SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

Coimbatore-35

Elevator effects - Stick fixed Neutral point

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RECAP

What is the neutral point?

- **Neutral point**. A mathematical analysis of the longitudinal static stability of a complete **aircraft** (including horizontal stabilizer) yields the position of center of gravity at which stability is **neutral**. This position is called the **neutral point**.

5–5 Neutral Point (Stick-fixed)

From the studies just completed, the final stability equation can be written for the airplane in gliding flight with fixed controls with no propeller:

$$\frac{dC_m}{dC_L} = \frac{x_a}{c} + \left(\frac{dC_m}{dC_L}\right)_{\substack{Fus\\Nac}} - \frac{a_t}{a_w}\bar{V}\eta_t\left(1 - \frac{d\epsilon}{d\alpha}\right) \tag{5-32}$$

and the equilibrium equation:

$$C_{m_{cg}} = C_L \frac{x_a}{c} + C_{m_{ac}} + C_{m_{\substack{Fus\\Nac}}} - \frac{a_t}{a_w} C_L \bar{V} \eta_t \left(1 - \frac{d\epsilon}{d\alpha}\right) - a_t(\alpha_0 - i_w + i_t)\bar{V}\eta_t \quad (5\text{–}33)$$

The contributions of the various airplane components to its static longitudinal stability (dC_m/dC_L) are shown in Figure 5–17.

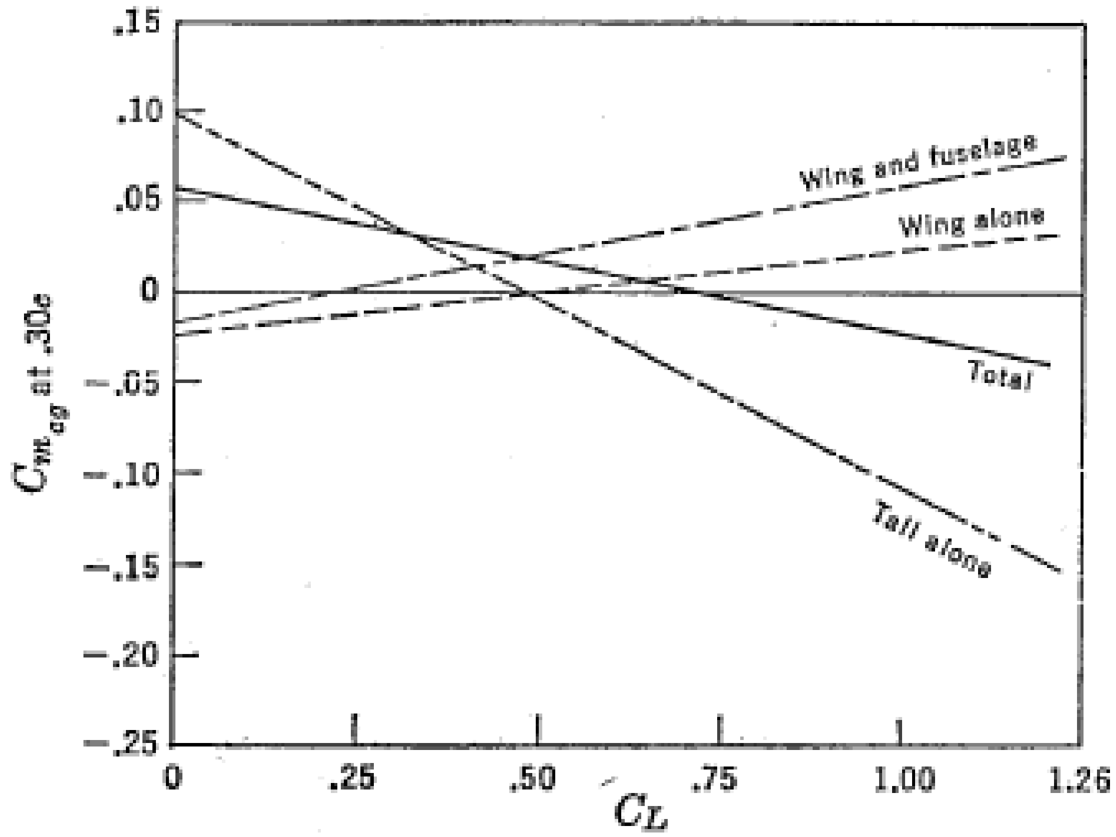


FIGURE 5–17. Typical longitudinal stability breakdown.

