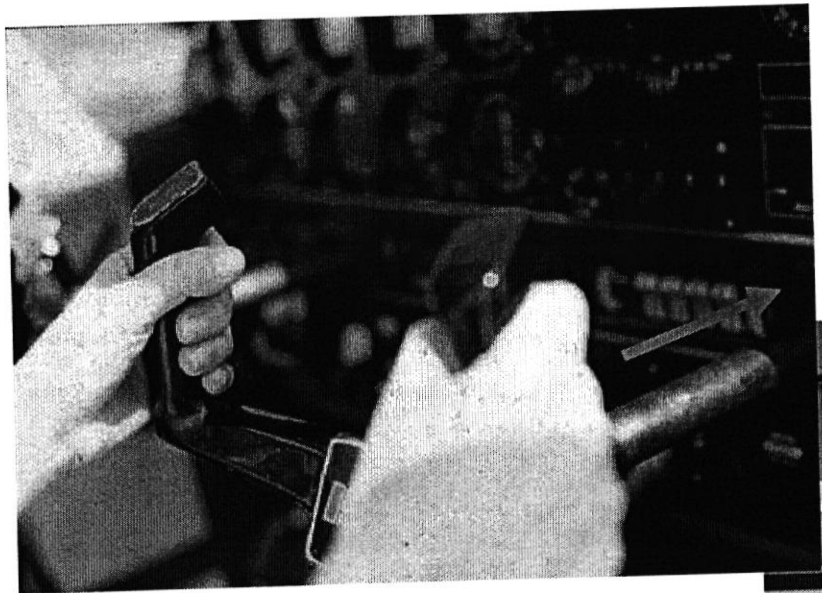
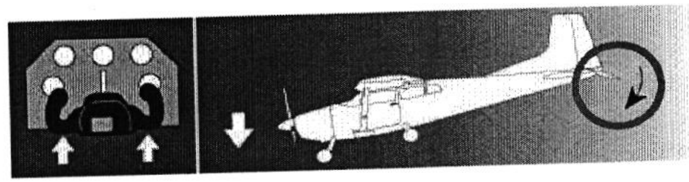
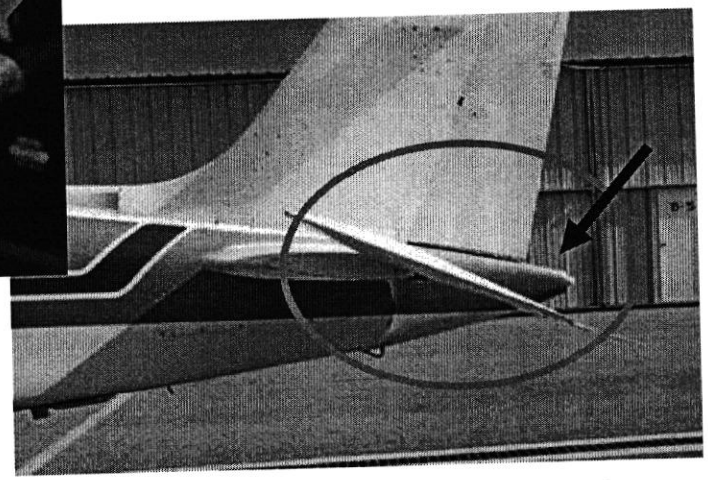
FLIGHT CONTROLS

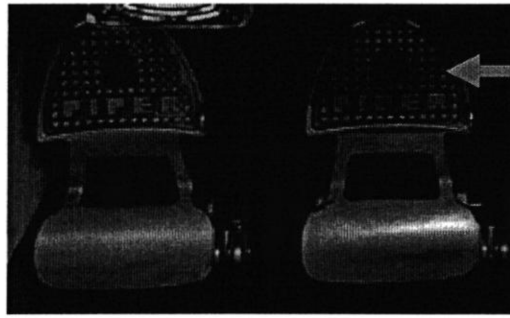




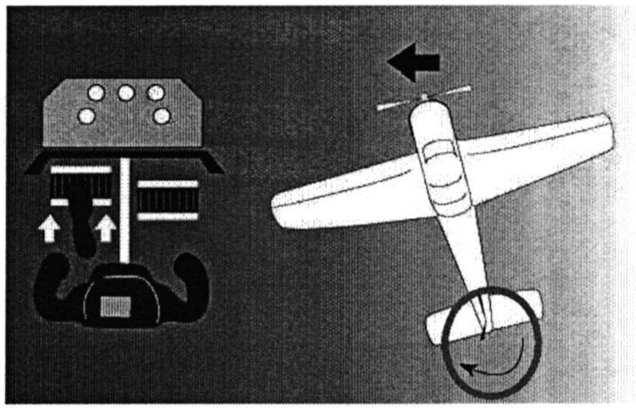


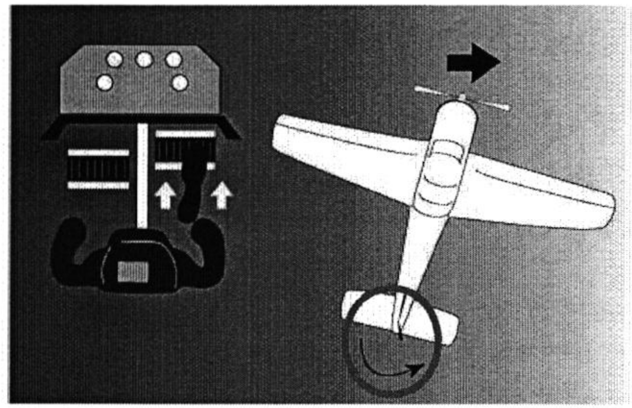
Pushing forward moves the elevator DOWN, moves the nose DOWN to descend.

