AOE 3104 Performance 1 Homework Set 6

Due March 19, 2003

Read Marchman Chapter 4 (All of it)
This is a tough (long) problem sheet so get started early. Its not a one night deal!

Note: For all problems where applicable, provide a sample calculation which will include equations used, numbers substituted, and results. Show that the sample calculation matches the results of a code or a spread sheet calculation. (It is good engineering practice to check one or more calculations by hand to validate your “code”). You may use any computer code or a spreadsheet. A sample calculation is a must. The graphs should have reasonable scales so that the curves of interests are readable.

28-30. Consider our “class” aircraft with a parabolic drag polar with $C_{D_{0L}}$ and K equal to 0.02 and 0.05 respectively. The Weight is 10,000 lbs and the wing area is 200 ft^2 . Assume the thrust level is constant with velocity and is 2000 lbs at sea level. Further, the thrust varies proportional to the density, that is, T at altitude equals $T_{SL} * \rho / \rho_{SL}$. In addition, $C_{Lmax} = 2.0$.

> a) Plot thrust and drag vs velocity for a standard atmosphere at 10,000 ft altitude increments, starting at sea level.
>
> b) Indicate V_{stall} on the drag curves, and connect the points to indicate the stall limited minimum airspeed.
>
> c) Either by selecting points of T = D from the plot in (a), or by solving for the points analytically, make another plot of maximum true airspeed vs altitude, and minimum airspeed vs altitude (the level flight envelope).
>
> d) Estimate the ceiling of this aircraft from your graph in (c). Then, under the assumptions given, it is possible to solve more precisely for the ceiling. In particular you can find the minimum drag thrust required (remember it is the same at all altitudes), and find the altitude at which thrust available equals that value. Do it, and compare with you estimate!

31. An aircraft weights 3000 lbs and has a wing area of 175 ft^2 , AR = 7 and an Oswald efficiency factor of 0.95.

> a) If $C_{D_{0L}}$ = 0.028, plot the drag versus equivalent airspeed at sea level and at 10,000 ft. Again, assume the thrust is constant with velocity and that it is proportional to the air density.
> b) The thrust at the throttle setting of interest is 400 lbs at sea level. Plot thrust vs equivalent airspeed at sea level and at 10,000 ft (on the same plot as in (a).
> c) From the plot find the maximum equivalent airspeed at sea level and at 10,000 ft.
> d) Also determine the maximum true airspeed at each of these altitudes.

Note, because of the assumptions, you can also do this problem analytically.

32-35. A small aircraft is powered by a piston engine. The propulsive efficiency is a dependent on airspeed and is included in the numbers given below, that is the HP given is the HP available. The aircraft has a wing area of S = 300 ft^2, W = 4000 lbs, $C_D = 0.036+0.105\ C_L^2$, $C_{Lmax} = 1.37$ (no flaps) and $C_{Lmax} = 2.00$ (with flaps). The engine properties are given in the following tables:

Engine Properties (at sea level)

V(ft/sec)	83.9	102.7	117.3	132.0	146.7	161.3	176.0	190.7	205.3	212.7	220.0
HP (sea level)	216	248	270	289	305	318	328	337	344	346	347

Engine Properties at Altitude

Altitude (ft)	0	5,000	10,000	12,500	15,000	17,000	20,000
% sea level HP	100	84	68	60	53	47.5	39

a) Plot Hp_{req} vs V (ft/sec) for altitudes 0, 5000, 10000, 12500, 15000 ft
b) On same plot as (a) plot HP_{avail} vs V
c) Plot altitude vs true airspeed (V_{max} and V_{min}) and altitude vs equivalent airspeed (V_{emax} and V_{emin}) Note this plot is just h vs V with two curves on it V_{true} and V_{eq}

Note: parts a, b, and c can be done by plotting HP*$\sqrt{\sigma}$ vs V_e. Such a plot will produce a single curve for the (power required*$\sqrt{\sigma}$) vs V_e and a separate curve for each altitude for (power available *$\sqrt{\sigma}$) . Alternatively, you can do this problem by plotting all the curves for power avail and power reqd. Vs V at each altitude. In either case we need altitude vs both V_{true} and V_{eq} for part c.

d) Determine both equivalent and true airspeed for min drag and min power at each altitude.
e) Determine L/D for min drag and min power.
f) Below what equivalent and true airspeeds must flaps be used at sea-level and at 10,000 ft

Note for this problem use the following "standard" densities:

altitude(ft)	density(slugs/ft^3)
0	0.002377
5K	0.002048
10K	0.001756
12.5K	0.001622
15K	0.001496