MAE 158 2022

Recommended Homework 5

From Shevell, *Fundamentals of Flight*

Problems 11.1, 11.2, 12.1 (b, d, f only)

From Anderson, Aircraft Performance and Design, Example 2.4

11.1. A twin turbofan transport airplane is cruising at 31,000 ft pressure altitude at a Mach number of 0.78. Outside air temperature is −60°F. The airplane gross weight is 98,000 lb. The airplane has unsealed aerodynamically balanced control surfaces. Following are the airplane dimensional data:

Wing	
Span	= 93.2 ft
Planform area	= 1000 ft^2
Average t/c	= 0.106
Sweepback angle	= 24.5 deg
Taper ratio	= 0.2
Root chord	= 17.8 ft
Wing area covered by fuselage	= 17%

Horizontal Tail	
Exposed planform area	= 261 ft^2
t/c	= 0.09
Sweepback	= 31.6 deg
Taper ratio	= 0.35
Root chord	= 11.1 ft

Pylons	
Total wetted area	= 117 ft^2
t/c	= 0.06
Sweepback	= 0 deg
Taper ratio	= 1.0
Chord	= 16.2 ft

Fuselage	
Length	= 107 ft
Diameter	= 11.5 ft
Wetted area	= 3280 ft^2

Vertical Tail	
Exposed planform area	= 161 ft^2
t/c	= 0.09
Sweepback	= 43.5 deg
Taper ratio	= 0.80
Root chord	= 15.5 ft

Nacelles	
Total wetted area	= 455 ft^2
Effective fineness ratio	= 5.0
Length	= 16.8 ft

Flap Hinge Fairings	
Δf	= 0.15 ft^2

Determine

(a) Incompressible parasite drag coefficient and equivalent flat-plate area.

(b) Induced drag coefficient.

(c) Total incompressible drag coefficient.

(d) Total incompressible drag in pounds.

(e) Ratio of lift to drag, neglecting compressibility.

11.2. At speeds where compressibility may be ignored,

$$C_D = C_{D_P} + \frac{C_L^2}{\pi \mathrm{AR} e}$$

(a) Determine the C_L for best C_L/C_D. (Try for minimum C_D/C_L).

(b) What is the maximum ratio of lift to drag (C_L to C_D) in terms of C_{D_P}, AR, and e?

Let's finish problem 12.1:

12.1. An airplane with an unswept, 12% thick wing, a wing planform area of 450 ft^2, a span of 60 ft, and a mean aerodynamic chord (m.a.c.) of 8 ft is flying at a density altitude of 28,000 ft at a speed of 400 mph. The ambient temperature is 430°R. The gross weight is 30,000 lb. The exposed wing area is 80% of the total wing area. The wing parasite drag is 35% of the total parasite drag. The airfoil is a conventional peaky type. Determine

(b) Total parasite drag in pounds.

(d) Induced drag in pounds.

(f) Compressibility drag and total drag in pounds and the ratio of lift to drag.

You can use $\mu_0 = 3.25 \times 10^{-7}$ lb-s/ft^2 from Fig 10.14 (homework 2)

2.4 For the NACA 2412 airfoil, with the measured data in Fig. 2.6 calculate the location of the aerodynamic center.

For Problem 11.1, 12.1:

