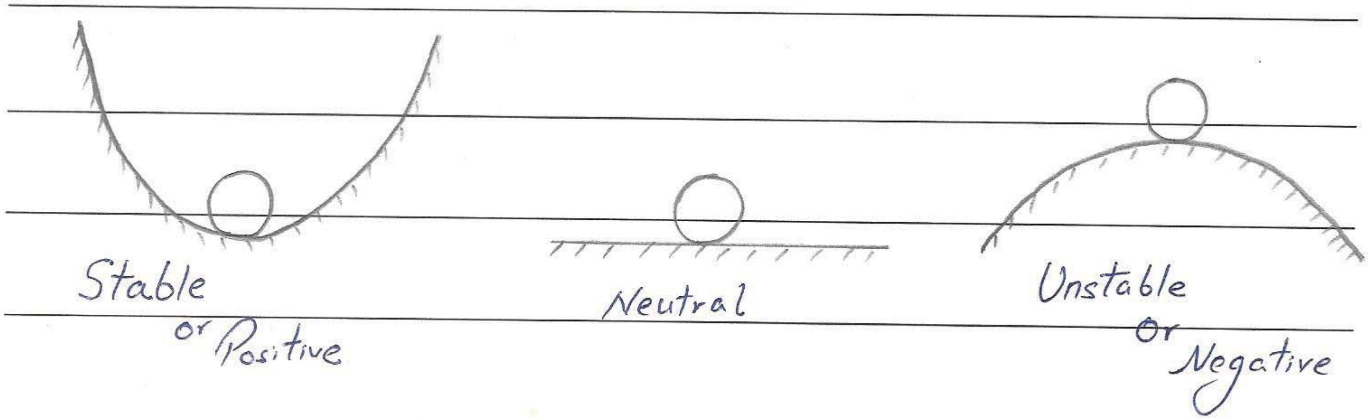
* Aircraft Stability *

"Any Mechanical system when subjected to the small disturbance and if the system tends to maintain its original equillibrium state by applying restoring force, then the system is said to be stable."

→ If the system doesnot react to the disturbance and maintain its new position as an equillibrium state, then the system is said to be 'Neutrally Stable'.

→ If the system react to the disturbance and keep moving away from its original equillibrium state, then the system is called 'Unstable system'.



Stability

Static Stability

↓

Here, system response is considered without considering 'time'.

Dynamic Stability

↓

Here, system response is considered with 'time'.

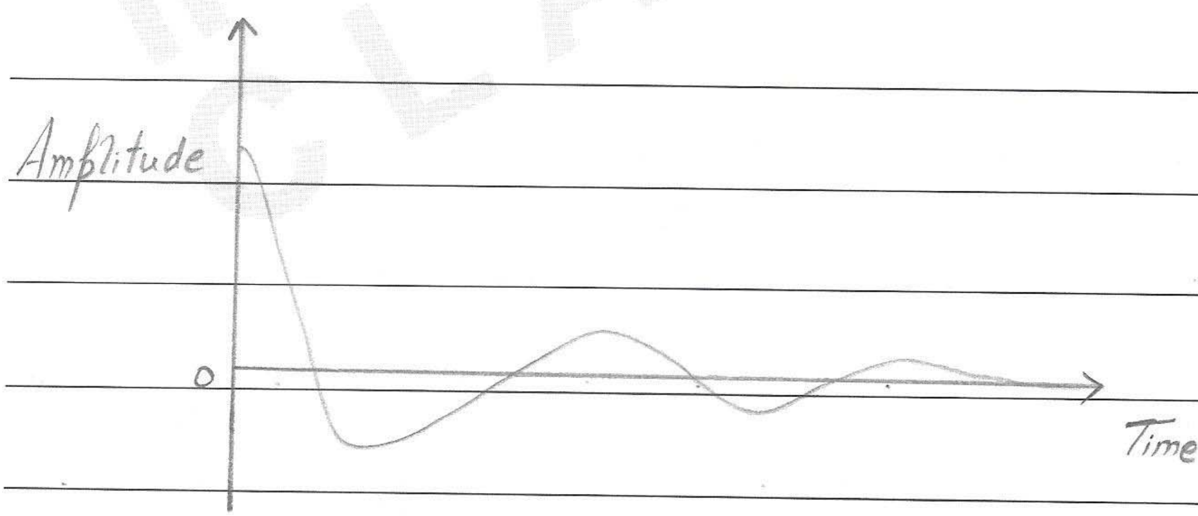
→ A system can be statically stable without being dynamically stable. That is, a statically stable system maynot be dynamically stable.

