16.00 Introduction to Aerospace and Design
Problem Set #3

AIRCRAFT PERFORMANCE FLIGHT SIMULATION LAB
Solution

I collected flight data at 10 different conditions, and also flew from 10,000 ft to 9,000 ft to get more time to fly stably and more accurately measure vertical speed.

Data are shown in the table below.
Indicated airspeed computed directly from the airspeed indicator and converted to ft/s
True airspeed = 1.154 x (indicated airspeed) as per Problem Set #3 handout
Vertical speed computed from the Flight Analysis tool, converted to ft/s

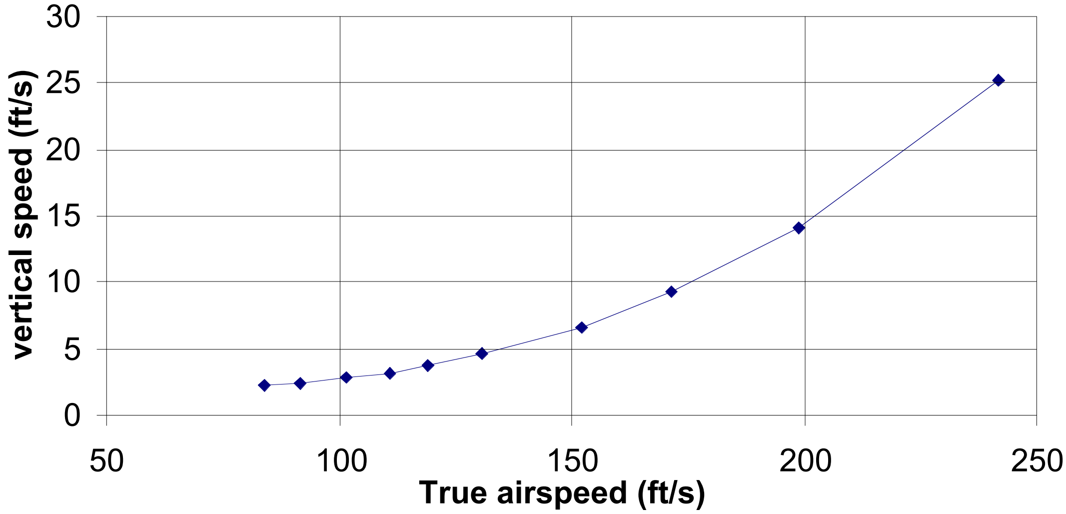
Flight path angle computed from $\gamma = \sin^{-1}\left(\frac{\dot{h}}{v}\right)$

Lift computed from L = W cos(γ)
L/D computed from L/D = cot(γ)

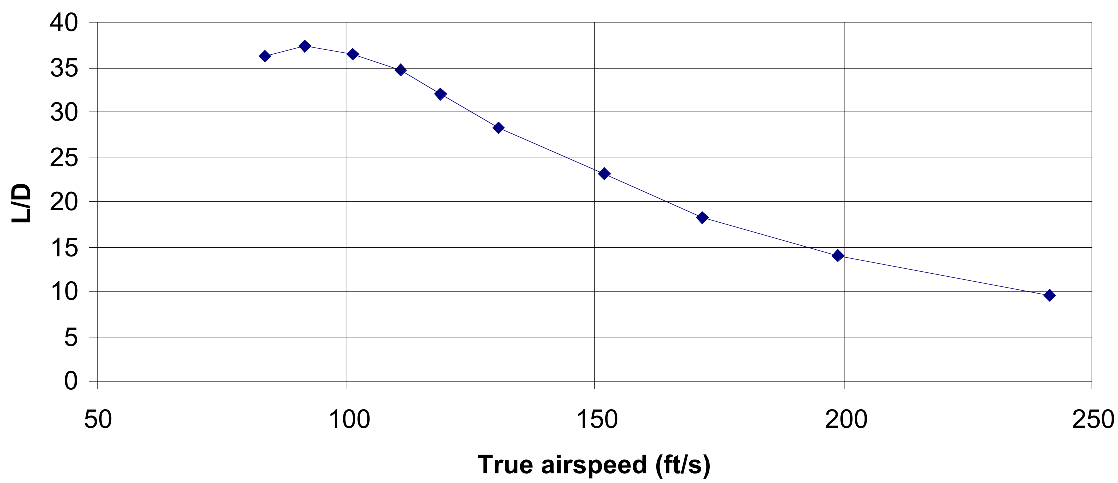
C_L computed from $C_L = \frac{L}{\frac{1}{2}\rho v^2 S}$

