Trey Fortmuller
Joey Kroeger
David D. Hooper
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ME136 PS1

1) $F_L = F_W$ at the stall speed

$$F_L = \frac{1}{2}\rho V_\infty^2 A C_L = F_W$$

$$\sqrt{\frac{2F_W}{\rho A C_L}} = V_\infty = \sqrt{\frac{2(9.81\cdot 900)}{(1.225)(16)(1.6)}} = \boxed{23.73\ m/s}$$

2) a) propellor speeds

$$f_T = \frac{1}{4}f_W = \frac{1}{4}mg = C_T\Omega^2$$

$$\Omega = \sqrt{\frac{mg}{4C_T}}$$

$$= \sqrt{\frac{(.5)(9.8)}{4(6.41e\text{-}6)}} = \boxed{437.38\ rad/s}$$

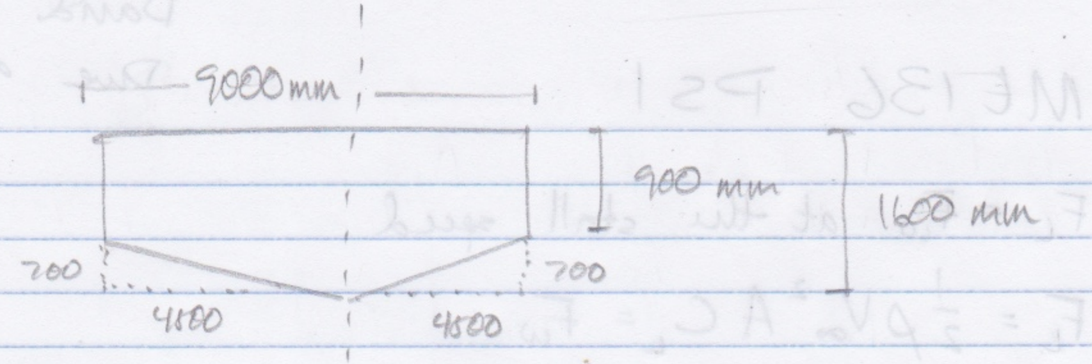
$$= 4176\ rpm$$

b) mechanical power at hover

$$P = \Omega\tau = \Omega\gamma f_T = \frac{\Omega\gamma mg}{4}$$

$$= \frac{(437.38)(.017)(.5)(9.81)}{4}$$

$$= \boxed{9.11\ W}$$



3)

$C_l = 2\pi\alpha \qquad m = 1000\ kg$

a) AR ?

$$S = [9000 \times 1600] - [4500 \times 700]$$

$$= 11.25 \times 10^6\ mm^2$$

$$AR = \frac{b^2}{S} = \frac{(9000)^2}{11.25 \times 10^6} = \boxed{7.2}$$

b) $$C_L = \left(\frac{AR}{AR+2}\right) C_l \alpha = 2\pi\left(\frac{AR}{AR+2}\right)\alpha^2$$

$$C_L = 2\pi\left(\frac{7.2}{9.2}\right)\alpha^2$$

$$C_L = \boxed{4.917\,\alpha^2}$$

c) $$f_L = f_w = \frac{1}{2}\rho V_\infty^2 A C_L = mg \quad \text{at } V_\infty = 55\ m/s$$

$$= \frac{1}{2}\rho V_\infty^2 A (4.917)\alpha^2 = mg$$

$$\alpha = \sqrt{\frac{2mg}{\rho V_\infty^2 A \cdot 4.917}} = \boxed{.309\ rad} = 17^\circ$$

4) $Re = \frac{V_\infty l \rho}{\mu}$

$f_D = f_w$ at terminal velocity

$$f_D = \frac{1}{2}\rho V_\infty^2 A C_D(Re) = mg$$

$$V_\infty = \frac{Re\,\mu}{l\rho}$$

$$f_D = \frac{1}{2}\rho\left(\frac{Re\,\mu}{l\rho}\right)^2 A\, C_D \qquad A = \frac{\pi l^2}{4}$$

$$f_D = \frac{1}{8}\cancel{\frac{1}{2}}\cancel{\rho}\left(\frac{Re^2\mu^2}{\cancel{l^2}\rho^{\cancel{2}}}\right)\left(\frac{\pi \cancel{l^2}}{\cancel{4}}\right) C_D$$

$$f_D = \frac{Re^2\mu^2\pi C_D}{8\rho}$$

$$Re^2 = \frac{f_D\,\rho}{\mu^2\,C_D}\,\frac{8}{\pi} \qquad f_D = f_w \text{ at terminal velocity} = mg$$

$$Re^2 = \frac{8}{\pi}\,\frac{mg\rho}{\mu^2}\,\frac{1}{C_D}$$

we plug in values for C_D and check that a corresponding Re exists on the given curve.

$C_D = .4 \rightarrow Re = 1.3 \times 10^6$ which is not on the curve

$C_D = .15 \rightarrow Re = 2.1 \times 10^6$ which is on the curve, we use this value to calculate V_∞.

$$V_\infty = \sqrt{\frac{8mg}{\pi l^2 C_D}} = \boxed{157.34\ m/s} = 350\ mph$$