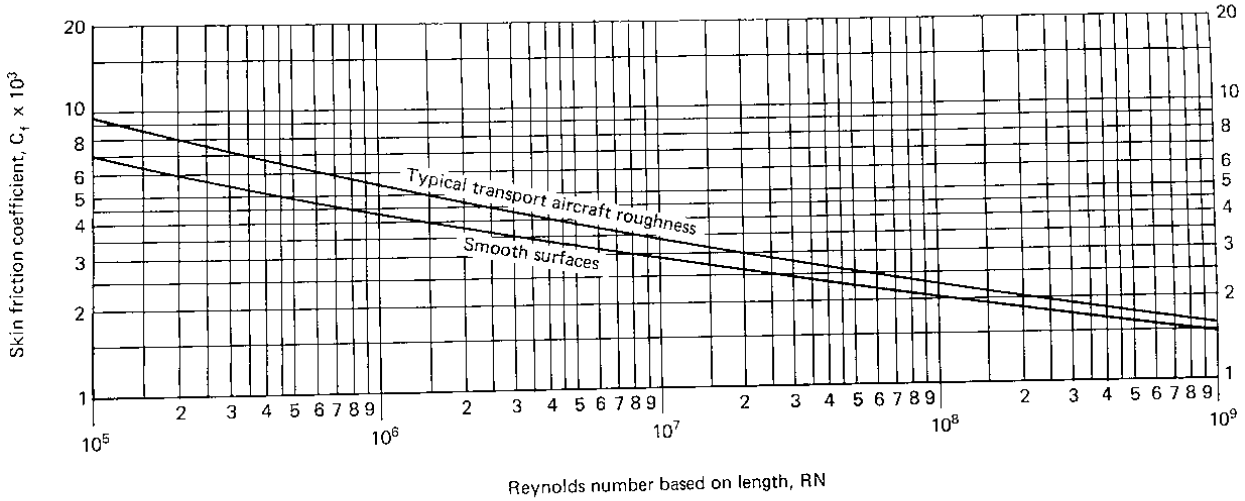


Figure 11.2 Flat-plate skin friction coefficient; turbulent boundary layer; $M = 0.50$.

$$M_0 = 0.5$$

$$K = [1 + Z(t/c) + 100(t/c)^4]$$

where

$$Z = \frac{(2 - M_0^2)\cos \Lambda_{C/4}}{\sqrt{1 - M_0^2 \cos^2 \Lambda_{C/4}}}$$