FLIGHT CONTROLS



Brakes are located at the top or "toe" of the pedal





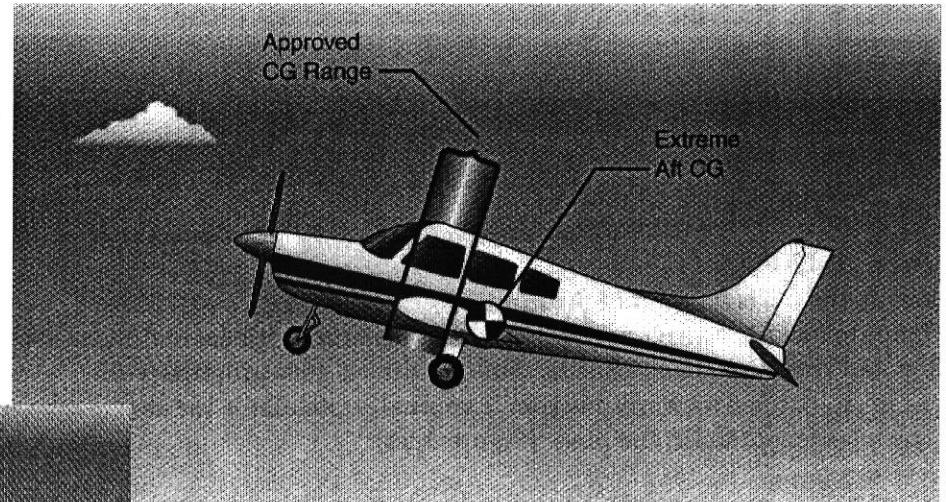
Pilots use rudder pedals on the floor to move the rudder LEFT or RIGHT to help the airplane turn.

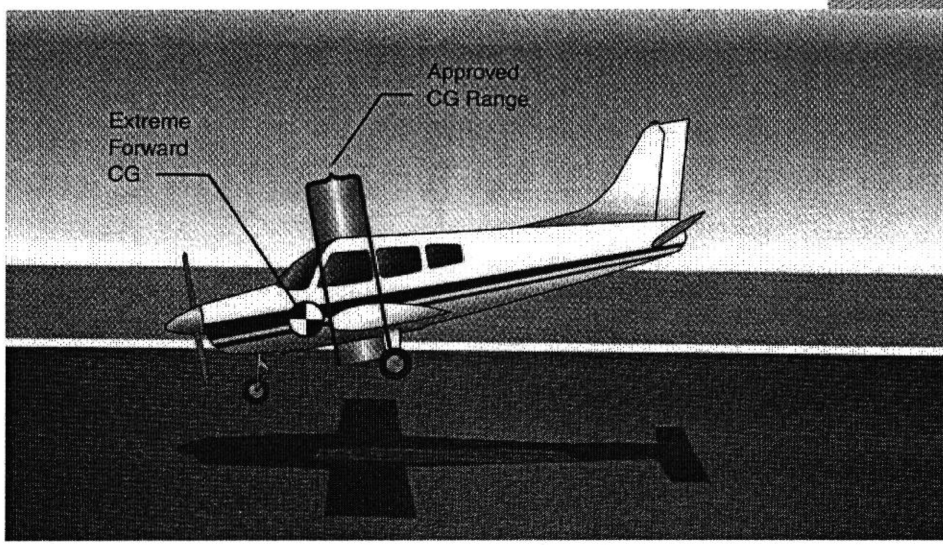
Stick Force

- Force exerted by pilot to move the control surface
  - Stick Force Gradients
- Trim Tabs

Stability and Control

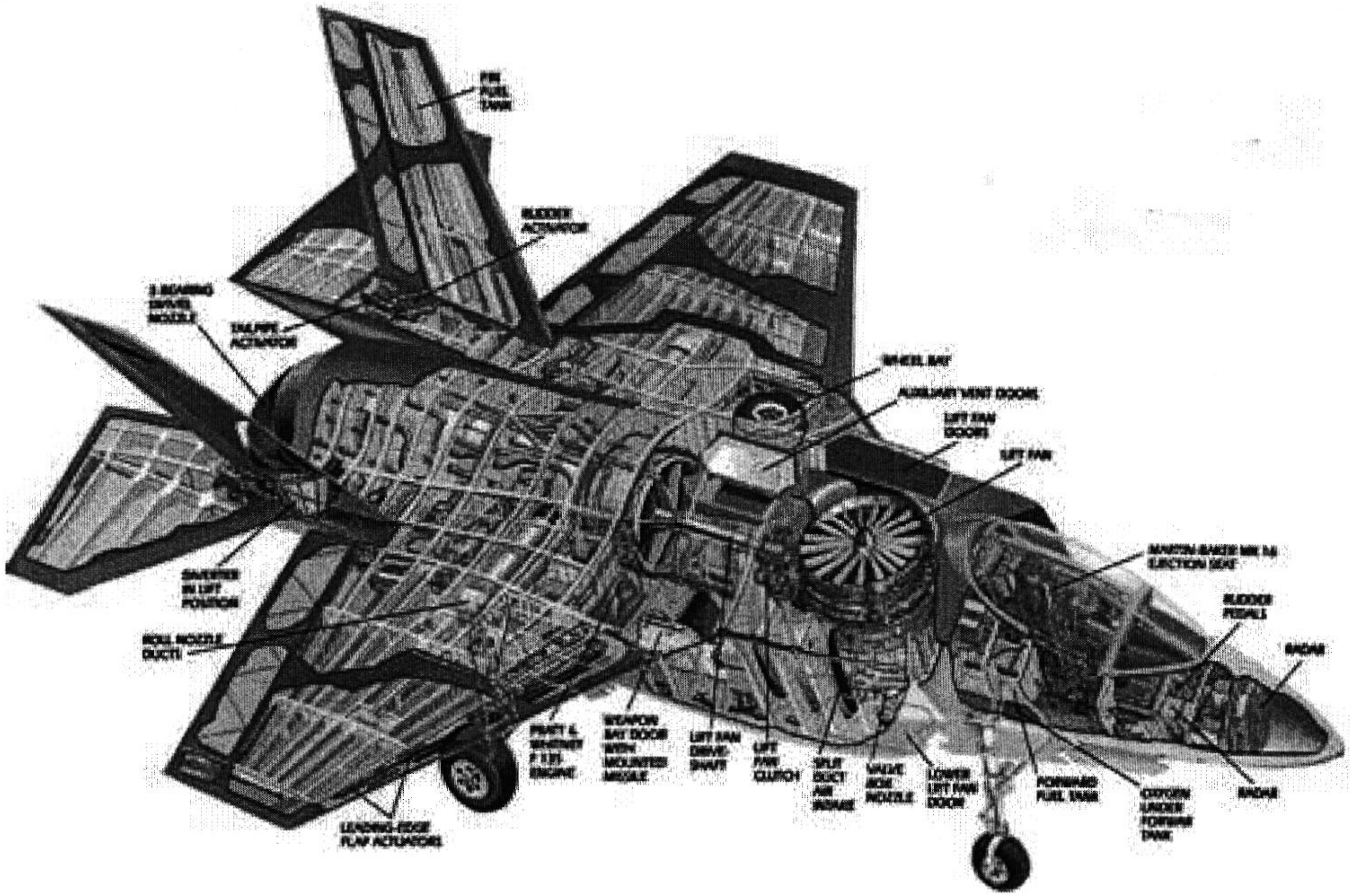
- Inherently stable airplane returns to its original condition after being disturbed. Requires less effort to control



