UNIVERSITY OF NOTRE DAME
DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING

Professor H.M. Atassi
113 Hessert Center
Tel: 631-5736
Email:atassi@nd.edu

AME-60639
Advanced Aerodynamics

Compressibility Effects on Airfoil Lift

The Prandtl-Glauert rule gives

$$C_p = \frac{C_{p,0}}{\sqrt{1-M_\infty^2}} \tag{1}$$

$$C_\ell = \frac{C_{\ell,0}}{\sqrt{1-M_\infty^2}} \tag{2}$$

$$C_m = \frac{C_{m,0}}{\sqrt{1-M_\infty^2}} \tag{3}$$

The Karman-Tsien rule gives

$$C_p = \frac{C_{p,0}}{\sqrt{1-M_\infty^2} + [M_\infty^2/(1+\sqrt{1-M_\infty^2})]C_{p,0}/2}, \tag{4}$$

and the Laitone's rule states

$$C_p = \frac{C_{p,0}}{\sqrt{1-M_\infty^2} + \left(M_\infty^2\{1+[(\gamma-1)/2]M_\infty^2)\}/2\sqrt{1-M_\infty^2}\right)C_{p,0}}, \tag{5}$$

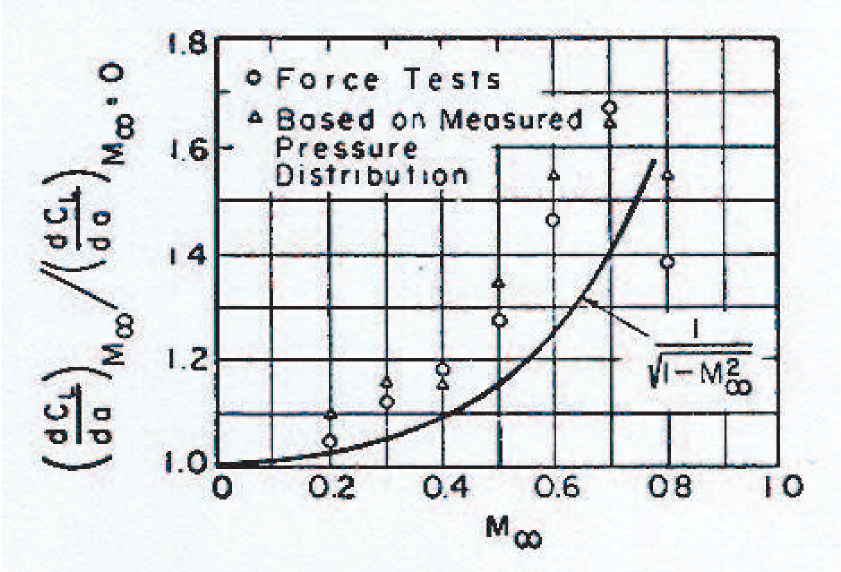

Figure 1: Comparison of measured lift-curve slopw for NACA 4412 profile with Prandtl-Glauert rule.

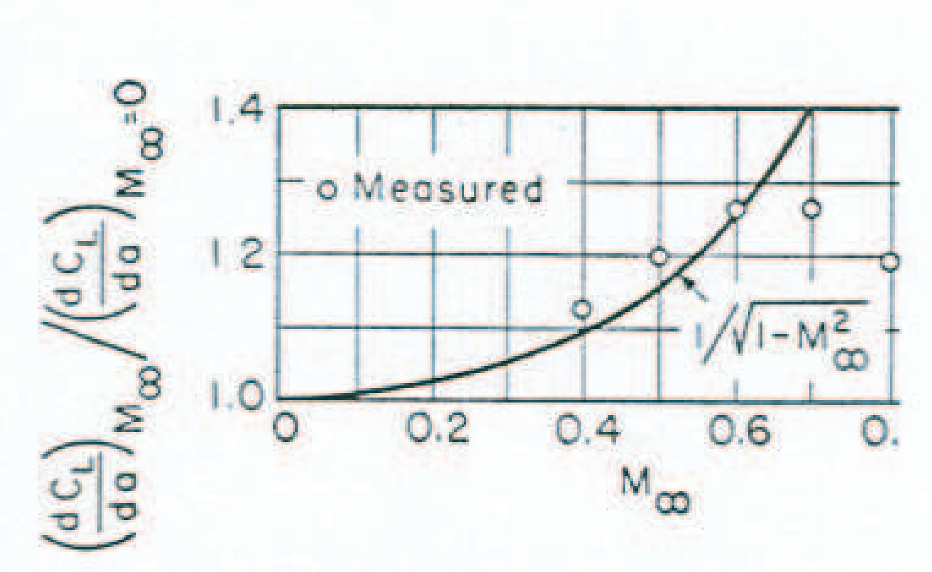

Figure 2: Comparison of measured lift-curve slopw for a propeller section of 6% thickness with Prandtl-Glauert rule.

