Chapter 9 斜激波与膨胀波

9.1 引言P602

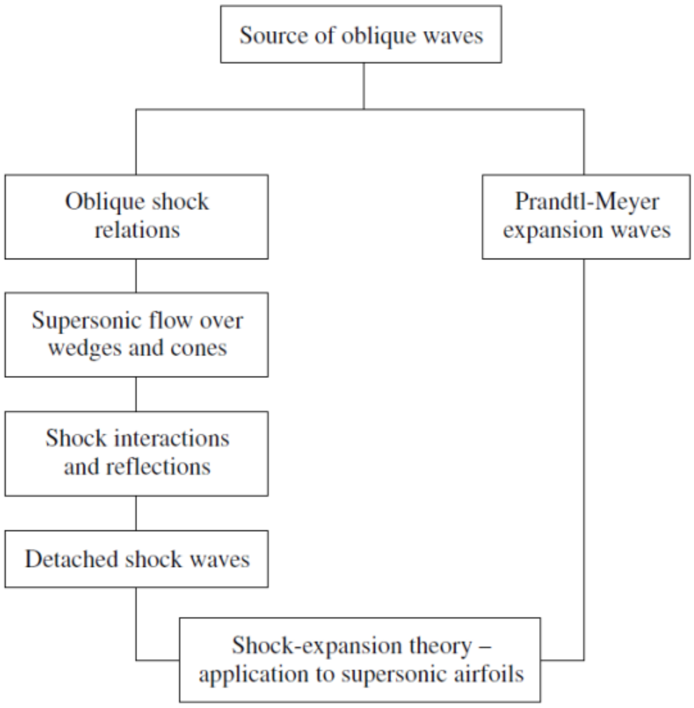


Figure 9.6 Road map for Chapter 9.

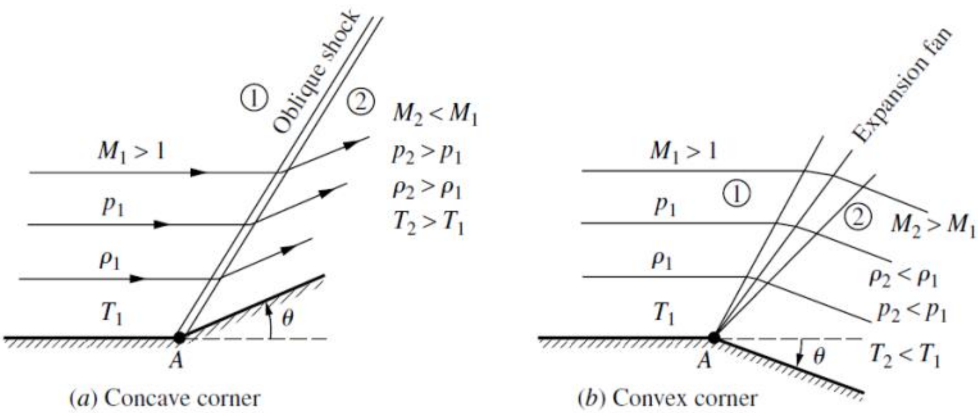


Figure 9.2 Supersonic flow over a corner.