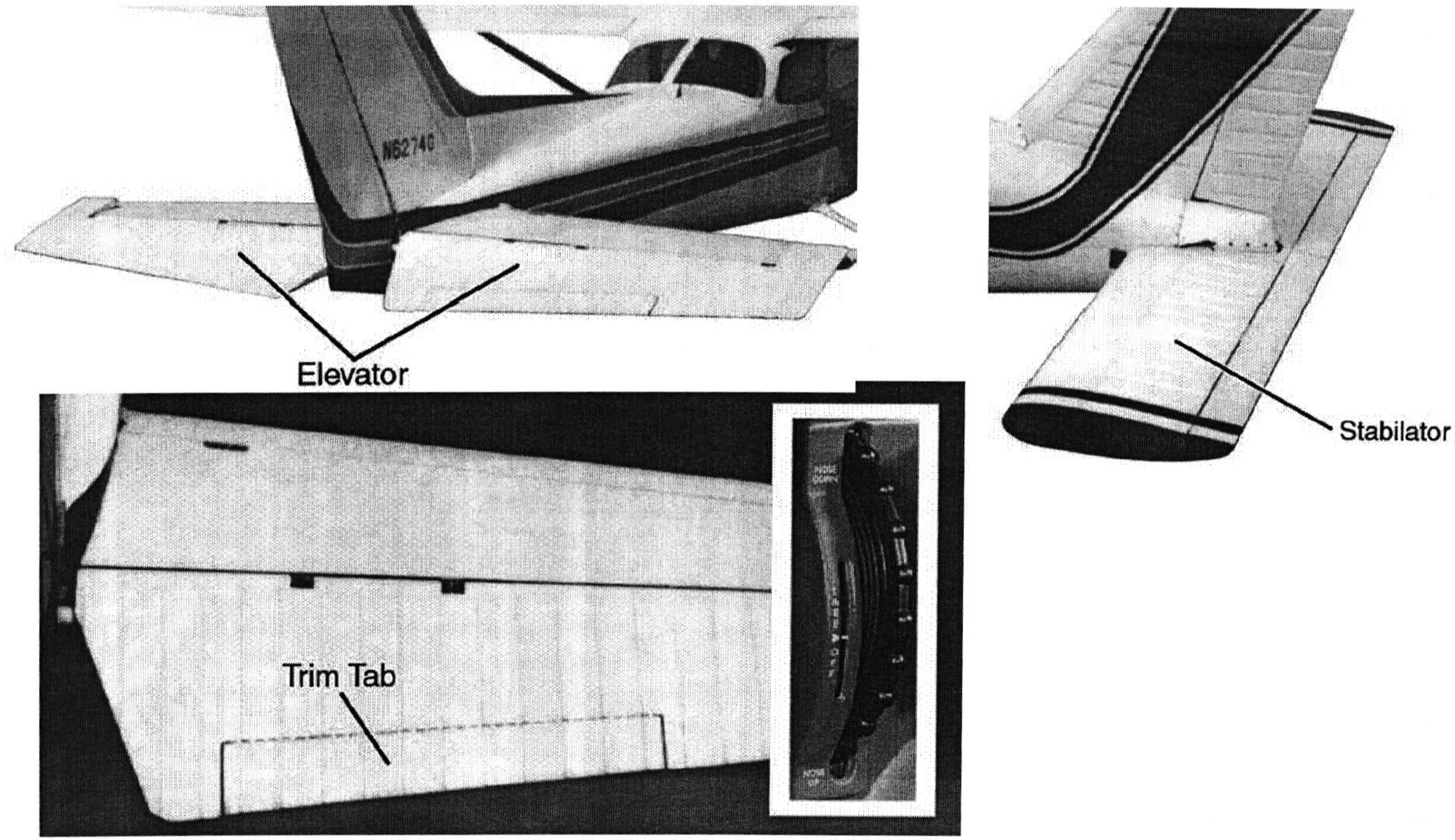


- Center of Gravity concerns:
  - Unable to compensate with elevator in pitch axis
  - Weight and Balance becomes critical – taught in a coming lecture