$$\left(\frac{dC_m}{dC_L}\right)_{Wing} = x_{cg} - x_{ac}$$

$$N_0 = x_{cg(dC_m/dC_L=0)} = x_{ac} - \left(\frac{dC_m}{dC_L}\right)_{\substack{Fus\\Nac}} + \frac{a_t}{a_w}\bar{V}\eta_t\left(1 - \frac{d\epsilon}{d\alpha}\right)$$

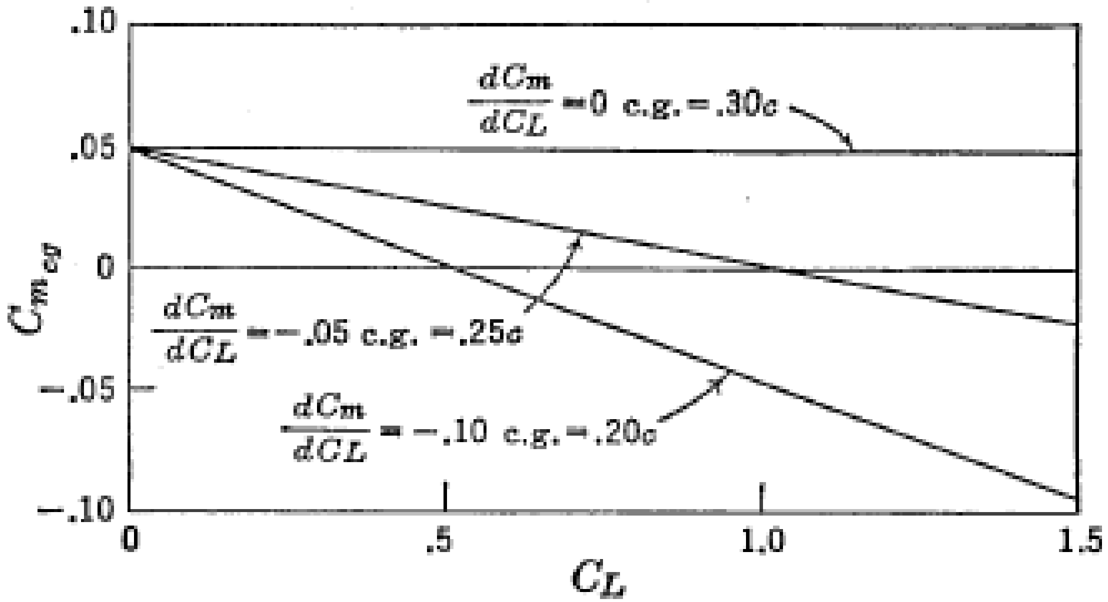


FIGURE 5–18. Typical effect of c.g. shift on pitching moments.

$$\frac{dC_m}{dC_L} = x_{cg} - N_0$$

Static margin

- In aircraft analysis, **static margin** is defined as the distance between the center of gravity and the neutral point of the aircraft, expressed as a percentage of the mean aerodynamic chord of the wing.


ACTIVITY

ELEVATOR EFFECT

$$\frac{dC_m}{d\delta_e} = -\left(\frac{dC_L}{d\alpha}\right)_t \bar{V}\eta_t \frac{d\alpha_t}{d\delta_e}$$

