Aircraft Dynamic Stability
Glider Construction Tips

Lesson Overview

• Review
• Dynamic Stability
  – Longitudinal Modes
    • Short Period
    • Phugoid
  – Lateral-Directional Modes
    • Spiral
    • Dutch Roll
    • Roll

Stability

Static Stability – the initial tendency to return to trim

Dynamic Stability – the long-term tendency to return to trim
Positive Static Stability

(Also Positive Static)

Positive Dynamic Stability

Decreasing Amplitude

(Also Positive Static)

Negative Dynamic Stability

Increasing Amplitude

(Also Positive Static)
5 Dynamic Stability Modes

- Longitudinal
  - Short Period
  - Phugoid
- Lateral-Directional
  - Spiral
  - Dutch Roll
  - Roll

Longitudinal Modes

Short Period
Phugoid

Short Period Mode

Trim

$- C_M (+\alpha)$
Longitudinal Static Stability

\[ + C_M \]

Short Period Mode

\[ - C_M \]

\[ + \alpha \]

\[ - \alpha \]
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Short Period Mode
• Quick, high frequency ("short period")
• Well Damped (few overshoots)
• Pitch and $\alpha$ vary

Phugoid Mode
• Slow, low frequency ("long period")
• Lightly Damped (many overshoots)
• Pitch and $V$ vary
  – Trade altitude and airspeed
  – Rollercoaster in the sky
Lateral-Directional Modes

- Spiral
- Dutch Roll
- Roll

Spiral Mode

- Bank and sideslip ($\beta$) steadily increase
- Spiral / cork screw into ground
- Large $C_{N\beta}$

$$\frac{|C_{N\beta}|}{|C_{1\beta}|} > \frac{2}{3}$$

*How to correct?*
Dutch Roll Mode

- Bank and sideslip ($\beta$) oscillate side to side
- High frequency / lightly damped
- Large $C_{L\beta}$

$$\left| \frac{C_{NB}}{C_{L\beta}} \right| < \frac{1}{3}$$

*How to correct?*

Lateral-Directional Coupling

$$\frac{1}{3} \leq \left| \frac{C_{NB}}{C_{L\beta}} \right| \leq \frac{2}{3}$$

*Dutch Roll*  *Spiral Mode*
Stability and Control Review

IF AN AIRCRAFT HAS LONGITUDINAL STATIC STABILITY, IT WILL ALSO HAVE LONGITUDINAL DYNAMIC STABILITY?

A. TRUE
B. FALSE
C. MAYBE

Stability and Control Review

THE Y AXIS FOR AN AIRCRAFT IS

A. OUT THE RIGHT WING
B. OUT THE BOTTOM OF THE AIRCRAFT
C. OUT THE NOSE

Stability and Control Review

AN AIRCRAFT THAT IS VERY STABLE WILL LIKELY BE

A. VERY EASY TO CONTROL
B. SLUGGISH TO CONTROL
Stability and Control Review

THE SYMBOL FOR THE MOMENT ABOUT THE Z AXIS IS

A. L
B. M
C. N

Stability and Control Review

MOTION ABOUT THE X AXIS IS CALLED

A. PITCH
B. ROLL
C. YAW

Stability and Control Review

WHY DO WE DISPLAY THE AERODYNAMIC FORCES AT THE AERODYNAMIC CENTER FOR A PARTICULAR SURFACE (WING, TAIL)?

A. BECAUSE THE MOMENT COEFFICIENT DOES NOT VARY WITH ANGLE-OF-ATTACK
B. BECAUSE THE LOCATION OF THE AERODYNAMIC CENTER DOES NOT VARY WITH ANGLE-OF-ATTACK
C. BOTH THE ABOVE
Stability and Control Review

THE MOMENT COEFFICIENT ABOUT THE AERODYNAMIC CENTER FOR A POSITIVELY CAMBERED WING IS

A. POSITIVE
B. NEGATIVE
C. NEED MORE INFORMATION

Stability and Control Review

IF $C_{m\alpha}$ IS LESS THAN ZERO, THE AIRCRAFT WILL HAVE __________ LONGITUDINAL STATIC STABILITY.