Control Surfaces and their Function

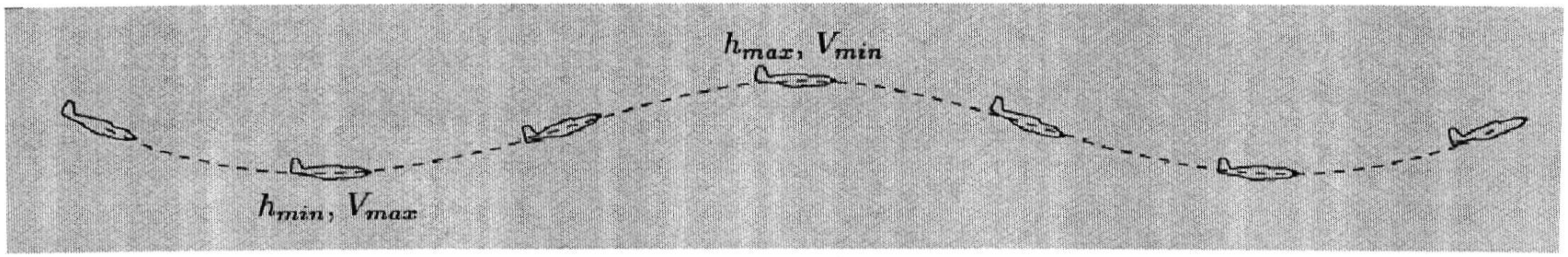


Aerodynamic Surfaces

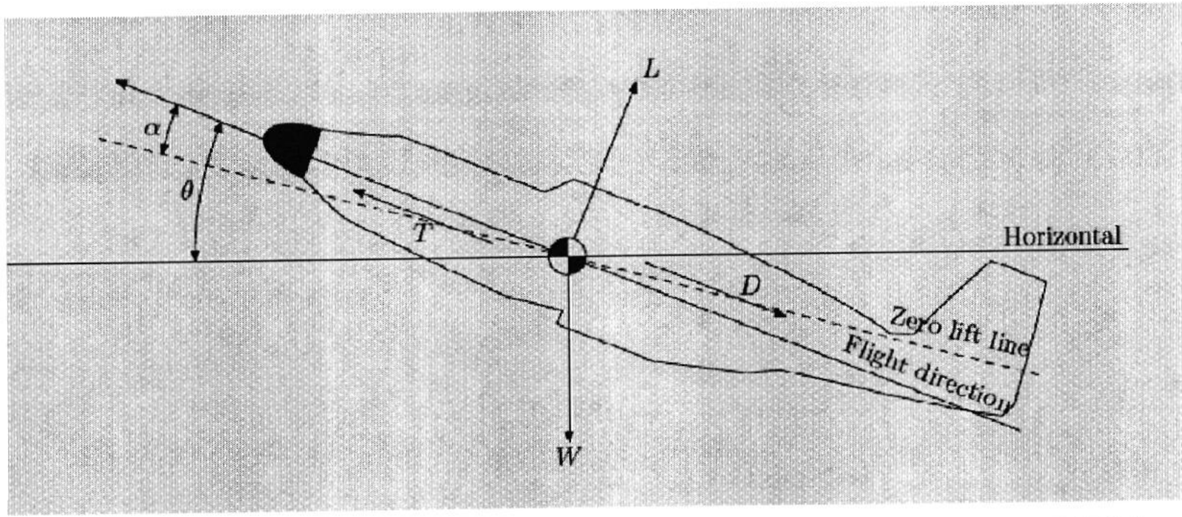


Phugoid Motion

- Phugoid mode is a lightly damped long period oscillation.
- The incidence is almost constant and the aircraft varies altitude at constant energy, trading potential for kinetic and back again