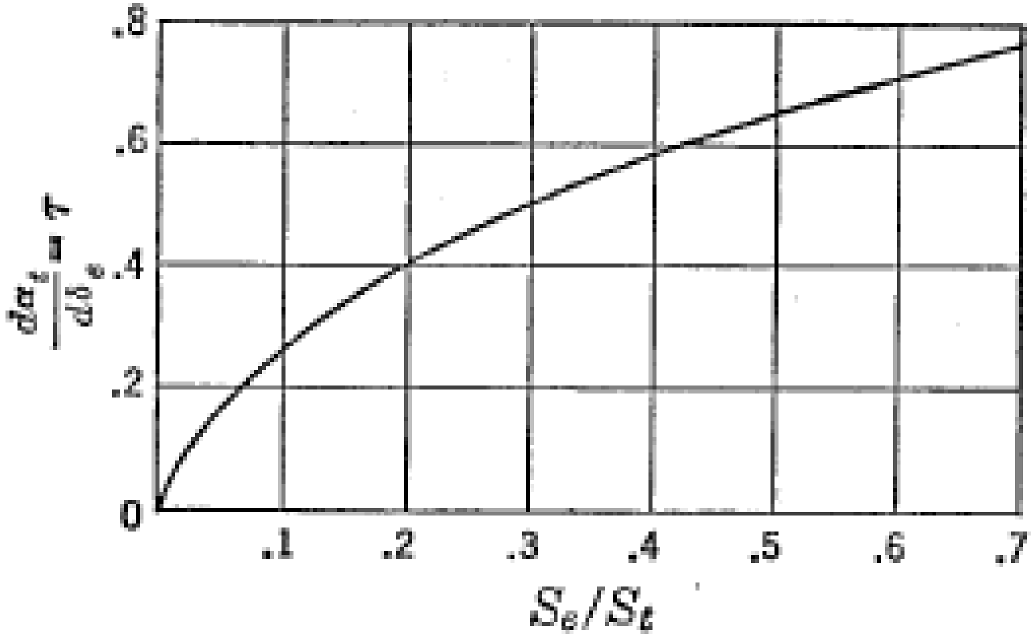


FIGURE 5–33. Elevator effectiveness.

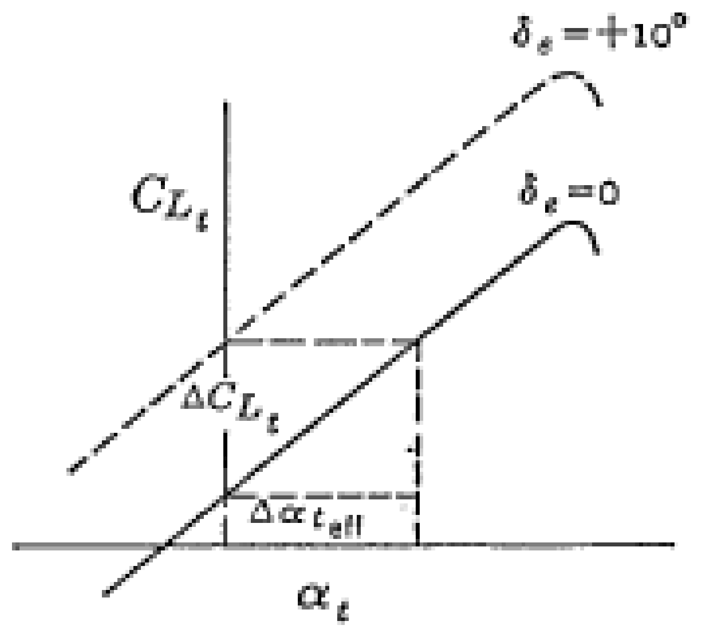


FIGURE 5–34. Effect of elevator deflection on horizontal tail lift.

Elevator Angle versus Equilibrium Lift Coefficient

$$\alpha_t = (\alpha_w - \epsilon - i_w + i_t + \tau\delta_e)$$

The propeller-off equilibrium equation can be rewritten

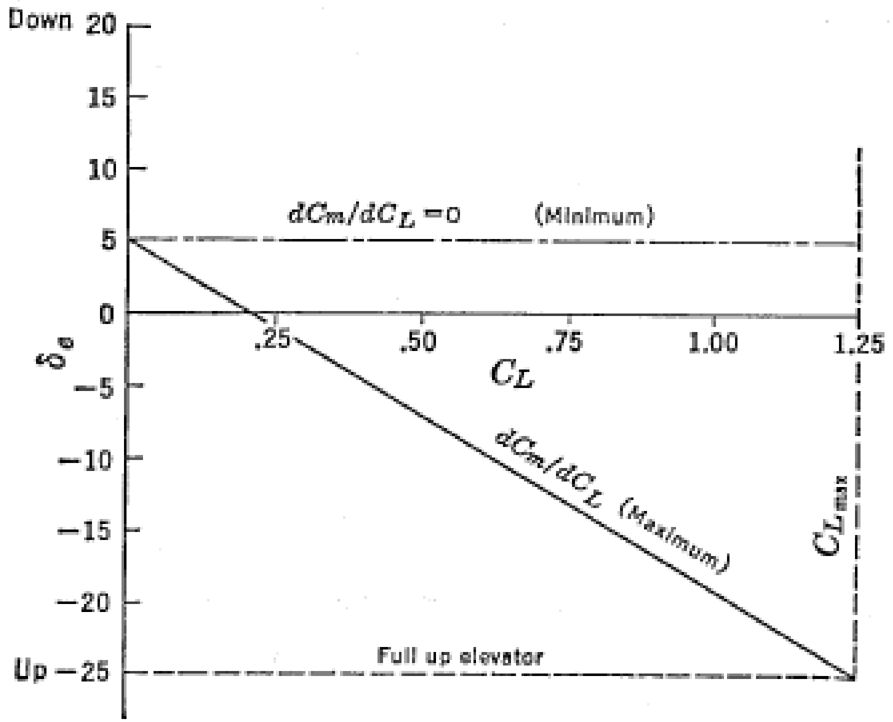
$$C_{m_{cg}} = C_{m_{ac}} + C_L \frac{x_a}{c} + C_{m_{\substack{Fus\\Nac}}} - a_t(\alpha_w - \epsilon - i_w + i_t + \tau\delta_e)\overline{V}\eta_t$$