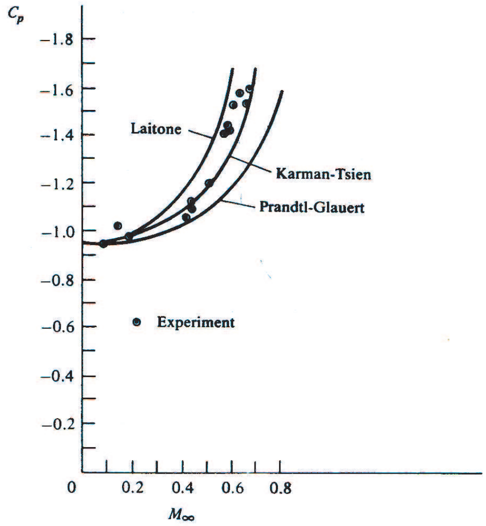

Figure 3: Compressibility corrections for C_p compared with experimental results for a NACA 4412 airfoil at an angle of attack of $\alpha = 1^o53'$. C_p is measured at 0.30-chord location.

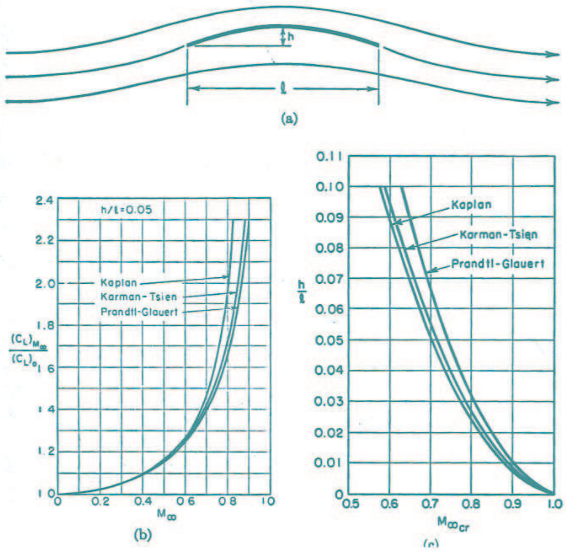

Figure 4: Flow past a circular arc profile.

(a) Streamlines.
(b) Effect of M_∞ on lift coefficient.
(c)Low critical Mach number as a function of camber.

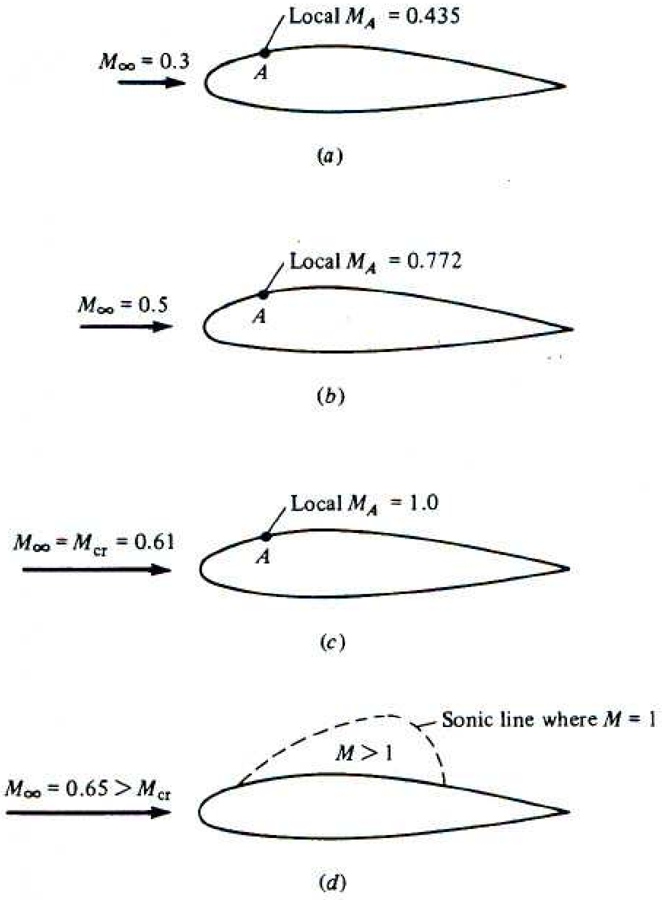

Figure 5: The Critical Mach number. Point A is the location of minimum pressure (maximum velocity) on the top surface of the airfoil