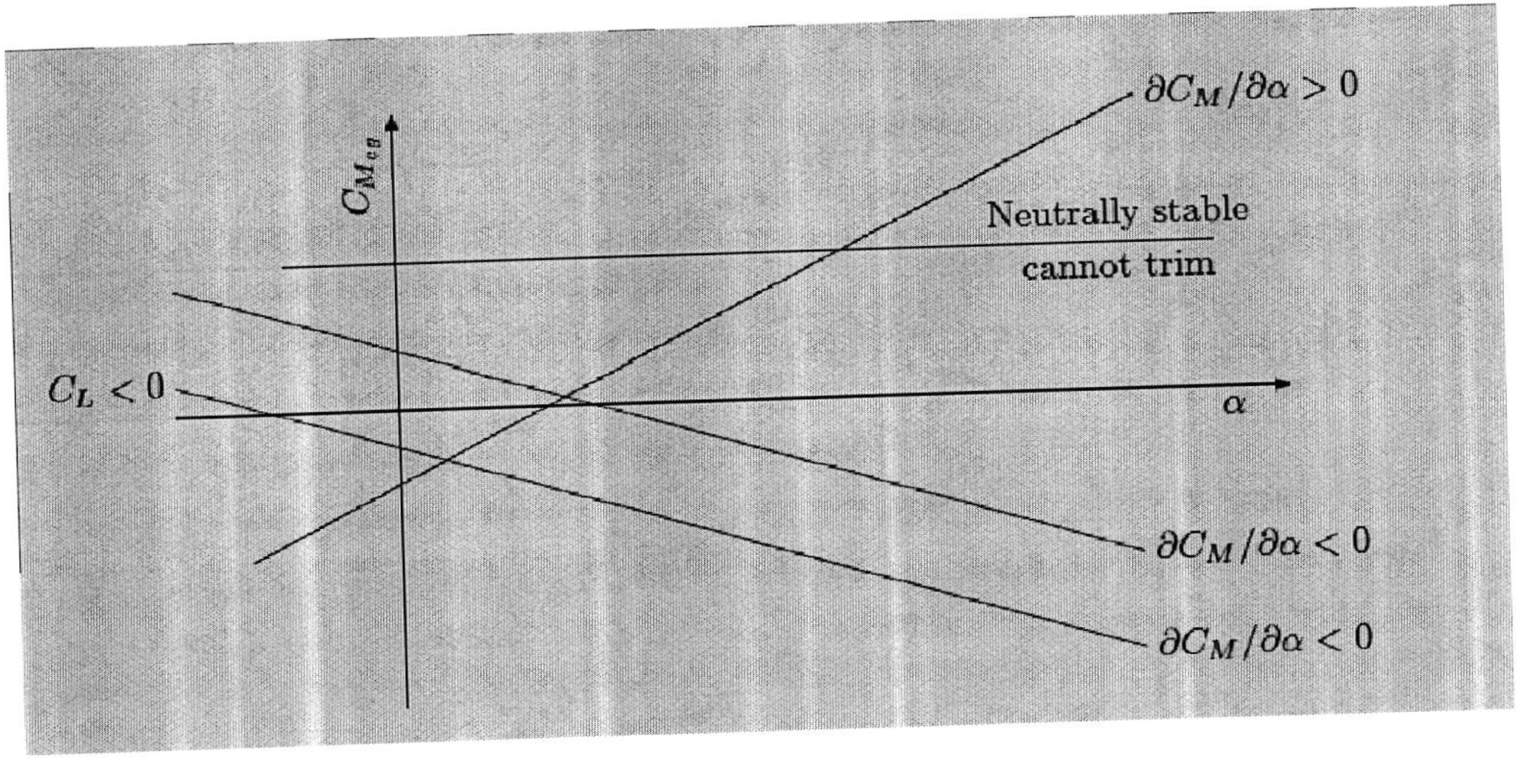
Trim and Stability



$$\text{Perpendicular:} L - W\cos\theta = 0,$$
$$\text{Parallel:} T - D - W\sin\theta = 0,$$
$$\text{Moments about the c.g.:} M_{cg} = 0.$$

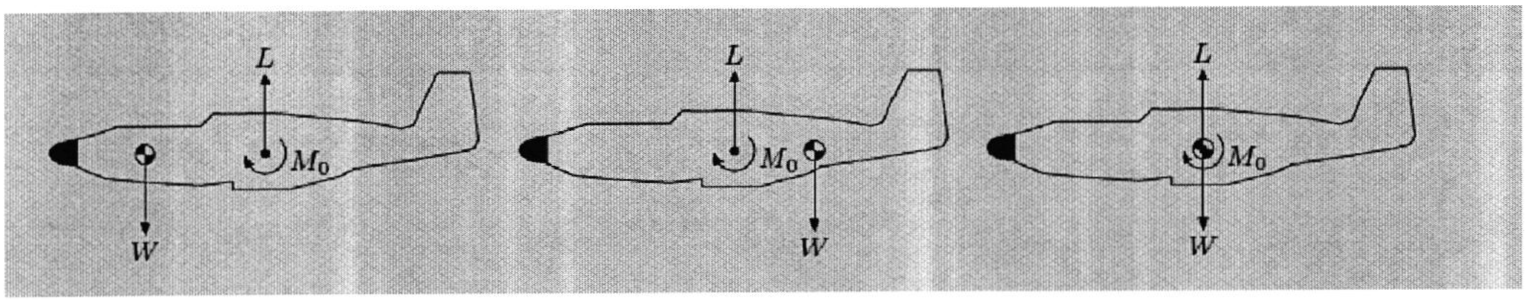
Stability and Moment coefficient variation

- How the moment coefficient CM varies with angle-of-attack determines the stability of the aircraft

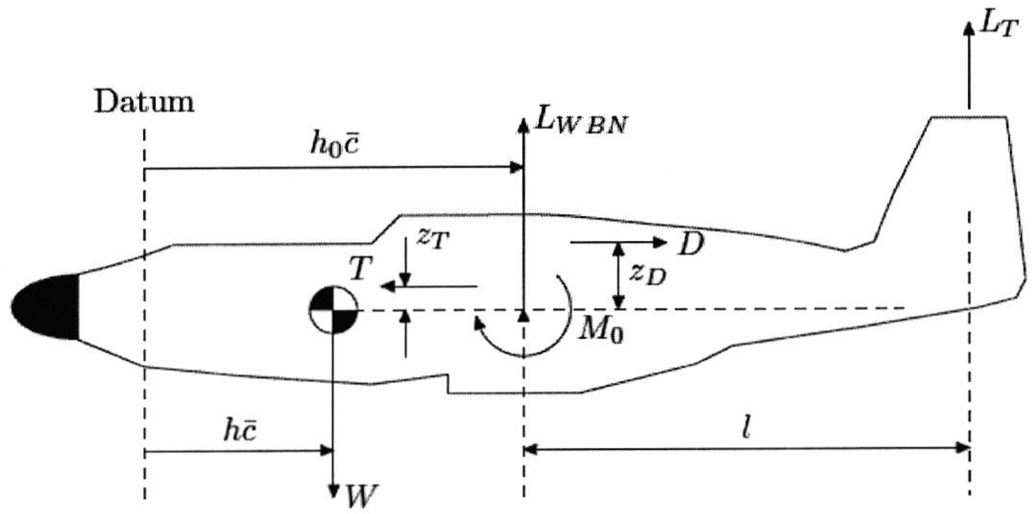


Effect of C. G. Position on Stability

- If the c.g. is forward of the aerodynamic centre, dMcg/dα will be negative and the aircraft will therefore be statically stable.
- If the c.g. is aft of the aerodynamic centre, dMcg/dα will be positive and the aircraft will therefore be statically unstable.
- If the c.g. is at the aerodynamic centre, dMcg/dα will be zero and the aircraft will therefore be neutrally stable.



