6.1 (a) $V_\infty = 350$ km/hr $= 97.2$ m/sec

$$q_\infty = \frac{1}{2}\rho_\infty V_\infty^2 = \frac{1}{2}(1.225)(97.2)^2 = 5787 \text{ N/m}^2$$

$$C_L = \frac{W}{q_\infty S} = \frac{38220}{(5787)(27.3)} = 0.242$$

$$C_D = C_{D_o} + \frac{C_L^2}{\pi e AR} = 0.03 + \frac{(0.242)^2}{\pi\ (0.9)(7.5)}$$

$$C_D = 0.03 + 0.0028 = 0.0328$$

$$C_L/C_D = 0.242/0.0328 = 7.38$$

$$T_R = \frac{W}{C_L / C_D} = \frac{38220}{7.38} = \boxed{5179\ \text{N}}$$

(b) $$q_\infty = \frac{1}{2}\rho_\infty V_\infty^2 = \frac{1}{2}(0.777)(97.2)^2 = 3670 \text{ N/m}^2$$

$$C_L = \frac{W}{q_\infty S} = \frac{38220}{(3670)(27.3)} = 0.38$$

$$C_d = C_{D_o} + \frac{C_L^2}{\pi e AR} = 0.03 + \frac{(0.38)^2}{\pi\ (0.9)(7.5)}$$

$$C_D = 0.03 + 0.0068 = 0.0368$$

$$C_L/C_D = 0.38/0.0368 = 10.3$$

$$T_R = \frac{W}{C_L / C_D} = \frac{38220}{10.3} = \boxed{3711\ \text{N}}$$

6.2 $$V_\infty = 200\ \frac{88}{60} = 293.3 \text{ ft/sec}$$

$$q_\infty = \frac{1}{2}\rho_\infty V_\infty^2 = \frac{1}{2}(0.002377)(293.3)^2 = 102.2 \text{ lb/ft}^2$$

$$C_L = \frac{L}{q_\infty S} = \frac{W}{q_\infty S} = \frac{5000}{(102.2)(200)} = 0.245$$

$$C_{D_i} = \frac{C_L^2}{\pi e AR} = \frac{(0.245)}{\pi\ (0.93)(8.5)} = 0.0024$$

Since the airplane is flying at the condition of maximum L/D, hence minimum thrust required, $C_{D_i} = C_{D_e}$. Thus,

$$C_D = C_{D_0} + C_{D_i} = 2\ C_{D_i} = 2\ (0.0024) = 0.1048$$

$$D = q_\infty S\ C_D = (102.2)(200)(0.0048) = \boxed{98.1 \text{ lb.}}$$

6.3 (a) Choose a velocity, say $V_\infty = 100$ m/sec

$$q_\infty = \frac{1}{2}\rho_\infty V_\infty^2 = \frac{1}{2}(1.225)(100)^2 = 6125 \text{ N/m}^2$$

$$C_L = \frac{W}{q_\infty S} = \frac{103047}{(6125)(47)} = 0.358$$

$$C_D = C_{D_o} + \frac{C_L^2}{\pi e AR} = 0.032 + \frac{(0.358)^2}{\pi\ (0.87)(6.5)}$$

