Submit your solution on MS Teams as one (1) PDF file

Goals

- Be able to describe and explain the system architeture of a small unmanned aircraft
- Understand the design process for development of an autopilot.
- Be able to express frame relationships: translation and rotation
- Familiarize yourself with some custom aircraft frame and angle conventions.
- Familiarize yourself with Python code for numerical integration.

Reading

- Beard and McLain (BM), *Small Unmanned Aircraft: Theory and Practice*: Chapter 1, 2.

Excercise 1: Search the web and find a small unmanned aircraft (fixed-wing aircraft with a wingspan of less than 5 feet). Figure out how the aircraft is steered around. What is a coordinated turn? How do you perform one?

Excercise 2: Sketch a block diagram of the system architecture of an unmanned air vehicle (UAV). What is this useful for?

Excercise 3: Why is it useful to develop a simulator for a UAV as we will do in this class?

Excercise 4: Consider a drone flying in still air that is about to go into a descending banked turn. The center of mass of the drone is located 10 m above a reference point on earth, its velocity components in the body frame are $(15, 1, 0.5)$ m/s, its orientation is given by the Euler angles: yaw $2°$, pitch $10°$, and roll $20°$.

(a) A battery on the drone is sitting 0.2 m away from the center of mass (COM) in the nose direction (measured in body frame). What is its location (position vector) with respect to the earth-fixed frame?

(b) What is the velocity in the earth-fixed frame?

(c) What is the flight-path angle (in degrees)?

(d) What is the angle of attack?

(e) What are the heading and course angles? Explain the difference.

Excercise 5: Download Python files for numerical integration from MS Teams (see attached files). For this question you will Implement a mass-spring system with parameters: $m = 1$, $b = 0.25$, and $k = 1$ (in appropriate units).

(a) First run the downloaded simulation, and try to understand the code.

(b) Next, integrate the mass-spring system first with the `Euler` method, and second with the `Heun` method. Experiment with suitable step sizes `dt`. Compare the numerical solution with the analytical solution (see e.g. Systems Engineering notes). Attach your plots and describe your findings.

(c) **(bonus)** Plot the step response of the system.