Problem 5.30
Consider a finite wing with an aspect ratio of 7 and a span efficiency factor of 0.9. The airfoil section is symmetric with an infinite wing lift curve slope of 0.11 per degree. The lift-to-drag ratio is 29 when the lift coefficient is equal to 0.35. The angle of attack remains the same and the aspect ratio is increased to 10 by adding extensions to the wing. Determine the new value of the lift-to-drag ratio.

For an aspect ratio AR = 7

\[ C_L = a \alpha = \frac{a_o \alpha}{1 + 57.3 \ a_o / (\pi \ e_1 AR)} \]

\[ \alpha = \frac{C_L}{a_o} \ [1 + 57.3 \ a_o / (\pi \ e_1 AR)] \]

\[ = \frac{0.35}{0.11} \ \{1 + 57.3 \ (0.11)/(\pi \ (0.9)(7))\} = 4.2^\circ \]

\[ C_D = \frac{C_L}{(C_L / C_D)} = \frac{0.35}{29} = 0.012 \]

\[ C_D = c_d + \frac{C_L^2}{\pi e AR} \]

\[ c_d = C_D - \frac{C_L^2}{\pi e AR} = 0.012 - \frac{(0.35)^2}{\pi \ (0.9)(7)} = 0.00588 \]
Problem 5.30
Consider a finite wing with an aspect ratio of 7 and a span efficiency factor of 0.9. The airfoil section is symmetric with an infinite wing lift curve slope of 0.11 per degree. The lift-to-drag ratio is 29 when the lift coefficient is equal to 0.35. The angle of attack remains the same and the aspect ratio is increased to 10 by adding extensions to the wing. Determine the new value of the lift-to-drag ratio.

For an aspect ratio \( AR = 10 \) with the same angle of attack:

\[
C_L = a \cdot \alpha = \frac{a_o \cdot \alpha}{1 + 57.3 \cdot \frac{a_o}{(\pi \cdot e_i \cdot AR)}}
\]

\[
= \frac{(0.11)(4.2)}{1 + 57.3 \cdot \frac{(0.11)}{[\pi \cdot (0.9)(10)]}} = 0.3778
\]

\[
C_D = c_d + \frac{C_L^2}{\pi e_i AR} = 0.00588 + \frac{(0.3778)^2}{\pi \cdot (0.9)(10)} = 0.00588 + 0.00504 = 0.011
\]

Hence, the new value of \( L/D \) is

\[
\frac{C_L}{C_D} = \frac{0.3778}{0.0112} = 33.7
\]
Problem 6.2
An airplane weighing 5000 lb is flying at standard sea level with a velocity of 200 mi/hr. At this velocity, the L/D ratio is a maximum. The wing area and aspect ratio are 200 ft$^2$ and 8.5, respectively. the Oswald efficiency factor is 0.93. Determine the total drag on the airplane.

\[
V_\infty = 200 \frac{88}{60} = 293.3 \text{ ft/sec}
\]

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

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

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

Since the airplane is flying at the condition of maximum L/D

\[
C_{D_i} = C_{D_e}
\]

\[
C_D = C_{D_o} + C_{D_i} = 2 \ C_{D_i} = 2 (0.0024) = 0.0048
\]

\[
D = q_\infty S \ C_D = (102.2)(200)(0.0048) = 98.1 \text{ lb.}
\]
Problem 6.4
Consider an airplane with an aspect ratio of 6.2, wing area of 181 ft², an Oswald efficiency factor of 0.91, a weight of 3000 lb, and a zero-lift drag coefficient of 0.027. The airplane is powered by a single engine with 345 hp maximum at sea level. Assume the power is proportional to the free-stream density. The two-blade propeller has an efficiency of 0.83. Determine a) power required at sea level, and b) the maximum velocity at sea level.

(a) Choose a velocity, say \( V_\infty = 100 \text{ ft/sec} \)

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

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

\[
C_D = C_{D_e} + \frac{C_L^2}{\pi eAR} = 0.027 + \frac{(1.39)^2}{\pi (0.91)(6.2)}
\]

\[
C_D = 0.027 + 0.109 = 0.136
\]

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

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

\[
P_R = \frac{29350}{550} = 53.4 \text{ hp}
\]
Problem 6.4
Consider an airplane with an aspect ratio of 6.2, wing area of 181 ft², an Oswald efficiency factor of 0.91, a weight of 3000 lb, and a zero-lift drag coefficient of 0.027. The airplane is powered by a single engine with 345 hp maximum at sea level. Assume the power is proportional to the free-stream density. The two-blade propeller has an efficiency of 0.83. Determine a) power required at sea level, and b) the maximum velocity at sea level.

<table>
<thead>
<tr>
<th>$V_{\infty}$ (ft/sec)</th>
<th>$C_L$</th>
<th>$C_D$</th>
<th>$C_L/C_D$</th>
<th>$P_R$ (hp)</th>
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</thead>
<tbody>
<tr>
<td>70</td>
<td>2.85</td>
<td>0.485</td>
<td>5.88</td>
<td>64.9</td>
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<tr>
<td>100</td>
<td>1.39</td>
<td>0.136</td>
<td>10.22</td>
<td>53.4</td>
</tr>
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<td>0.62</td>
<td>0.0487</td>
<td>12.73</td>
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<td>0.0339</td>
<td>10.29</td>
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</tr>
<tr>
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<td>0.0284</td>
<td>5.46</td>
<td>300</td>
</tr>
<tr>
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<td>0.0277</td>
<td>4.12</td>
<td>463</td>
</tr>
</tbody>
</table>

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