$$C_D = 0.032 + 0.007 = 0.0392$$

$$T_R = \frac{W}{C_L / C_D} = \frac{103047}{9.13} = 11287 \text{ N}$$

$$P_R = T_R V_\infty = (11287)(100) = 1.129 \times 10^6 \text{ watts}$$

$$P_R = 1129 \text{ kw}$$

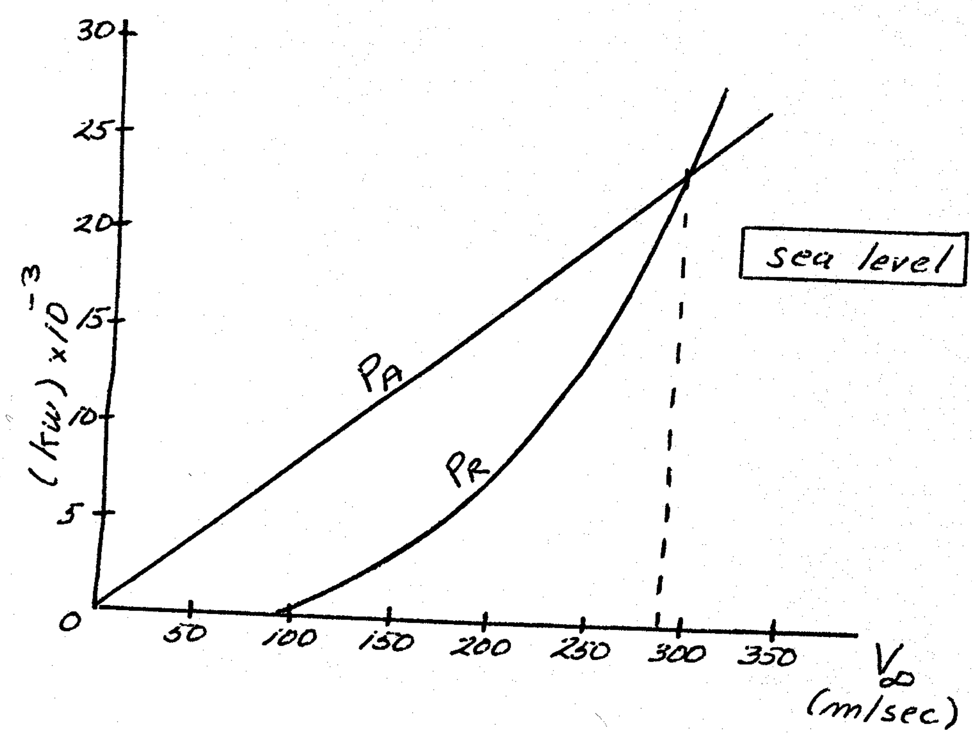
A tabulation for other velocities follows on the next page:

V (m/sec)	C_L	C_D	C_L/C_D	P_R (kw)
100	0.358	0.0392	9.13	1129
130	0.212	0.0345	6.14	2182
160	0.140	0.0331	4.23	3898
190	0.099	0.0325	3.05	6419
220	0.074	0.0323	2.29	9900
250	0.057	0.0322	1.77	14550
280	0.046	0.0321	1.43	20180
310	0.037	0		

.0321 1.15 27780

(b) $P_A = T_A V_\infty = (2)(40298)\ V_\infty = 80596\ V_\infty$

The power required and power available curves are plotted below.



From the intersection of the P_A and P_R curves, we find,

$$V_{max} = \boxed{295 \text{ m/sec}} \text{ at sea level}$$

(c) At 5 km standard altitude, $\rho = 0.7364$ kg/m^3

Hence,

$$(\rho_o/\rho)^{1/2} = (1.225/0.7364)^{1/2} = 1.29$$

$$V_{alt} = (\rho_o/\rho)^{1/2} V_o = 1.29\ V_o$$

$$P_{R\,alt} = (\rho_o/\rho)^{1/2}\ P_{R_o} = 1.29\ P_{R_o}$$

From the results from part (a) above,

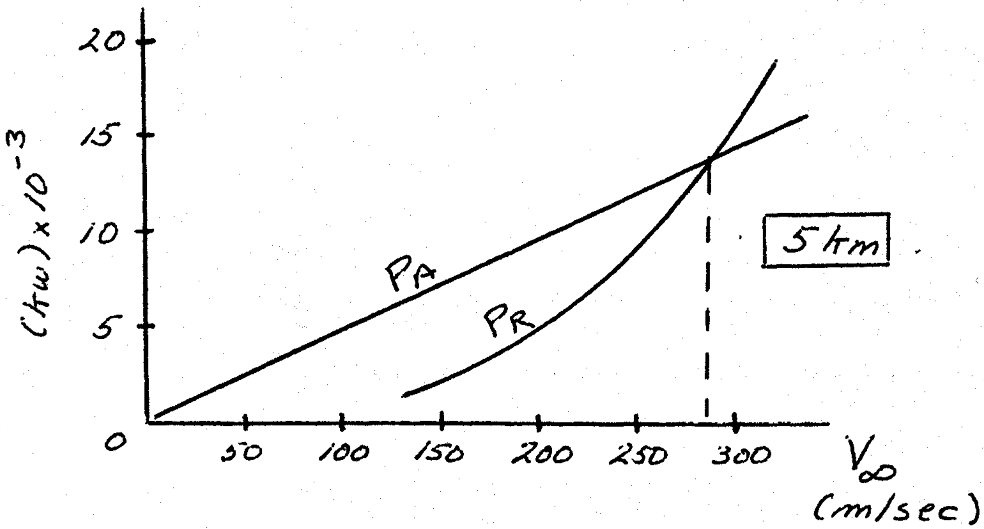
V_o (m / sec)	P_{R_o} (kw)	V_{alt} (m / sec)	$P_{R_{alt}}$ (kw)
100	1129	129	1456
130	2182	168	2815
160	3898	206	5028
190	6419	245	8281
220	9900	284	12771
250	14550	323	18770

(d) $T_{A_{alt}} = T_{A_o}\left(\dfrac{\rho}{\rho_o}\right) = 0.601\ T_{A_o}$

Hence,

$$P_{A_{alt}} = T_{A_{alt}}\ V_\infty = (0.601)(80596)\ V_\infty = 48438\ V_\infty$$

The power required and power available curves are plotted below.



