Aero4200 Simulation Tutorial: Linearised Dynamics and Controller Design

In this tutorial, we look at the longitudinal dynamics of a four-engine jet transport aircraft. The aerodynamic data and simulation framework is taken from Blakelock’s *Automatic Control of Aircraft and Missiles*.

The states in the simulation are velocity, angle of attack, pitch rate, and pitch angle:

1) Open Execution.py, Constants.py and Functions.py in Spyder. Study Execution.py and identify the modules called. What is the calling order of the modules, and what are each of their functions?

Run Execution.py. Are there any perturbations - is the aircraft trimmed, or off-trim?

2) Introduce an elevator pulse input by uncommenting the appropriate lines of code. Run Execution.py and observe the perturbations. Identify the short period and phugoid modes. Change the time scale (tfinal) of the simulation to examine the different modes. (use tfinal = 20 for SPO, and tfinal = 200 for phugoid)

3) Comment out the elevator pulse input. Introduce a disturbance in the xhist list (line 10). xhist = [(0,0.05,0,0)] disturbs the angle of attack by a few degrees. Does this aircraft exhibit static stability? Explain why it does or doesn’t exhibit dynamic stability.

4) Identify the definition of the control module in Functions.py, and where it is called in Execution.py.

1. Write a simple stability augmentation controller that regulates the pitch angle to zero by outputting elevator commands. Proportional action with pitch rate damping should suffice:
2. Tune your controller such that with the disturbance from Q3, we are able to get to within +- 0.5 degrees pitch within 20 seconds. (hint: Kp < 0; Kq > 0 for stability)

Reflect: What tools from METR4201 would have been useful here? Why do we need correct signs for Kp and Kq to ensure stability?