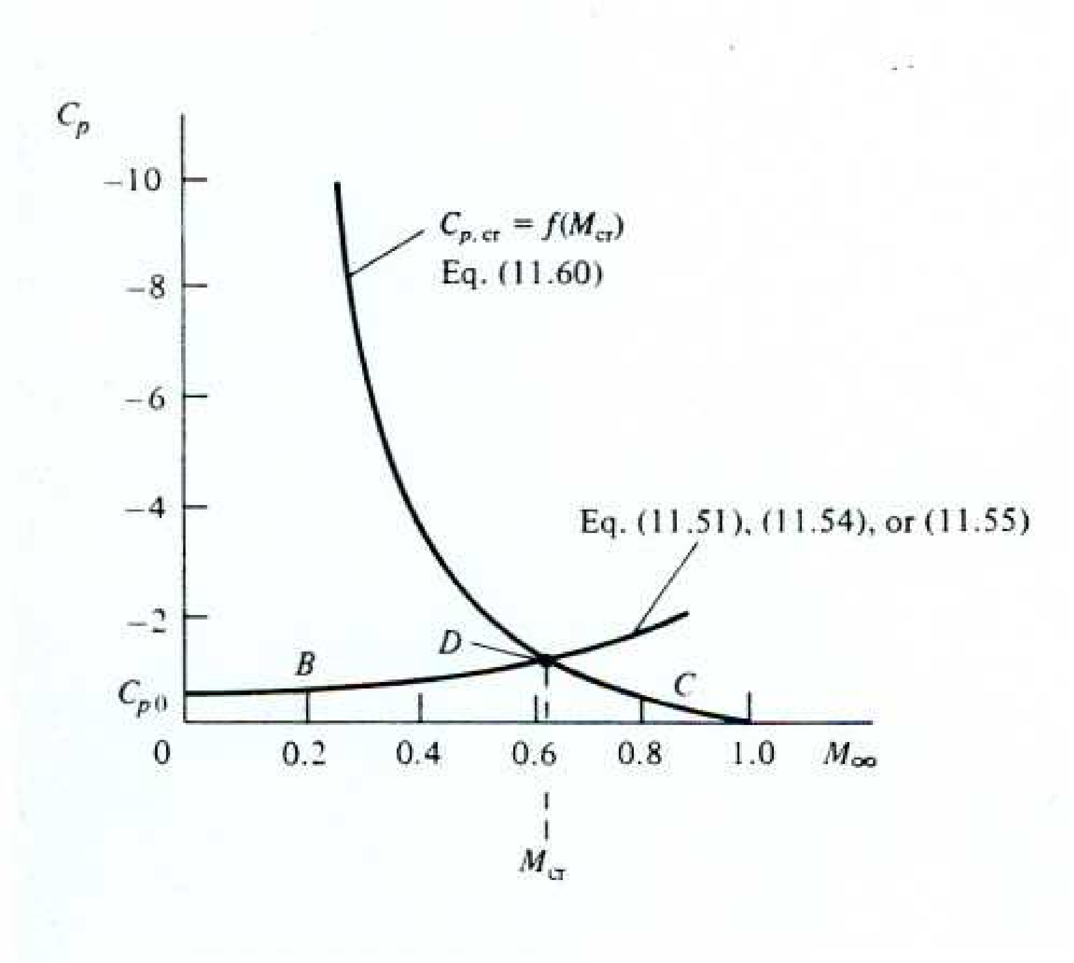

Figure 6: Determination of the critical Mach number.

(B) C_p.
(C) $C_{p,cr}$.
(D)Intersection gives critical Mach number.

