Problem 9.142

Assume the Boeing 727 aircraft has wings with NACA 23012 section, planform area of 1600 $\text{ft}^2$, double-slotted flaps and effective aspect ratio of 6.5. If the aircraft flies at 150 knots in standard air at 175,000 lb gross weight, estimate the thrust required to maintain level flight.

**Given:** Boeing 727 aircraft, with NACA 23012 section, $A_p = 1600\text{ft}^2$, and effective aspect ratio, $a_r = 6.5$. Aircraft flies at $V = 150\text{knot}$, with $W = 175,000\text{lbf}$.

\[
\begin{align*}
A_p &: = 1600\text{ft}^2 & a_r &: = 6.5 & V &: = 150\text{knot} & \text{knot} &: = (6076)\text{ft/hr}
\end{align*}
\]

\[
\rho &: = 0.00238\text{slug/ft}^3 & W &: = 175000\text{lbf} & C_{DO} &: = 0.04
\]

**Find:** Estimate thrust needed to maintain steady, level flight.

**Solution:**

For steady level flight, thrust equals drag and lift equals weight.

Computing equations:

\[
\begin{align*}
F_L &= W = C_L A \frac{1}{2} \rho V^2 \\
F_D &= T = C_D A \frac{1}{2} \rho V^2 \\
C_D &= C_{D,\infty} + C_{D,\delta} = C_{D,\infty} + \frac{C_L^2}{\pi a_r}
\end{align*}
\]

Assumptions: (1) standard air
(2) data from Fig. 9.23 apply

\[
q &= \rho \frac{V^2}{2}
\]

\[
q = 76.271\frac{\text{lbf}}{\text{ft}^2}
\]

Now

\[
C_L := \frac{W}{q \cdot A_p}
\]

\[
C_L = 1.434
\]

From Fig. 9.23, this corresponds to operation with a single slot open, and $C_{D,\infty} = 0.04$. Thus

\[
C_D := C_{DO} + \frac{C_L^2}{\pi a_r}
\]

\[
C_D = 0.141
\]
To find thrust

\[ \frac{T}{F_L} = \frac{C_D}{C_L} \left( \frac{qA}{qA} \right) = \frac{C_D}{C_L} \quad \text{F}_L := W \]

\[ T := \left( \frac{C_D}{C_L} \right) F_L \]

\[ T = 1.717 \times 10^4 \text{ lbf} \]

Thrust needed, \( T = 17170 \text{ lbf} \)