hand calcs - drag & power

$D_p = C_{D_0} S \frac{1}{2} \rho V^2$, $D_i = \frac{W^2}{\frac{1}{2}\rho V^2 \pi e AR S}$, $q = \frac{1}{2}\rho V^2$

$= C_{D_0} S q$, $= \frac{W^2}{q \pi e AR S}$

$D = D_p + D_i$, $P_{req} = DV/550$

$[D] = lbf$ $[P] = hp$

$[\rho] = slug/ft^3$
$[V] = ft/s^2$
$[AR] = 1$
$[OE] = 1$
$[CD_0] = 1$
$[W] = lbs$
$[q] = lbf/ft^2$

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baseline sealevel:

$V = 70 knots = 118 ft/s$
$\rho = .0024 slug/ft^3$
$AR = 5.63$
$OE = .78$
$CD_0 = .0275$
$W = 1050 lbs$
$q = 16.6 lbf/ft^2$
$S = 127$

$D_i = \frac{(1050 lbf)^2}{(16.6 lbf/ft^2)\pi(.78)(5.63) ft^2} = 37.9 lbf$

$D_p = .0275(16.6 (lbf/ft^2)) 127 ft^2 = 58.1 lbf$

$D = 95.9 lbf$

$P_{req} = 95.9 lbf \ 118 ft/s / 550 = 20.6 hp$

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base 7500ft

$\rho = .0009 slug/ft^3$

everything else same

$q = 13.24 lbf/ft^2$

$D_i = \frac{(1050 lbf)^2}{(13.24 (lbf/ft^2))(127 ft^2)\pi(.78)(5.63)}$

$= 47.6 lbf$

$D_p = .0275(13.24 (lbf/ft^2))(127 ft^2) = 46.24 lbf$

$D = 93.8 lbf$, $P = 93.8 lbf \ 118 ft/s / 550 = 20.12 hp$

Landing sealevel:

baseline except:

$C_{D_0} = .0975$

$D_i = \frac{(1050 lbf)^2}{16.6 lbf/ft^2 \ \pi(.78)(5.63) ft^2} = 37.9 lbf$

$D_p = .0975(16.6 lbf/ft^2)(127 ft^2) = 205.7 lbf$

$D = 243.6$, $P = 243.6 (118 ft/s)/550 = 52.3 hp$

heavy scaled
same as base except
W = 1.32 lbf

$$D_i = \frac{(1320\ lbf)^2}{(\rho)(16.6\ lbf/ft^2)(127 ft^2)\pi(78)(5.63)}$$

$$= 59.81 lbf$$

$$D_p = (.028)(16.61 lbf/ft^2)(127 ft^2) = 58 lbf$$

$$D = 117.81 lbf, P = 25.3 hp$$

Write up:

Cruise: the cruise graph for drag is "shifted" to the right of the baseline graph. This is because cruise has a lower ρ than baseline due to its higher altitude. This makes q which appears in the denominator of D_i but the numerator of D_p. This means the point where $D_i = D_p$ ie lowest D is moved right. because P is proportional to D at a given V, P is similarly shifted.

Landing: The landing graph is much steeper than the others because C_{D_0} is much much larger. The graph starts sooner because $C_{L_{max}}$ is greater. This allows the weight to be held up with lower V. However since C_{D_0} shows up in D_p and is so much higher, D increases very fast with V

Heavy: The heavy graph is similar to base but needs to fly slightly faster, this is because W^2 is in numerator for D_i, this means D_i is much higher. More power and greater speed are needed to support this greater D and W