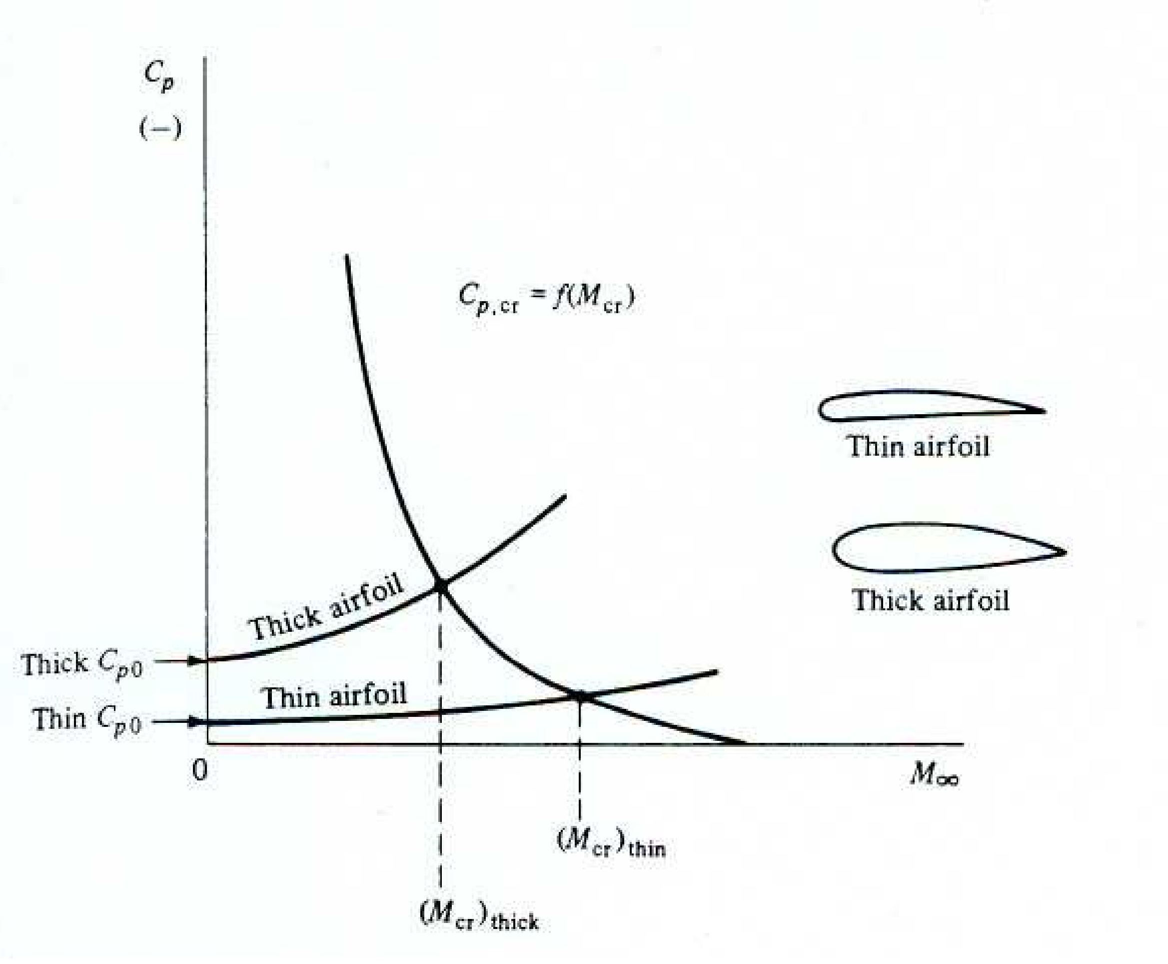

Figure 7: Effect of airfoil thickness on critical Mach number.