C_D computed from $C_D = C_L \frac{D}{L}$

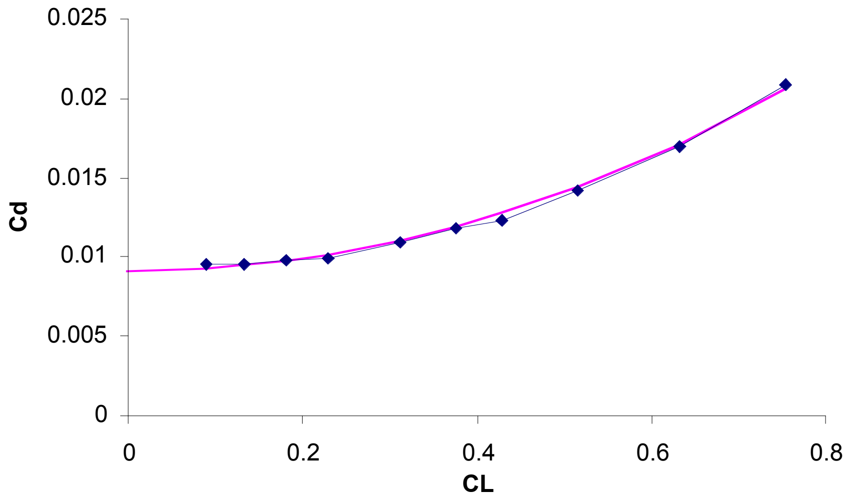
Flight Condition	indicated airspeed (ft/s)	true airspeed (ft/s)	vertical speed (ft/s)	flight path angle (deg)	Lift (N)	L/D	Cl	Cd
1	72.62	83.81	2.31	1.58	849.68	36.30	0.76	0.02
2	79.38	91.60	2.45	1.53	849.70	37.34	0.63	0.02
3	87.82	101.35	2.78	1.57	849.68	36.48	0.52	0.01
4	96.27	111.09	3.19	1.65	849.65	34.76	0.43	0.01
5	103.02	118.89	3.73	1.80	849.58	31.89	0.38	0.01
6	113.16	130.58	4.61	2.02	849.47	28.29	0.31	0.01
7	131.73	152.02	6.54	2.47	849.21	23.21	0.23	0.01
8	148.62	171.51	9.35	3.12	848.74	18.32	0.18	0.01
9	172.27	198.80	14.17	4.09	847.84	14.00	0.13	0.01
10	209.42	241.67	25.24	6.00	845.35	9.52	0.09	0.01



From the data above, the aircraft should fly at approximately 84 ft/s true airspeed (or 43 kt indicated) to maximize time aloft (minimum sink rate).



The maximum L/D occurs at a true airspeed of 92 ft/s (47 kt indicated).



The plot above shows the data from the flight test, along with a parabolic curve fit with C_{D0} = 0.009 and efficiency e = 0.88.

Theory predicts $\left(\frac{L}{D}\right)_{max} = \frac{1}{2}\sqrt{\frac{\pi e AR}{C_{D_0}}}$ = 37.2, Observed maximum L/D = 37.3

Theory predicts $v_{max_{L/D}} = \sqrt{\frac{2W}{\rho S \sqrt{C_{D_0} \pi e AR}}}$ = 88.9 ft/s, Observed $v_{max\ L/D}$ = 92 ft/s

Errors between theory and observation are due to:
- inaccurate dynamic model in the flight simulator, especially close to stall
- inaccurate data recording or non-steady flight during the flight test
- inaccuracies in the curve fit in the C_D vs. C_L drag polar to predict C_{D0} and e.