From the intersection of the P_R and P_A curves, we find

$$V_{max} = \boxed{290 \text{ m/sec}} \text{ at 5 km}$$

<u>Comment</u>: The mach numbers corresponding to the maximum velocities in parts(b) and (d) are as follows:

At sea level

$$a_\infty = \sqrt{\gamma R T_\infty} = \sqrt{(1.4)(287)(288.16)} = 340 \text{ m/sec}$$

$$M_\infty = \frac{V_\infty}{a_\infty} = \frac{295}{340} = 0.868$$

At 5 km altitude

$$a_\infty = \sqrt{\gamma R T_\infty} = \sqrt{(1.4)(287)(255.69)} = 321 \text{ m/sec}$$

$$M_\infty = \frac{V_\infty}{a_\infty} = \frac{290}{321} = 0.90$$

These mach numbers are slightly larger than what might be the actual drag-divergence Mach number for an airplane such as the A-10. Our calculations have not taken the large drag rise at drag-divergence into account. Hence, the maximum velocities calculated above are somewhat higher than reality.

6.4 (a) Choose a velocity, say $V_\infty = 100$ ft/sec

$$q_\infty = \frac{1}{2}\rho_\infty V_\infty^2 = \frac{1}{2}(0.002377)(100)^2 = 11.89 \text{ lb/ft}^2$$

$$C_L = \frac{W}{q_\infty S} = \frac{3000}{(11.89)(181)} = 1.39$$

$$C_D = C_{D_o} + \frac{C_L^2}{\pi e AR} = 0.027 + \frac{(1.39)^2}{\pi\ (0.91)(6.2)}$$

$$C_D = 0.027 + 0.109 = 0.136$$

$$T_R = \frac{W}{C_L / C_D} = \frac{3000}{(1.39)/(0.136)} = \frac{3000}{10.22} = 293.5 \text{ lb}$$

$$P_R = T_R V_\infty = (293.5)(100) = 29350 \text{ ft lb/sec}$$

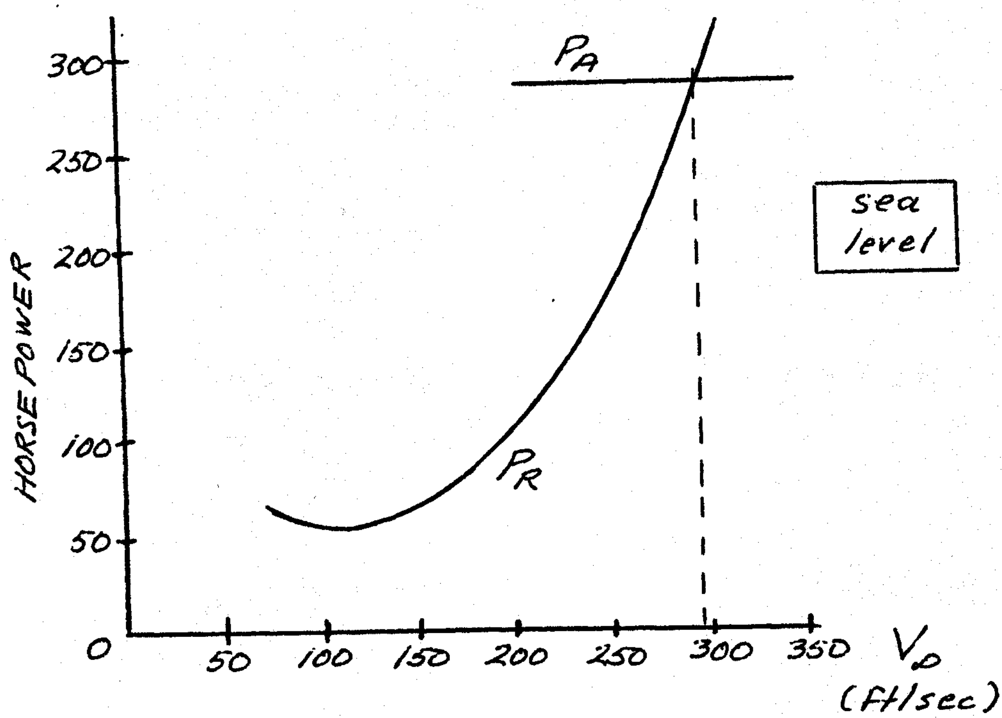
In terms of horsepower,

$$P_R = \frac{29350}{550} = 53.4 \text{ hp}$$

A tabulation for other velocities follows:

V_∞ (ft/sec)	C_L	C_D	C_L/C_D	P_R (hp)
70	2.85	0.485	5.88	64.9
100	1.39	0.136	10.22	53.4
150	0.62	0.0487	12.73	64.3
200	0.349	0.0339	10.29	106
250	0.223	0.0298	7.48	182
300	0.155	0.0284	5.46	300
350	0.114	0.0277	4.12	463

(b) At sea level, maximum $P_A = 0.83\ (345) = 286$ hp. The power required and power available are plotted below.