Forces and Locations Conventional A/c



where $h\bar{c}$ is the distance of the c.g. aft of a reference point and $h_n\bar{c}$ is the distance of the neutral point aft of a reference point.

$$\begin{aligned} M_{cg} &= M_0 - L_{WBN}(h_0 - h)\bar{c} - L_T((h_0 - h)\bar{c} + l) - Tz_T + Dz_D \\ &= M_0 - (h_0 - h)\bar{c}(L_{WBN} + L_T) - L_T l - Tz_T + Dz_D \\ &= M_0 - (h_0 - h)\bar{c}L - L_T l - Tz_T + Dz_D. \end{aligned}$$

$$M_{cg} = M_0 - (h_0 - h)\bar{c}L - L_T l.$$

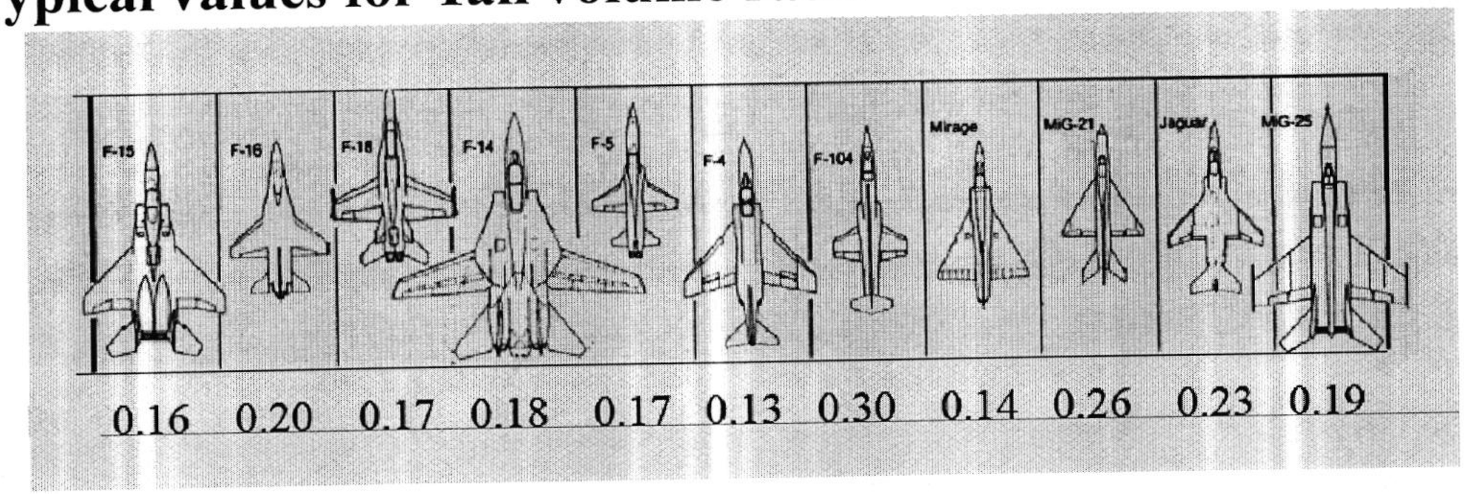
Assuming T, D and Z_T and Z_D are small

Forces and Locations Conventional A/c

- L is bigger than D and T so it is a fair to drop the last 2 terms giving. $M_{cg} = M_0 - (h_0 - h)\bar{c}L - L_T l.$

- Using non-dimensional coefficients and defining tail volume ratio as $\overline{V} = \frac{S_T}{S}\frac{l}{\bar{c}}$

Typical values for Tail volume ratio



Typical Values for Tail Volume Ratio

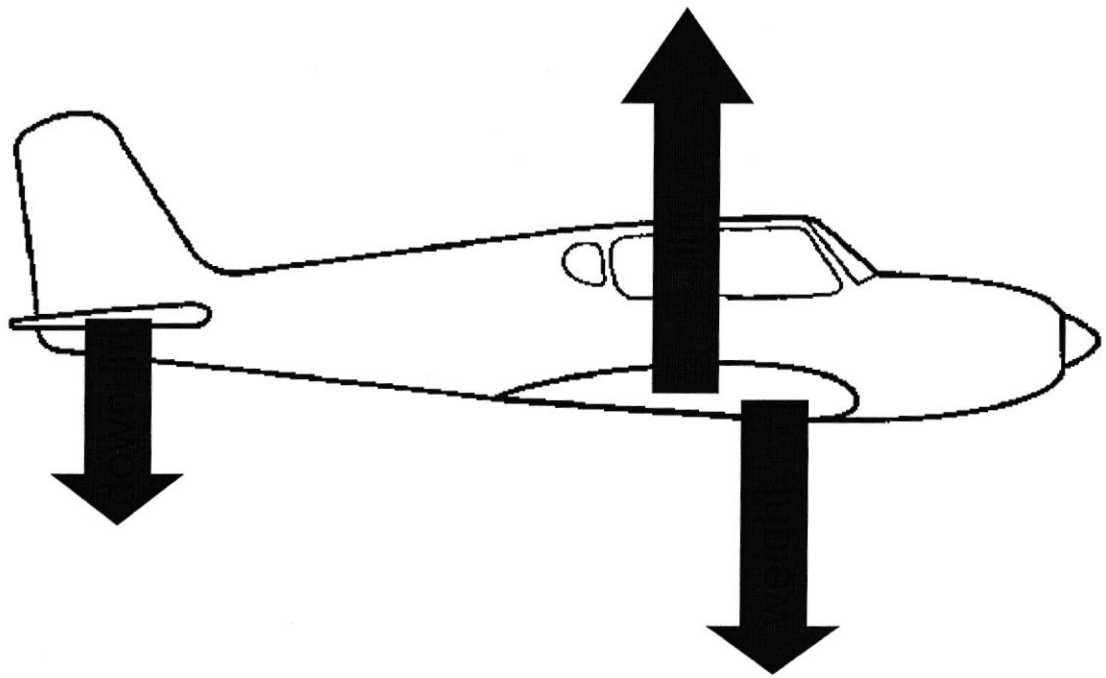
$$C_{M_{cg}} = C_{M_0} - (h_0 - h)C_L - \overline{V}C_{L_T}$$