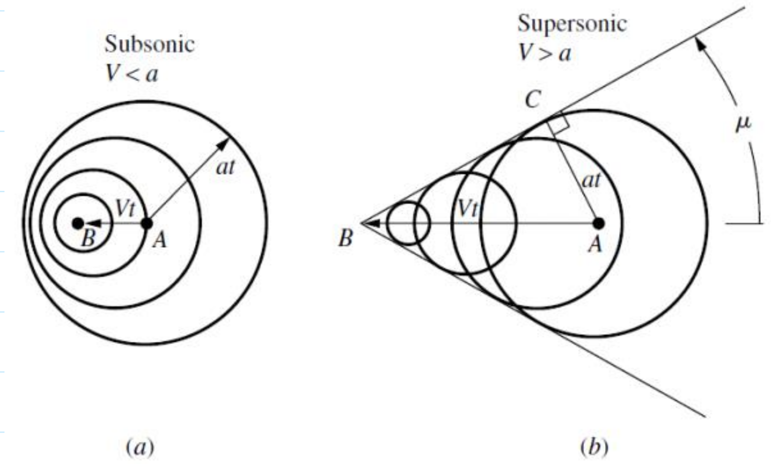
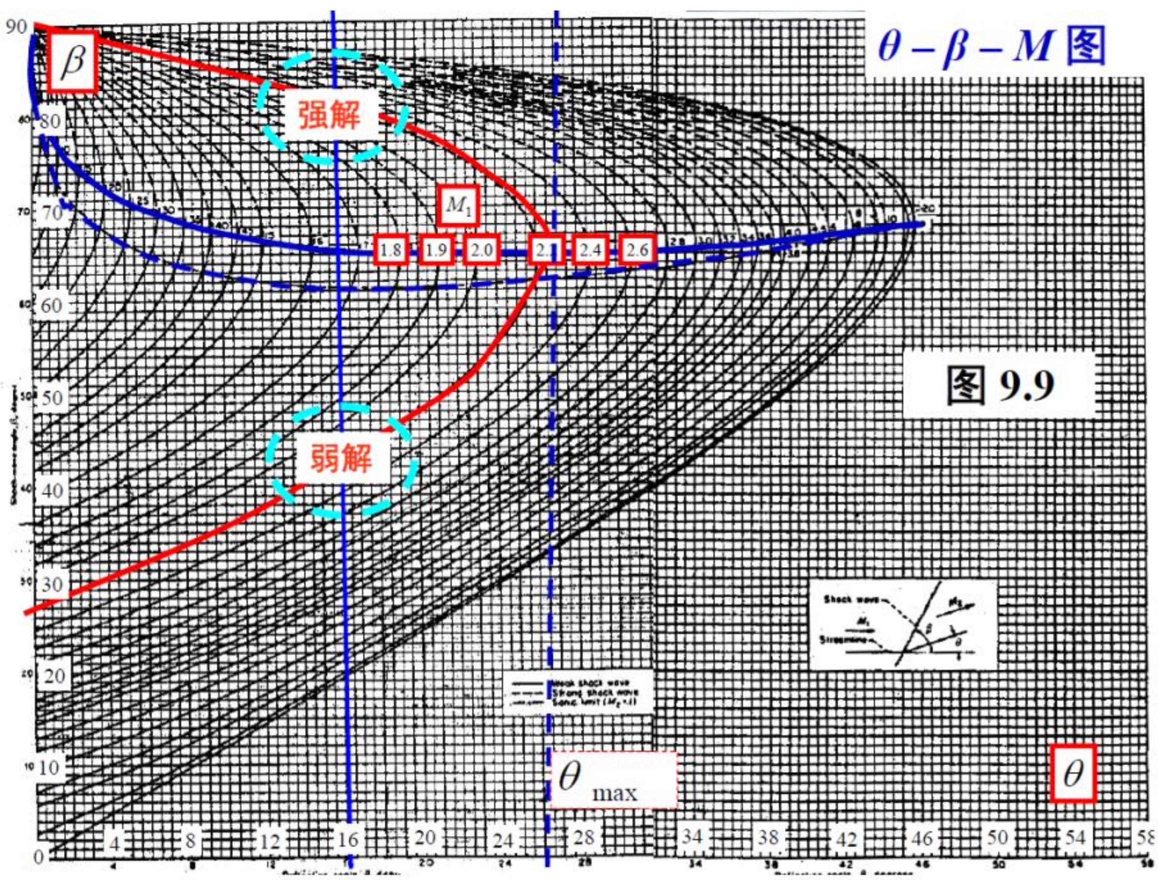


Figure 9.4 Another way of visualizing the propagation of disturbances in (*a*) subsonic and (*b*) supersonic flow.

9.2 斜激波关系式P608

$\boldsymbol{\theta-\beta-M}$ Relation Figure



9.3 尖楔与圆锥的超声速绕流P622

9.3.1 关于超声速升力系数和阻力系数的说明P625

9.4 激波干扰与反射P626

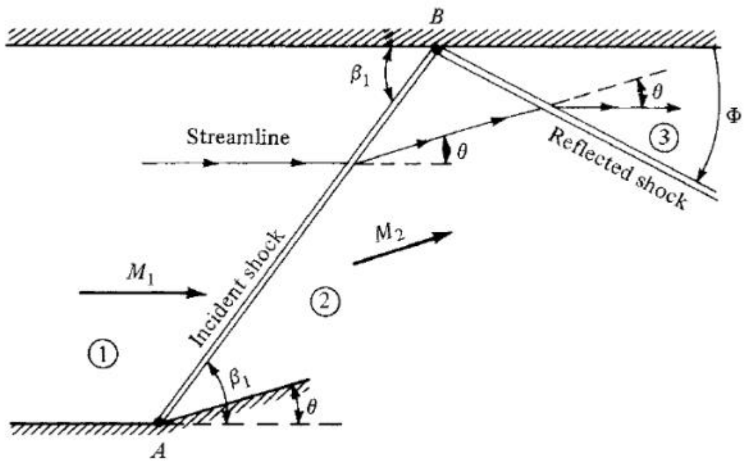


Figure 9.19 Regular reflection of a shock wave from a solid boundary.