From the intersection of the P_A and P_R curves,

$$V_{max} = \boxed{295 \text{ ft/sec} = 201 \text{ mph}} \text{ at sea level}$$

(c) At a standard altitude of 12,000 ft,

$$\rho = 1.648 \times 10^{-3} \text{ slug/ft}^3$$

Hence,

$$(\rho_o/\rho)^{1/2} = (0.002377/0.001648)^{1/2} = 1.2$$

$$V_{alt} = (\rho_o/\rho)^{1/2}\, V_o = 1.2\, V_o$$

$$P_{R_{alt}} = (\rho_o/\rho)^{1/2}\, P_{R_o} = 1.2\, P_{R_o}$$

Using the results from part (a) above,

V_o (ft / sec)	P_{R_o} (hp)	V_{alt} (ft / sec)	$P_{R_{alt}}$ (hp)
70	64.9	84	77.9
100	53.4	120	64.1
150	64.3	180	76.9
200	106	240	127
250	182	300	218
300	300	360	360

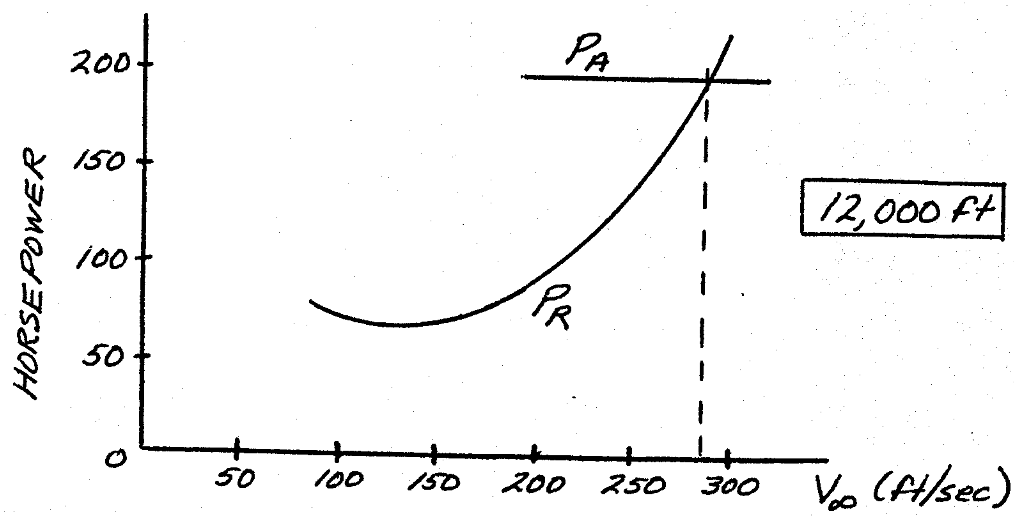
(d) Assuming that the power output of the engine is proportional to ρ_∞,

$$P_{A_{alt}} = (\rho/\rho_o)\, P_{A_o} = \left(\frac{0.001648}{0.002377}\right) P_{A_o} = 0.693\, P_{A_o}$$

At 12,000 ft,

$$P_A = 0.693\,(286) = 198 \text{ hp}$$

The power required and power available curves are plotted below.



From the intersection of the P_A and P_R curves,

$$V_{max} = \boxed{290 \text{ ft/sec} = 198 \text{ mph}} \text{ at } 12{,}000 \text{ ft.}$$

6.5 From the P_A and P_B curves generated in problem 6.3, we find approximately:

excess power = 9000 kw at sea level

excess power = 5000 kw at 5 km

Hence, at sea level

$$R/C = \frac{\text{excess power}}{W} = \frac{9 \times 10^6 \text{ watts}}{1.0307 \times 10^5 \text{ N}} = \boxed{87.3 \text{ m/sec}}$$

and at 5 km altitude,

$$R/C = \frac{5 \times 10^6}{1.03047 \times 10^5} = \boxed{48.5 \text{ m/sec}}$$

6.6 From the P_A and P_R curves generated in problem 6.4, we find approximately:

6.9 $R = h\,(L/D)_{max} = 5000\,(7.7) = \boxed{38{,}500 \text{ ft} = 729 \text{ miles}}$