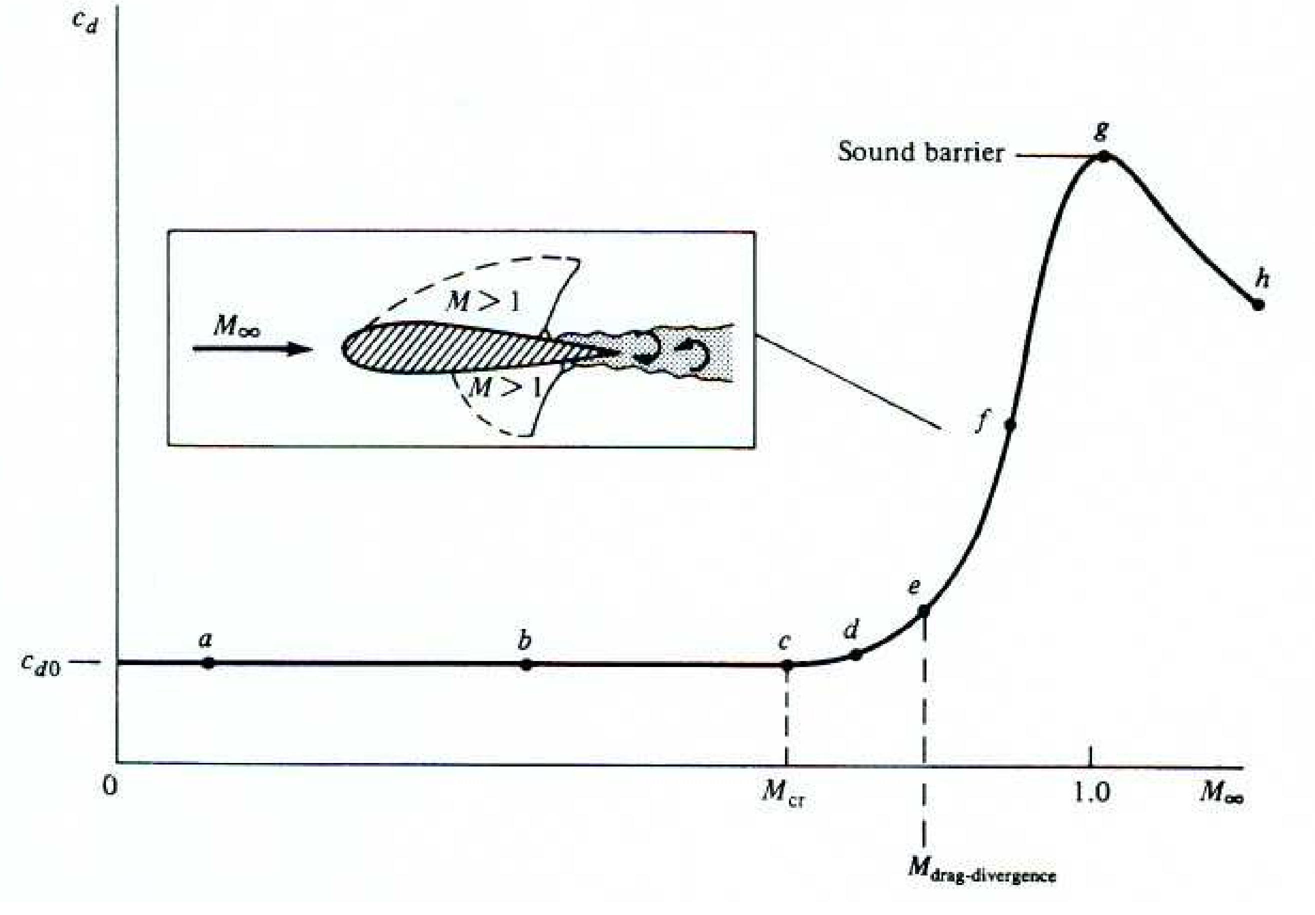

Figure 8: Sketch of the variation of profile drag coefficient with free-stream Mach number, illustrating the critical and drag-divergence Mach numbers and showing the large drag rise near Mach 1.