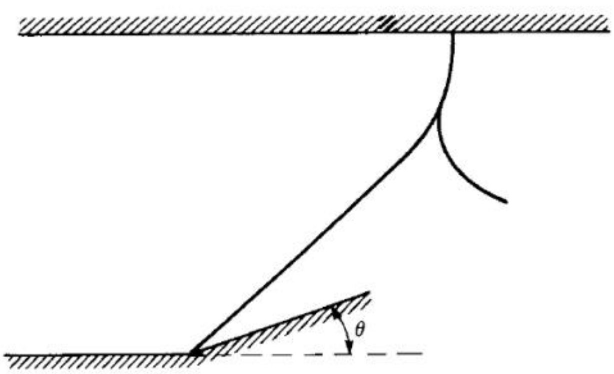


Figure 9.20 Mach reflection.

9.5 钝头体前的脱体激波P632

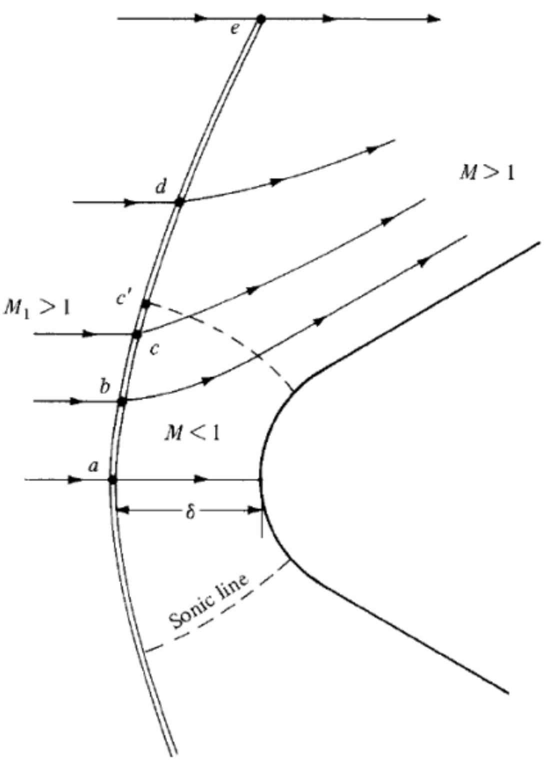


Figure 9.23 Flow over a supersonic blunt body.

9.5.1 关于弯曲激波后流场的说明：熵梯度和旋度P636

9.6 普朗特—迈耶膨胀波P636

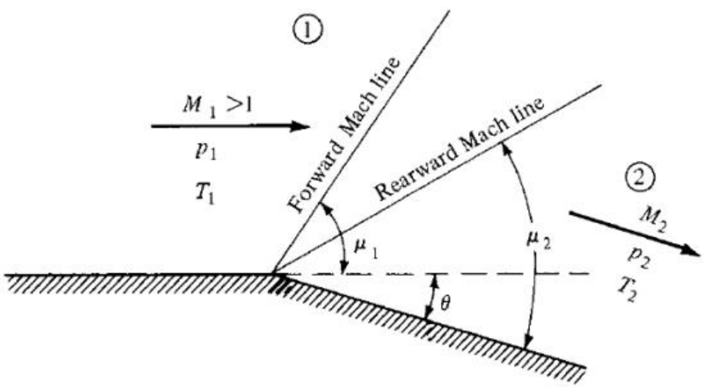


Figure 9.26 Prandtl-Meyer expansion.

9.7 激波—膨胀波理论：对超声速翼型的应用P648

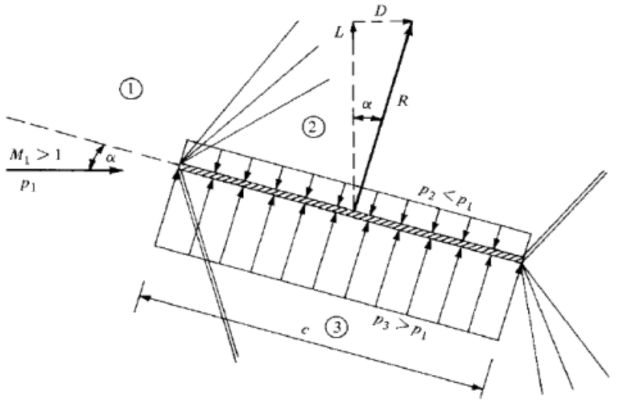


Figure 9.36 Flat plate at an angle of attack in a supersonic flow.

