THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Aerospace Engineering and Engineering Mechanics

HOT neglected

ASE 367K FLIGHT DYNAMICS
Fall 2024

• small angle approx

a condition: constant velocity → zero beta, body fixed frame aligned with nominal velocity vector

HOMEWORK 6
Due: Friday 2024-10-25 at 11:59pm via Canvas

this model assumes: Δp is small, linearized about a condition, perturbations are small

Problem 1

Given the linear system model provided on Slide 8 of Lecture 15 and the dimensional stability derivatives for the B747 at "low cruise" provided on Slide 13 of Lecture 15: → looks at longitudinal motion only

a. Determine the damped frequency, natural frequency, damping ratio, the time to damp to half the initial amplitude, and the number of cycles to damp to half the initial amplitude for BOTH the short period and the Phugoid (long period) modes.

b. Develop a simulation (using the either MATLAB or Python) for this model and use it to determine and plot the values of the state variables Δu, $\Delta\alpha$, Δq, and $\Delta\theta$ (as functions of time) in response to the step and impulse elevator deflections of maximum amplitude.

Problem 2

Given the following approximate model for the "short period mode," i.e., developed assuming $\Delta u = 0$, $\sin\theta_1 \approx 0$, $\|Z_{\dot\alpha}\| \ll \|u_1\|$, $\|Z_q\| \ll \|u_1\|$, and $M_{T_\alpha} = 0$, and the dimensional stability derivatives for the B747 at "low cruise" provided on Slide 13 of Lecture 15:

$$\begin{bmatrix} u_1 & 0 \\ -M_{\dot\alpha} & 1 \end{bmatrix} \begin{bmatrix} \Delta\dot\alpha \\ \Delta\dot q \end{bmatrix} = \begin{bmatrix} Z_\alpha & u_1 \\ M_\alpha & M_q \end{bmatrix} \begin{bmatrix} \Delta\alpha \\ \Delta q \end{bmatrix}$$

a. Determine the damped frequency, natural frequency, damping ratio, the time to damp to half the initial amplitude, and the number of cycles to damp to half the initial amplitude for this approximate model.

b. Develop a simulation (using the either MATLAB or Python) for this approximate model and use it to determine and plot the values of $\Delta\alpha$ and Δq (as functions of time) in response to the same step and impulse elevator inputs used in Problem 1.

Problem 3

Given the following "Phugoid (long period) mode" approximate model, and the dimensional stability derivatives for the B747 at "low cruise" provided on Slide 13 of Lecture 15:

$$\begin{bmatrix} \Delta\dot{u} \\ \Delta\dot{\theta} \end{bmatrix} = \begin{bmatrix} X_u + X_{T_u} & -g \\ -Z_u/u_1 & 0 \end{bmatrix} \begin{bmatrix} \Delta u \\ \Delta\theta \end{bmatrix}$$

a. Determine the damped frequency, natural frequency, damping ratio, the time to damp to half the initial amplitude, and the number of cycles to damp to half the initial amplitude for this approximation.
b. Develop a simulation (using the either MATLAB or Python) for this approximate model and use it to determine and plot the values of Δu and $\Delta\theta$ (as functions of time) in response to the same step and impulse elevator inputs used in Problem 1.

Problem 4

Compare the results of Problems 1 through 3 and:

a. Explain any differences between the full model and the two approximations in terms of the computed damped frequency, natural frequency, damping ratio, the time to damp to half the initial amplitude, and the number of cycles to damp to half the initial amplitude.
b. Use the plots to support your findings in part a.