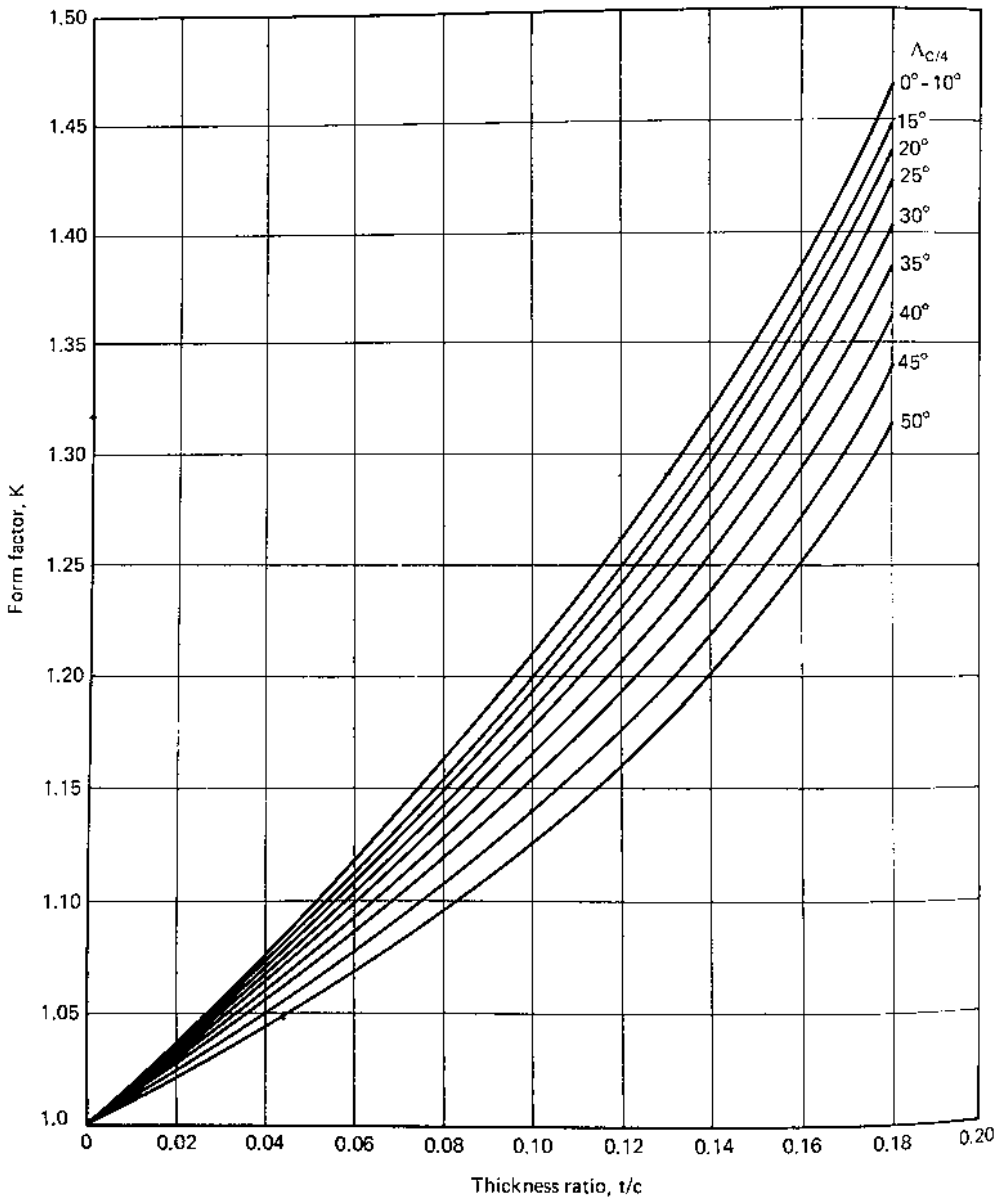


Figure 11.3 Aerodynamic surface form factor.

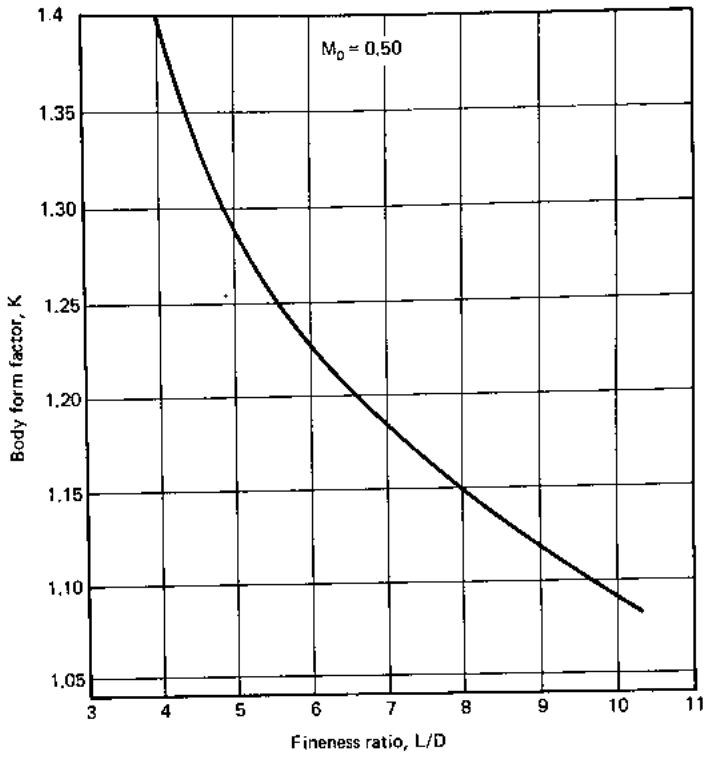


Figure 11.4 Effect of fineness ratio on body form factor.

