PS4 solution

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a] According to Breguet Range Equation,

$$R = \underbrace{\frac{h}{g}}_{\text{fuel type}} \underbrace{\eta_{ov}}_{\text{efficiency}} \left(\frac{L}{D}\right) \underbrace{\ln\left(\frac{W_{initial}}{W_{final}}\right)}_{\text{structure}}$$

↑ aerodynamics

From the problem sentence, η_{ov} = constant

We can also assume $\frac{h}{g}$, $\ln\left(\frac{W_{initial}}{W_{final}}\right)$ constant and independent of flight condition. Thus, max range is achieven when $\frac{L}{D} = \frac{C_L}{C_D}$ is maximum.

From SPL 2 data, C_L is known, and $C_D = 0.013 + C_{D\_lab2}$.

By inspecting the slope, $\left(\frac{C_L}{C_D}\right)_{max} = 8.41$, at $C_L = 0.7$.

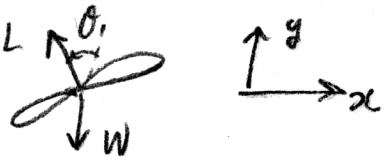
$$C_L = \frac{L}{\frac{1}{2}\rho V^2 S} \Leftrightarrow V = \sqrt{\frac{W/S}{\frac{1}{2}\rho C_L}} = \sqrt{\frac{5\ (Pa)}{\frac{1}{2} \cdot 1.22\ (kg/m^3) \cdot 0.7}} = \boxed{3.42\ (m/s)}$$

b] The maximum endurance condition corresponds with the minimum energy expenditure. The minimum power required occurs when $\frac{C_L^{3/2}}{C_D}$ is maximized.

From the dragonfly $C_L^{\frac{3}{2}}$ vs C_D curves, this condition is achieved for $C_L = 1.2$

$$V = \sqrt{\frac{2(W/S)}{\frac{1}{2}\rho C_L}} = \sqrt{\frac{5\ (Pa)}{\frac{1}{2} \cdot 1.22 \cdot 1.2}} = \boxed{2.61\ (m/s)}$$

c) For steady turning flight, the equilibrium equation in vertical direction is



$$\sum F_y = L\cos\theta - W = 0$$

$$\Leftrightarrow \quad L = \frac{W}{\cos\theta}.$$

$$C_L = \frac{L}{\frac{1}{2}\rho V^2 S} = \frac{W/\cos\theta}{\frac{1}{2}\rho V^2 S} \Leftrightarrow V = \sqrt{\frac{2(W/S)}{\frac{1}{2}\rho\cos\theta C_L}}$$

Banking does not change the C_L vs C_D curves.

Thus, for maximum range, $C_L = 0.7$.

$$V = \sqrt{\frac{5\,(Pa)}{\frac{1}{2}\cdot 1.22\cdot 0.7\cdot\cos 20}} = \boxed{3.53\ (m/s)}$$

For maximum endurance, $C_L = 1.2$

$$V = \sqrt{\frac{5}{\frac{1}{2}\cdot 1.22\cdot 1.2\cos 20^\circ}} = \boxed{2.70\ (m/s)}$$

SUMMARY

alpha	Cx	Cy	Cmo	C_D	C_L	C_D	C_L^1.5
0	0.053747	0.4792209	0.025275	0.066747075	0.479220931	0.066747	0.331744
4	0.025348	0.787663	-0.01676	0.093230741	0.783976137	0.093231	0.694151
8	-0.0257	1.0909157	-0.0545	0.139375967	1.083875815	0.139376	1.128416
12	-0.10353	1.3649608	-0.08272	0.195518875	1.35665926	0.195519	1.580179
16	-0.16713	1.487127	-0.08334	0.262252327	1.475585379	0.262252	1.792448
20	-0.14842	1.4024648	-0.05356	0.353199335	1.368649416	0.353199	1.601173