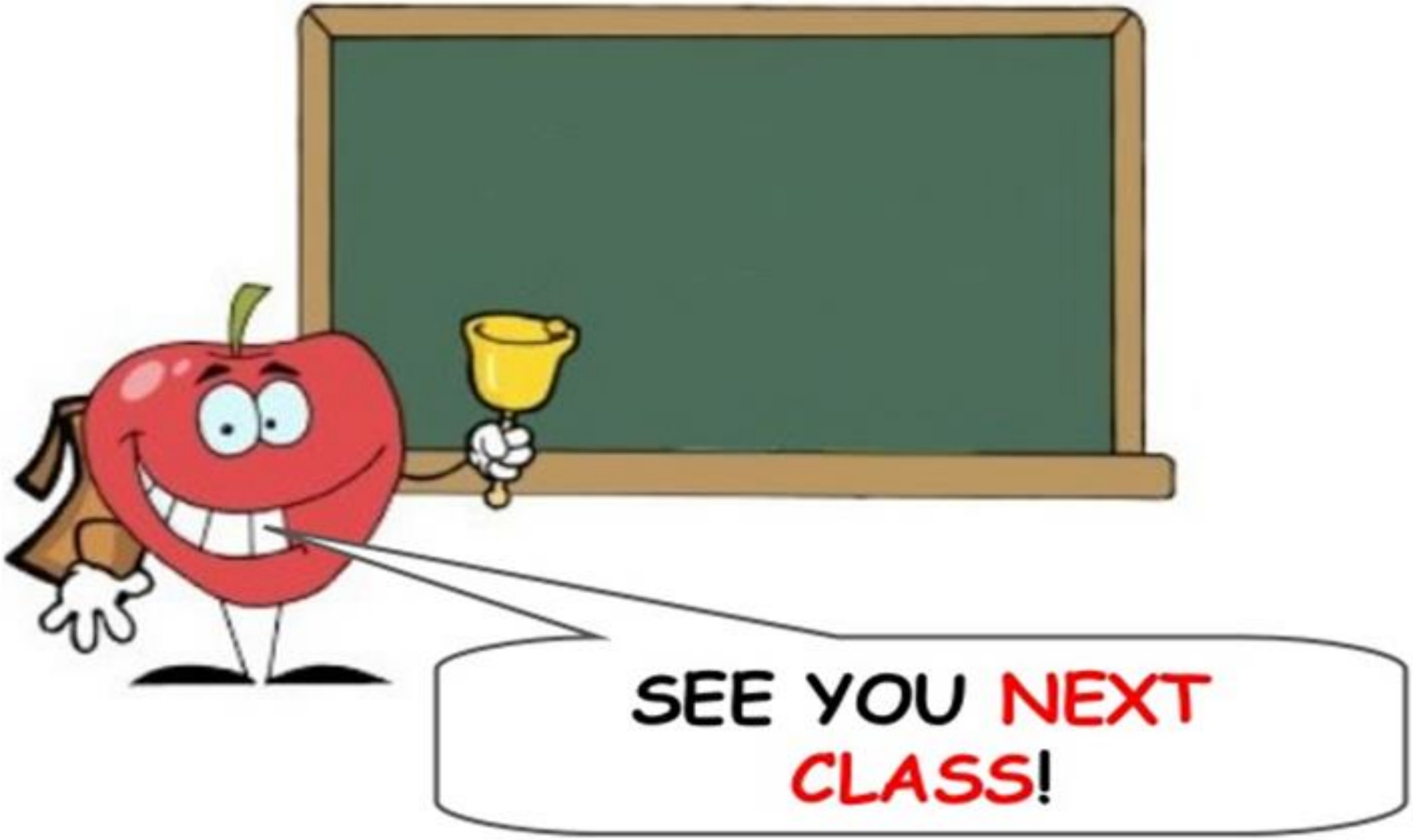
with δ_{e0} the elevator angle at zero lift:

$$\delta_e = \delta_{e0} + \frac{d\delta_e}{dC_L} C_L$$

$$\frac{d\delta_e}{dC_L} = -\frac{dC_m/dC_L}{C_{m\delta}}$$

This c.g. will then be the neutral point sought, and the slope dC_m/dC_L will also be zero.

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