Note : For Trim, LHS should be zero

This equation can answer the questions

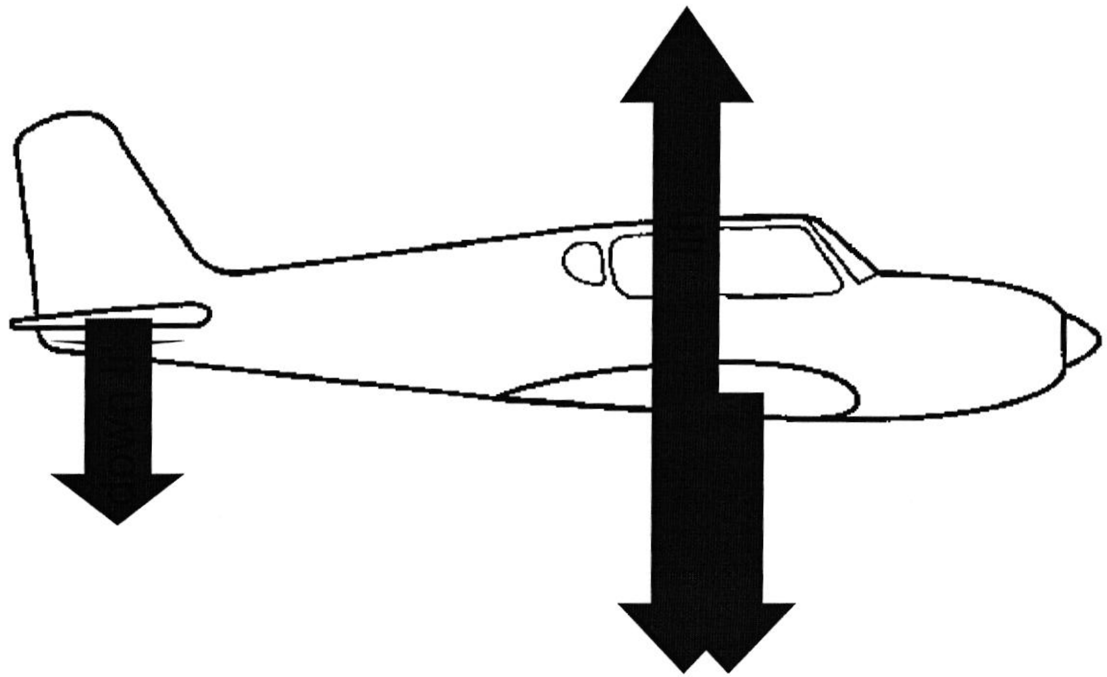
- “What is the lift required at the tailplane for trim.” or
- “Calculate the elevator angle required for trim.”

Longitudinal Stability



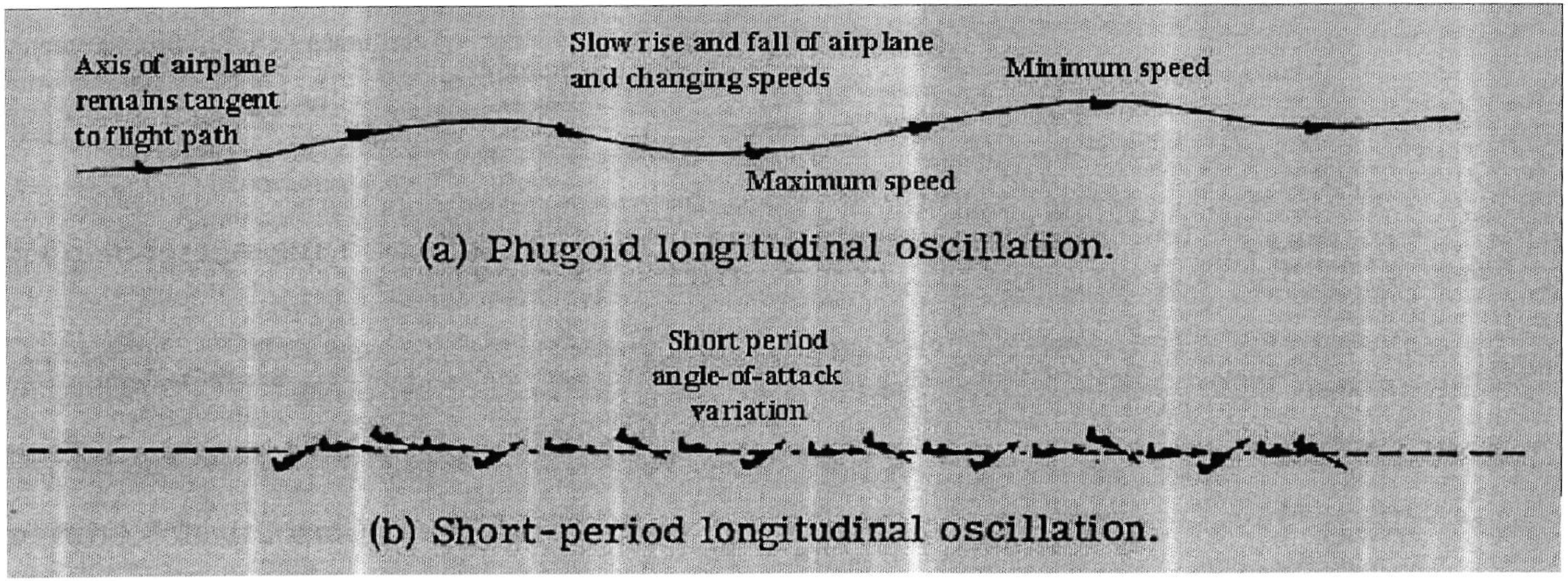
- Static stability (tendency to return after control input)
  - up elevator increases downward lift, angle of attack increases;
  - lift increases, drag increases, aircraft slows;
  - less downward lift, angle of attack decreases (nose drops).

