AER1216: Fundamentals of UAS

Assignment # 2
Due: Oct. 21st

1. **Multi-rotor configurations**: Two multirotor designs are being considered to lift a payload mass of 5 kg, with either four 30 cm diameter rotors or six 25 cm diameter rotors. The quadrotor vehicle weighs 2 kg and the hexacopter weighs 2.5 kg without payloads. Assume no losses, standard atmosphere, and state any other assumptions you make, if necessary.

   (a) What is the power requirement for each design to maintain stable hover? [**10 marks**]

   (b) Given a fixed battery size, what would the ratio of flight times be between the two designs? [**5 marks**]

2. **Propellers**: Using the UIUC database to find all required data, determine C_T and C_Q for the APC SF 10x4.7 propeller spinning at 6000 RPM for forward speeds from 0 to 17 m/s (in increments of 1 m/s) using the Momentum Blade Element Theory (use MATLAB or Python). Assume $c_d = 0.07$ and assume that the zero-lift-line is 5 degrees from the chord line (the twist of the blade in UIUC database is twist of chord line so the twist of the zll is larger). You may also assume that the slope of the linear lift curve for the blades is equal to 5.7 rad^{-1}. Compare the results (using plots) with the measured UIUC C_T and C_Q (careful with different helicopter and aircraft propeller coefficient definitions!). Hand in your code. [**25 marks**]

3. **Aircraft Configurations**: For a biplane with the same span and wing area ($b = 10$ m, $S = 20$ m^2) as a monoplane, determine the percent reduction in induced drag coefficient of the biplane compared to the monoplane if the biplane vertical wing spacing is 3 m. Assume both wings have elliptic distributions and both aircraft are otherwise identical (i.e. weight, cruising speed, ...) and list any other assumptions you need to make. (Hint: you will need a plot from the lecture notes.) [**5 marks**]

4. For the following prompts, present one advantage of choosing the selected vehicle configuration compared to the other specified arrangement, and very briefly discuss why that advantage exists. As well, mention an example of a real design that uses this advantage. If you believe there is no advantage, explain why. [**5 marks**]

   (a) Flying wing advantage over a conventional low-wing monoplane,

   (b) Canard monoplane advantage over a conventional aft-tailed monoplane,

   (c) Forward swept wing configuration advantage over an unswept wing configuration,

   (d) Octocopter advantage over conventional quadcopter,

   (e) Quadcopter advantage over a tricopter.