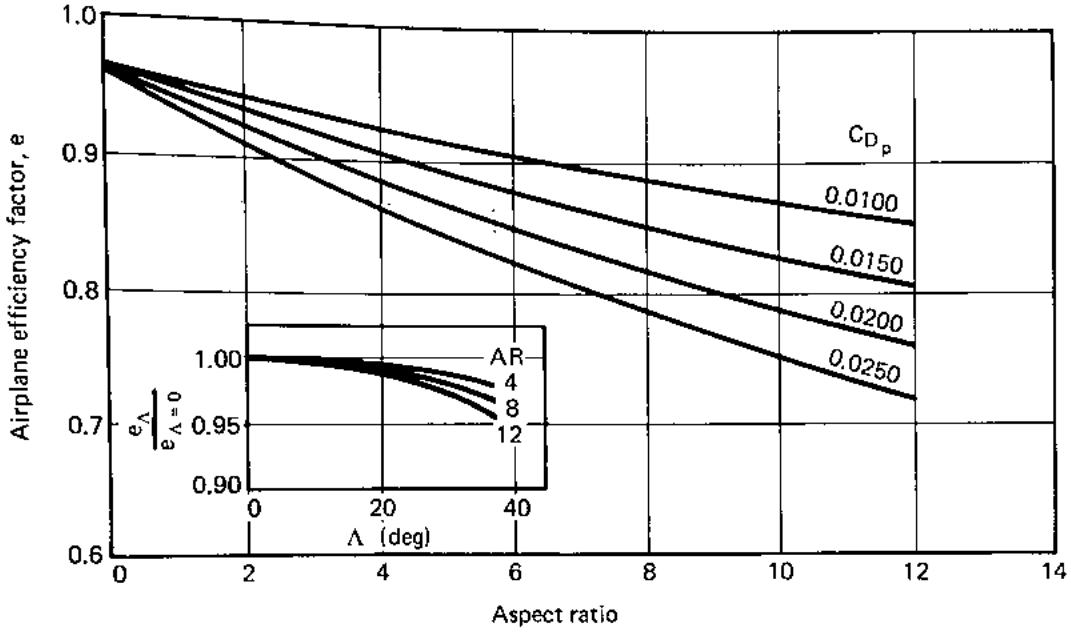
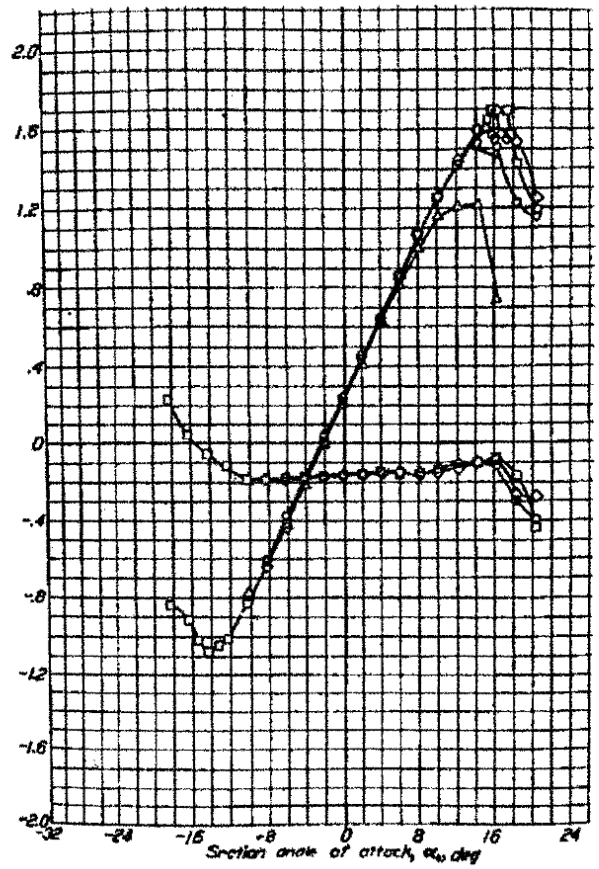


Figure 11.8 Airplane efficiency factor, *e*.

For Example 2.4:



(a)

Figure 2.6 Data for the NACA 2412 airfoil. (a) Lift coefficient and moment coefficient about the quarter-chord versus angle of attack.