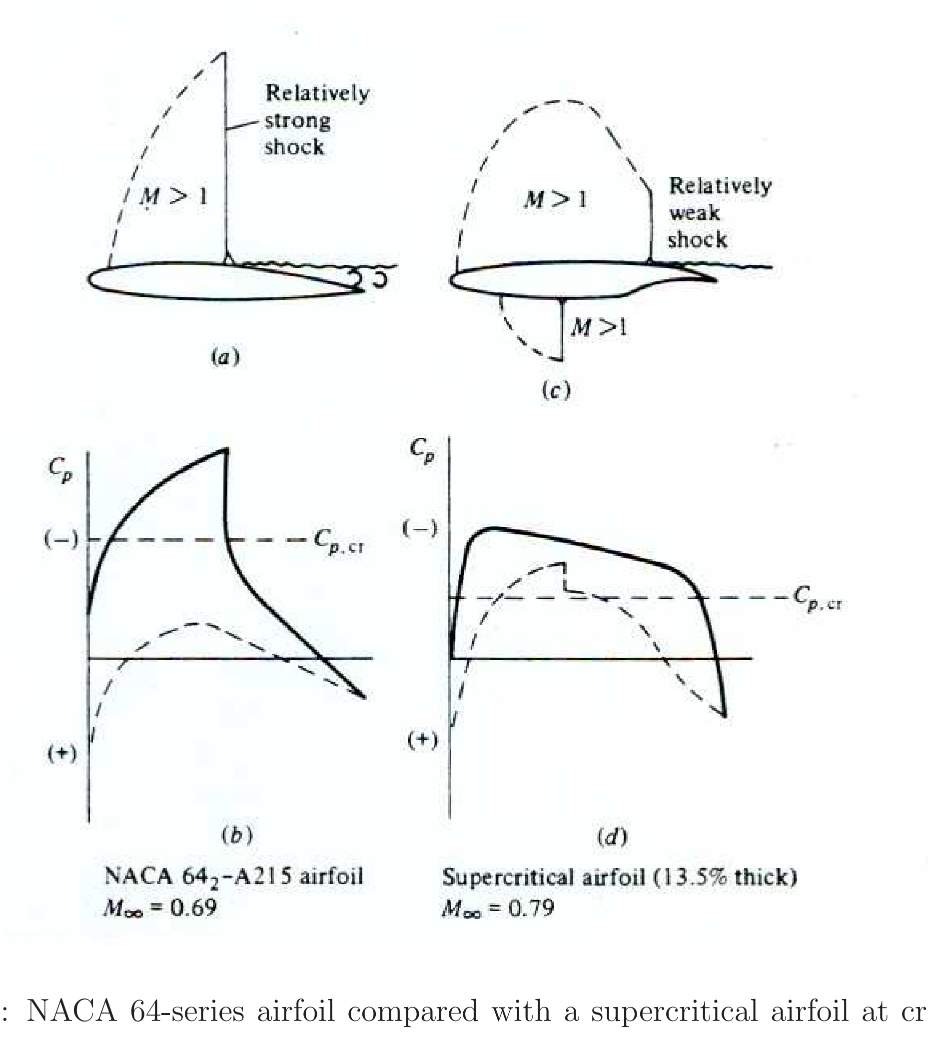

Figure 9: NACA 64-series airfoil compared with a supercritical airfoil at cruise conditions.

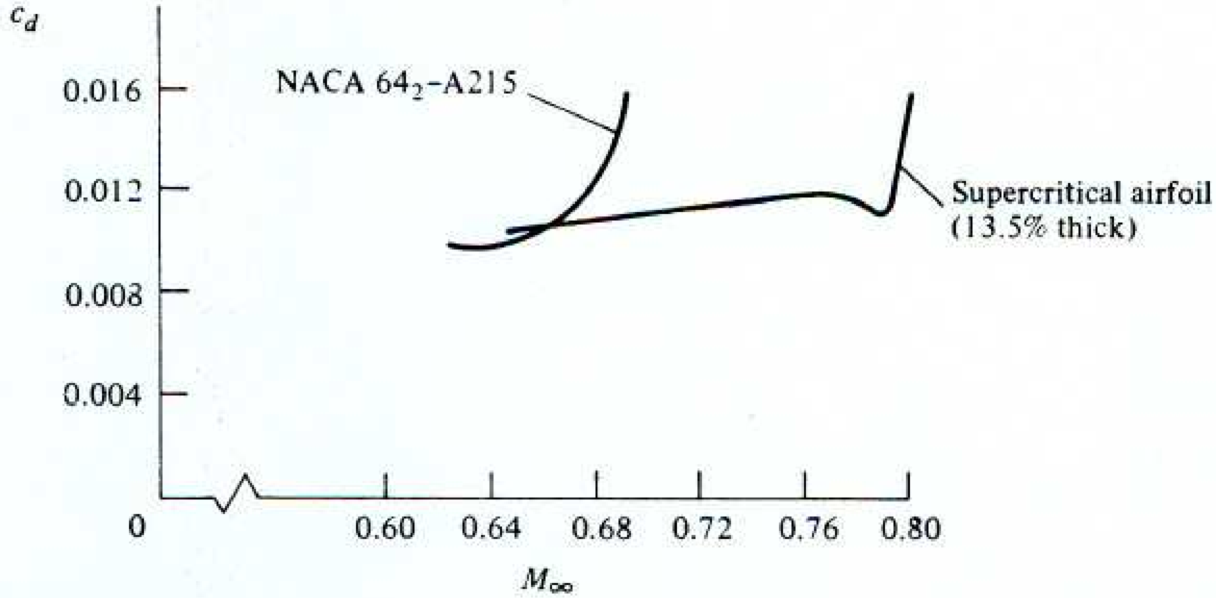

Figure 10: The drag-divergence properties of a standard NACA 64-series airfoil and a supercritical airfoil.