A. POSITIVE
B. NEGATIVE
C. NEUTRAL

Stability and Control Review

THE PRINCIPAL WAY TO ADJUST THE TRIM ANGLE-OF-ATTACK FOR YOUR GLIDER IS TO ADJUST THE INCIDENCE ANGLE OF THE HORIZONTAL TAIL?

A. TRUE
B. FALSE
Stability and Control Review

IF A PILOT WANTS TO ADJUST HIS TRIM AIRSPEED TO A LOWER VALUE, HE WILL ADJUST HIS TRIM ANGLE-OF-ATTACK (ALL OTHER FACTORS CONSTANT) TO

A. A HIGHER NUMBER
B. A LOWER NUMBER

Stability and Control Review

FOR LONGITUDINAL STATIC STABILITY, KEEP THE CENTER-OF-GRAVITY __________ THE NEUTRAL POINT.

A. IN FRONT OF
B. BEHIND
C. AT

\[ SM = \bar{x}_n - \bar{x}_{cg} \]

Stability and Control Review

AS AN AIRCRAFT ACCELERATES FROM SUBSONIC TO SUPERSONIC FLIGHT, WHAT HAPPENS TO THE LONGITUDINAL STATIC STABILITY OF THE AIRCRAFT (CONSIDER ONLY THE MOVEMENT OF THE WING AND TAIL AERODYNAMIC CENTERS)?

A. IT BECOMES MORE STABLE
B. IT BECOMES LESS STABLE
C. MORE INFORMATION IS NEEDED
Stability and Control Review

WHAT GOVERNS THE MAXIMUM TRIM ANGLE-OF-ATTACK THAT SHOULD BE AVAILABLE?

A. STALL
B. MAXIMUM AIRSPEED
C. PARASITE DRAG COEFFICIENT

Stability and Control Review

A DUTCH ROLL MEANS THAT _______STABILITY IS TOO STRONG COMPARED TO THE ________ STABILITY.

A. DIRECTIONAL, LATERAL
B. LONGITUDINAL, LATERAL
C. LATERAL, DIRECTIONAL
D. LATERAL, LONGITUDINAL

Stability and Control Review

NAME THE FIVE MODES OF DYNAMIC MOTION FOR AN AIRCRAFT.

Longitudinal Modes: Short Period, Phugoid
Lateral-Directional: Dutch Roll, Spiral Mode, Roll Mode
Stability and Control Review

IF A NEW AIRCRAFT DESIGN HAS POOR LATERAL STABILITY, WHICH OF THE FOLLOWING WOULD AN AERONAUTICAL ENGINEER CONSIDER TO IMPROVE THE SITUATION (MORE THAN ONE ANSWER MAY BE CORRECT).

A. INCREASE THE WING SWEEP
B. DECREASE THE WING DIHEDRAL

C. INCREASE THE SIZE OF THE VERTICAL TAIL ABOVE THE CG
D. PUT THE WING TO A LOWER POSITION ON THE AIRCRAFT

Stability and Control Review

FOR A CONVENTIONAL AIRCRAFT, THE WING CONTRIBUTION TO LONGITUDINAL STATIC STABILITY IS

A. STABILIZING
B. DESTABILIZING

Stability and Control Review

IF AN AIRCRAFT HAS A STATIC MARGIN OF -.02, THAT MEANS

A. THE SLOPE OF THE $C_m$ VERSUS $\alpha$ CURVE IS NEGATIVE
B. THE AIRCRAFT HAS STATIC STABILITY IN PITCH
C. THE CG IS IN FRONT OF THE NEUTRAL POINT
D. NONE OF THE ABOVE