AOE 3104 Problem Sheet 8

Due 9 April, 2003

Read Marchman, Chapters 5, and 6

41. A high speed aircraft has a parabolic drag polar with the coefficients varying according to Mach number. This variation is such that the values of the coefficients are constant prior to M = 0.8 and after M = 1.2. In between these two values assume that the coefficients vary as follows:

$$C_{D_{0L}} = C_{D_{0L_0}} + \left(C_{D_m} - C_{D_{0L_0}}\right) \sin^3\left[\left(\frac{M - 0.8}{0.6}\right)\pi\right]$$
$$e = e_0 - e_2(M - 0.8)^2 + e_3(M - 0.8)^3 \qquad \textbf{(1)}$$

Where $C_{D_{0L_0}}$ is the low speed (incompressible) value, $C_{D_{0L_m}}$ is the max value it obtains during transition, and ***M*** is the Mach number. Also the e_i, i = 0,2,3 are the constants associated with the Oswald efficiency factor, with e_0 the low speed (incompressible) value.

For this particular aircraft, the values of these constants are: C_{D0L0} = 0.015, C_{Dm} = 3 C_{D0L0}, e_0 = 0.7, e_2 = 7, and e_3 = 22. The aircraft properties are: W = 10,000 lbs., S = 200 ft^2, and C_L stall is 1.24. The aspect ratio of the wing is 6.

a) Plot C_D vs M, and K vs M for M = 0 to 2.0

b) Plot the thrust required Vs. Mach number for M = M (stall) to M = 2.0 at sea level conditions.

42. If we define the ratio of V/V_{md} = n, and assume a parabolic drag polar with constant coefficients (C_{D0L}, K), find an expression for (L/D) / $(L/D)_{max}$ as a function of m only.

43. An aircraft is powered by a turbojet engine where the thrust is independent of speed. The aircraft weighs 35,000 lbs and its wing area is 500 ft^2. The drag polar is given by $C_D = 0.016 + 0.045\ C_L^2$. At sea level the maximum rate of climb is 5250 ft/min and occurs at a flight speed of 500 ft/sec. Calculate the rate of climb at the same *angle of attack* with a rocket motor giving 10,000 lbs additional thrust.

44. The same aircraft as in Problem 43 has the same rocket motor attached, but this time the same *flight-path angle* (not angle of attack) is held constant. Determine the rate of climb under these conditions.

45. Our class executive jet has a thrust of 2000 lbs at sea-level and is independent of speed. The win area is 200 ft^2 and it has a parabolic drag polar of $C_D = 0.02 + 0.05\,C_L^2$. We want to estimate the time to climb to altitude by two methods.

a) The first method will use a single straight-line rate-of-climb curve fit with the data points calculated at h = 10,000 ft and h = 30,000 ft. Assume a maximum rate-of-climb climb schedule and using this fit, calculate the time-to-climb from sea-level to 10, 20, and 30,000 ft.

b) The second method will use two straight-line approximations to the rate-of-climb curve. The data points to calculate the first straight line segment are h = 0 and h = 15000 ft. The data points for the second straight line segment are at h = 15000 ft and at 30,000 ft.. Again, use the maximum rate-of-climb climb schedule. Using these fits, calculate the time to climb from sea-level to 10, 20 and 30, 000 ft.