# AER 410 Flight Dynamics Lab: Flight Plan

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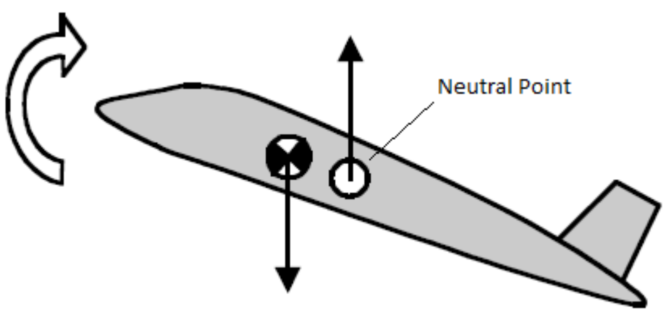
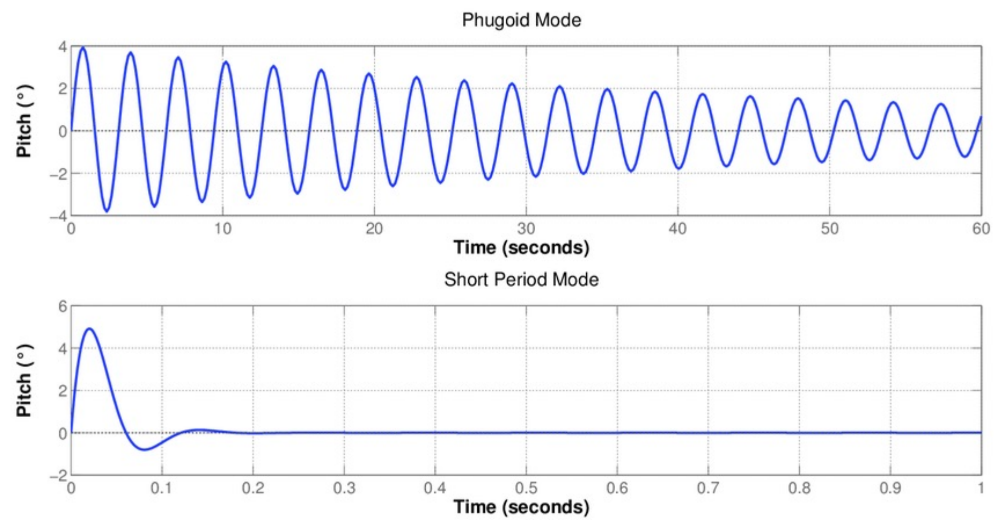
# Objectives

1. Experimentally determine the aircraft's neutral point
2. Experimentally determine the natural frequency ($\omega_n$) and the damping ratio ($\zeta$) of the aircraft's:
   a. Phugoid mode
   b. Short period mode



# Equipment

- REALSIMGEAR SRX AATD flight simulator
- Aircraft simulated: Cirrus SR22T

# 1. Finding the Neutral Point

1. Pre-flight
    a. Make sure data output for stick position, elevator angle, airspeed, air temperature, pressure (altitude), and fuel burn will be recorded
    b. Manipulate cargo, passenger, fuel weight, etc. to select three CG points
        i. First point next to fore boundary
        ii. Second point next to aft boundary
        iii. Third point in between first two
    c. Note the configuration used for each point
2. Flight Procedure
    a. Fly at stable altitude and airspeed and trim the aircraft
        i. Trim will not be readjusted once next step starts
    b. Keeping a constant altitude change the airspeed by $\pm 5$ and $\pm 10$

# 1. Finding the Neutral Point

3. Analysis
    a. Calculate lift coefficient using [1]
    b. Plot stick deflection against lift coefficient for each CG configuration and airspeed
        i. Note that fuel burn will change CG over time
    c. Find slope of the line of best fit for each stick deflection vs. $C_L$ data set for each CG config.
    d. Plot slopes $\left(\frac{ds}{dC_L}\right)$ against CG position (aft of datum) and extend the line of best fit connecting all three points to the x-axis $\left(\frac{ds}{dC_L} = 0\right)$. This position is the location of the neutral point of the aircraft.

4. Equation

$$C_L = \frac{L}{\left(\frac{1}{2}\right)\rho V^2 A} \qquad [1]$$

# 2a. Finding $\omega_n$ and $\zeta$ of the phugoid mode

1. Pre-flight
   a. Make sure data output for pitch angle, angle of attack, airspeed, and pressure (altitude) will be recorded
2. Flight Procedure
   a. Fly at stable altitude and airspeed and trim the aircraft
      i. Trim will not be readjusted once next step starts
   b. Provide an impulse pitch input to pitch the nose up or down until an airspeed 10-15 kts above or below the trimmed airspeed is reached
   c. Bring the pitch input back to the neutral position and let the aircraft dynamically pitch up and down

# 2a. Finding $\omega_n$ and $\zeta$ of the phugoid mode

3. Analysis
    a. Calculate z-axis acceleration data from pitch, airspeed, and angle of attack data
    b. Plot z-axis acceleration data vs. time – the result should be a waveform graph
    c. Perform DFT spectral analysis on the waveform plot to determine the maximum frequency and thus the period of the phugoid mode [2]
    d. Find the damped natural frequency with [3]
    e. Find the damping ratio with [4] where $t_1$ and $t_n$ are the times at any two peaks in the waveform graph found in b.
    f. Finally, find the natural frequency using [5]

4. Equations

$$t_{period} = \frac{1}{f_{max}} \quad [2]$$

$$\omega_d = \frac{2\pi}{t_{period}} = 2\pi f_{max} \quad [3]$$

$$\zeta = \frac{\frac{1}{n-1}\ln\left(\frac{t_1}{t_n}\right)}{\sqrt{4\pi^2 + \left[\frac{1}{n-1}\ln\left(\frac{t_1}{t_n}\right)\right]^2}} \quad [4]$$

$$\omega_n = \frac{\omega_d}{\sqrt{1-\zeta^2}} \quad [5]$$

# 2b. Finding $\omega_n$ and $\zeta$ of the short period mode

1. Pre-flight
   a. Make sure data output for pitch angle, angle of attack, and airspeed, and pressure (altitude) will be recorded
2. Flight Procedure
   a. Fly at stable altitude and airspeed and trim the aircraft
      i. Trim will not be readjusted once next step starts
   b. Induce a small, quick pitch disturbance by applying a doublet (brief elevator deflection)
   c. Quickly bring the pitch input back to the neutral position and let the aircraft dynamically pitch up and down

# 2b. Finding $\omega_n$ and $\zeta$ of the short period mode

3. Analysis
   a. Same process as for phugoid mode (see slide 7)
4. Equations
   a. Same as for phugoid mode (see slide 7)