AEM 313 PS. #6

1) Estimate the thrust and power required for a Boeing 747-8 at gross weight climbing out at 150 knots.

Aircraft specs.

$b = 224.5\ ft$ $\quad \Lambda_{LE} \approx 37°$

$S = 5960\ ft^2$

$MTOW = 987000\ lbf$ $\quad AR = \frac{b^2}{S} = 8.45$

Velocity:

$$\frac{150\ kts \mid 1.688\ ft}{1\ kt \mid s} = 253\ \frac{ft}{s}$$

Climb out

$L = W$

$$C_L = \frac{W}{\frac{1}{2}\rho V^2 S} = \frac{987000\ lbf \mid 2 \mid ft^3 \mid s^2 \mid}{0.00237\ slugs \mid 253^2\ ft^2 \mid 5960\ ft^2 \mid slugs\ ft / lbf\ s^2}$$

$$= 2.18$$

Oswald Efficiency

$$e \approx 4.61\left(1 - 0.045\ AR^{0.68}\right)\left(\cos \Lambda_{LE}\right)^{0.15} - 3.1$$

$$4.61\left(1 - 0.045 \cdot 8.45^{0.68}\right)\cos(37.5)^{0.15} - 3.1 = 0.497$$

$$C_{D_i} = \frac{C_L^2}{\pi AR e} = \frac{2.18^2}{\pi \cdot 8.45 \cdot 0.497} = 0.36$$

Thrust:

$$F = qSC_D = W \cdot \left(\frac{D}{L}\right) = 987000\ lbf \cdot \frac{0.36}{2.18} = \boxed{163000\ lbf = D}$$

Power:

$$P = F \cdot V = \frac{163000\ lbf \mid 253\ ft \mid Hp\ s}{s \mid 550\ ft\ lbf} = \boxed{75000\ Hp}$$

Wow!!!

2) $C_{D_0} = 180$ counts. Determ. excess thrust.

Aircraft:

4×66500 lbf engines

$$C_D = C_{D_0} + C_{D_i} = 0.0180 + 0.3600 = 0.378$$

$$D = 987000 \text{ lbf} \cdot \frac{0.378}{2.18} = 171140 \text{ lbf}$$

Excess thrust $= 4 \cdot 66500 - D$

Excess Thrust = 94900 lbf

Note: This would give about 0.1 g of acceleration at lift-off.

At 180 kts, $C_L = 1.5$, $C_{D_i} = 1737$ counts, $C_D = 1917$ counts

Excess thrust is 139000 lb $\Rightarrow$ 0.14_g

At 200 kts, $C_L = 1.22$, $C_{D_i} = 1128$ counts, $C_D = 1300$ counts

Excess thrust is 160000 lb $\Rightarrow$ 0.16_g

Thus, it takes about 10 seconds to accelerate from 150 to 180 knots at a level altitude.

You will revisit this concept next semester in AEM368.