Aside: CG and Center of Pressure Location



- Aft CG increases speed:
  - the tail creates less lift (less drag);
  - the tail creates less down force (wings need to create less lift).
  - This also decreases stall speed (lower angle of attack req'd).

Longitudinal Modes

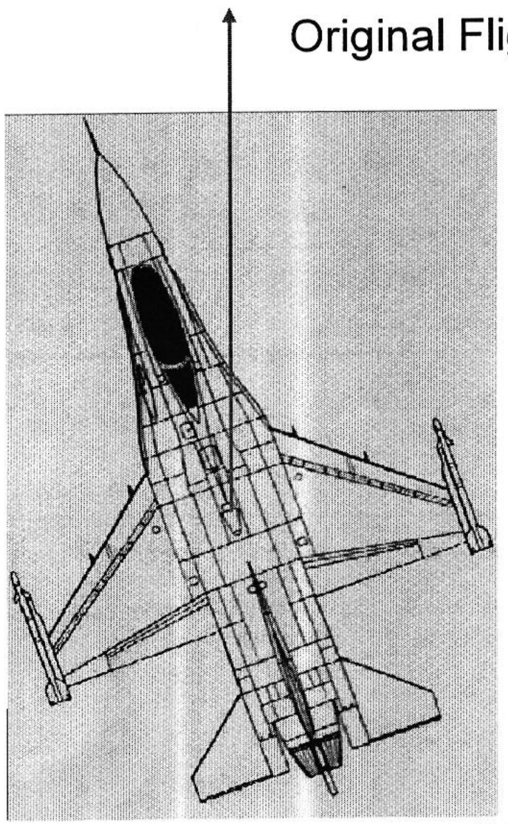


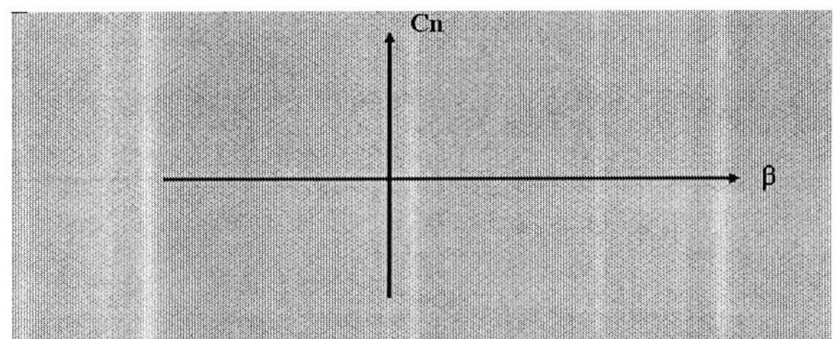
Lateral Stability

Lateral static stability : refers to the ability of the aircraft to generate a yawing moment to cancel disturbances in sideslip V

Question : Which direction should the yawing moment act to align the aircraft with the velocity vector ?

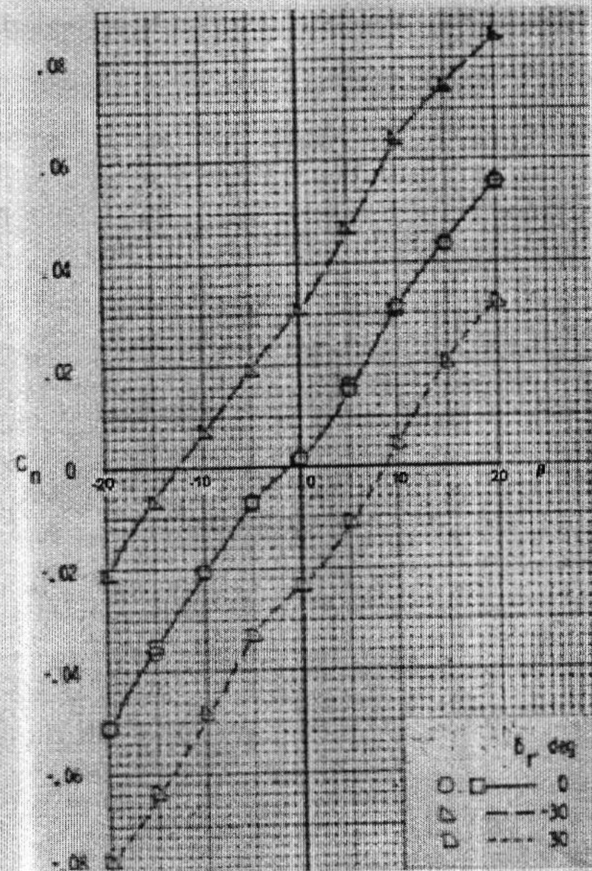
Original Flight Direction





1. Cn should be an anti symmetric function of β
2. $\partial Cn / \partial \beta$ (denoted as Cn_β) must be > 0 for lateral static stability

Typical Experimental results



Observe

1. Positive slope

2. Quasi linear variation

3. Effect of rudder

Source : NASA TN D6425