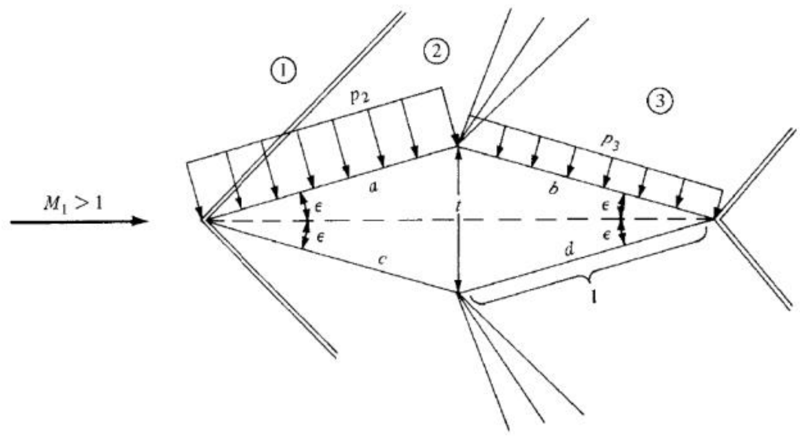
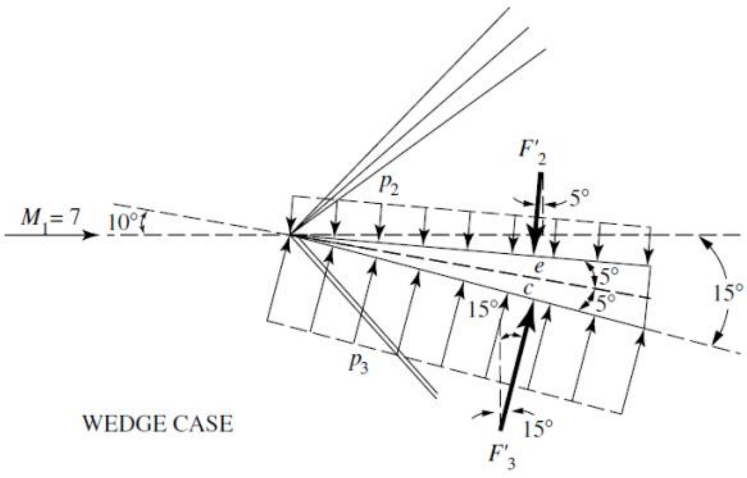


Figure 9.37 Diamond-wedge airfoil at zero angle of attack in a supersonic flow.

9.8 关于升力系数和阻力系数的评注P652

9.9 X-15及其楔形剖面尾翼P652



(b)

Note: Angles not to scale

Figure 9.39 Schematic of hypersonic flow over (a) a flat plate, and (b) a wedge, both at a 10° angle of attack. Not to scale.

9.10 粘性流动：激波/边界层干扰P657

9.11 历史摘记：马赫生平简介P659

9.12 总结662

An infinitesimal disturbance in a multidimensional supersonic flow creates a Mach wave that makes an angle μ with respect to the upstream velocity. This angle is defined as the Mach angle and is given by

$$\mu = \sin^{-1} \frac{1}{M} \tag{9.1}$$

Changes across an oblique shock wave are determined by the normal component of velocity ahead of the wave. For a calorically perfect gas, the normal component of the upstream Mach number is the determining factor. Changes across an oblique shock can be determined from the normal shock relations derived in Chapter 8 by using $M_{n,1}$ in these relations, where

$$M_{n,1} = M_1 \sin \beta \tag{9.13}$$

Changes across an oblique shock depend on two parameters, for example, M_1 and β, or M_1 and θ. The relationship between M_1, β, and θ is given in Figure 9.9, which should be studied closely.

Oblique shock waves incident on a solid surface reflect from that surface in such a fashion to maintain flow tangency on the surface. Oblique shocks also intersect each other, with the results of the intersection depending on the arrangement of the shocks.

The governing factor in the analysis of a centered expansion wave is the Prandtl-Meyer function $\nu(M)$. The key equation which relates the downstream Mach number M_2, the upstream Mach number M_1, and the deflection angle θ is

$$\theta = \nu(M_2) - \nu(M_1) \tag{9.43}$$

The pressure distribution over a supersonic airfoil made up of straight-line segments can usually be calculated exactly from a combination of oblique and expansion waves—that is, from exact shock-expansion theory.

9.13 作业题P663