)?

4.9 Consider the intersection of two shocks of opposite families, as sketched in Fig. 4.23. For $M_1 = 3$, $p_1 = 1atm$, $\theta_2 = 20^o$, and $\theta_3 = 15^o$, calculate the pressure in region 4 and $4^{'}$, and the flow direction Φ behind the refracted shocks.

4.13 Consider the incident and reflected shock waves as sketched in Fig. 4.17. Show by means of sketches how you will use shock polars to solve for the reflected wave properties.

4.16 Using shock-expansion theory, calculate the lift and drag on a symmetrical diamond airfoil of semiangle $= 15°$, (see Fig. 4.35) at an angle of attack to the free stream of 5° when the upstream Mach number and pressure are 2.0 and 1 atm, respectively. The maximum thickness of the airfoil is t = 0.5 m. Assume a unit length of 1 m in the span direction (perpendicular to the page in Fig. 4.35).