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Application Assignment: Aircraft Pitch Control

In this assignment, you will model, design, and simulate an aircraft pitch control system and consider the broader impacts of the design. The model will be based on a commercial Boeing aircraft.

Part 1: Read the following articles about the Boeing 737 MAX crashes and the resulting U.S. Congressional inquiry and think about the control system engineer's role. We will discuss these questions in class; be prepared to share:

- Q&A_ What led to Boeing's 737 MAX crisis _ The Seattle Times.pdf (11/2020)
- NPR - Congressional Inquiry Faults Boeing and FAA Failures for Deadly 737-Max Plane Crashes (9/2020)
- What can/should engineers do to mitigate problems with the systems they design?
- What is the role of an engineer in training users of the technology they design?
- What ethical responsibilities do engineers have?

Part 2: Read through this webpage to see how to model an aircraft pitch control system: https://ctms.engin.umich.edu/CTMS/index.php?example=AircraftPitch&section=SystemModeling

- We will use the model given in the transfer function in equation (9) that relates the aircraft pitch angle to the elevator deflection angle.
- Copy the code for the plant transfer function *P_pitch* given on the webpage into MATLAB.
- Plot the first 20 seconds of the unit step response and the impulse response of *P_pitch*; **include the plots in your submission.**
- Read https://ctms.engin.umich.edu/CTMS/index.php?example=AircraftPitch&section=SystemAnalysis to understand why the open-loop system is unstable given a step input.

Part 3: Follow the procedure described here https://ctms.engin.umich.edu/CTMS/index.php?example=AircraftPitch&section=ControlPID to design a PID aircraft pitch controller using the *controlSystemDesigner(P_pitch)* function in MATLAB that meets the following design requirements, given a step reference of 0.2 radians:

- Overshoot < 6%
- Rise time < 0.5 sec
- 2% settling time < 3 sec
- Steady-state error < 2%

After tuning the PID controller, **include the following in your submission:**

- the Kp, Ki, and Kd gain values
- the closed-loop transfer function (you can export from the Control System Designer)
- the overshoot, rise time, settling time, and steady-state error in response to a step reference of 0.2 radians
    - compare these to the design requirements (i.e., show that the requirements are met)
    - (Note: the MATLAB function *stepinfo* may be useful)
- a plot of the closed-loop step response given a 0.2 radian step reference