Dynamic Stability

- Positive or Stable
- Neutral
- Negative or Unstable

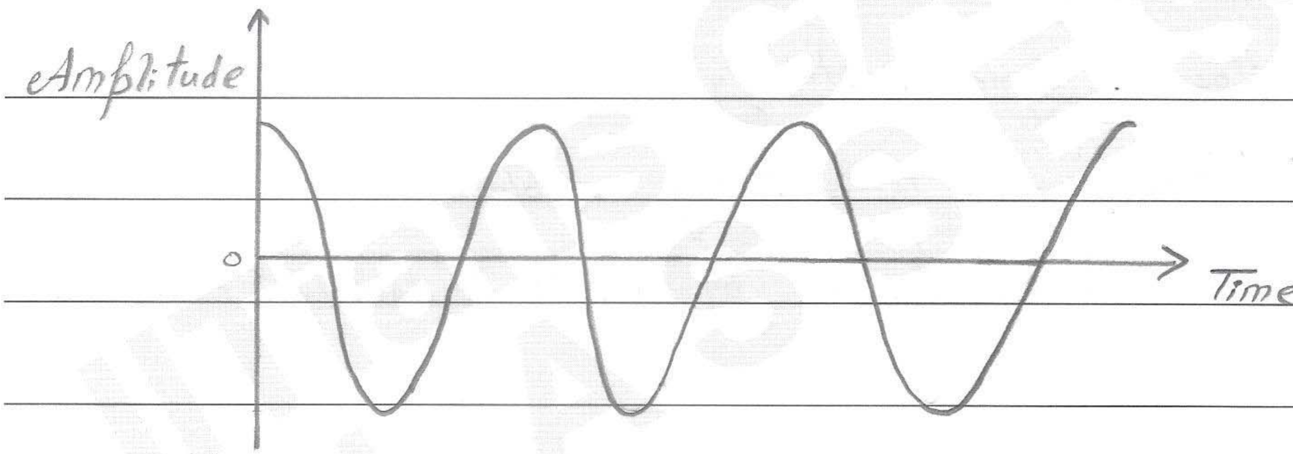
(i) Positive dynamic stability

"When system is statically stable and tends to attain the equilibrium position by an "underdamped" oscillation.



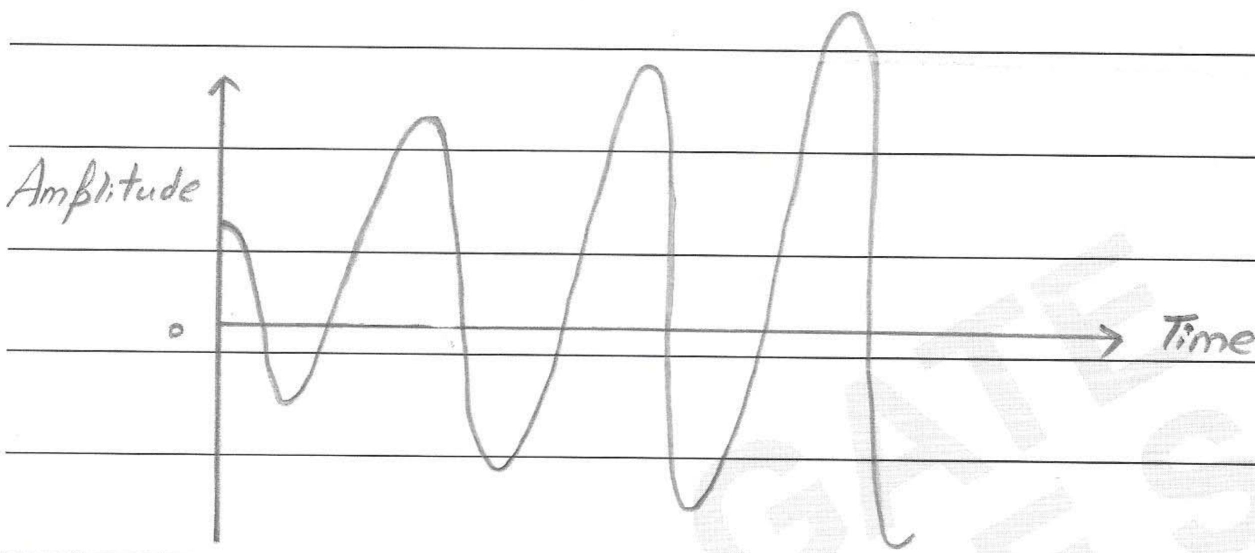
(ii) Neutral Dynamic Stability

"A mechanical system which tends to acheive original equillibrium position but keeps overshooting it by oscillating about it with a "constant" amplitude."

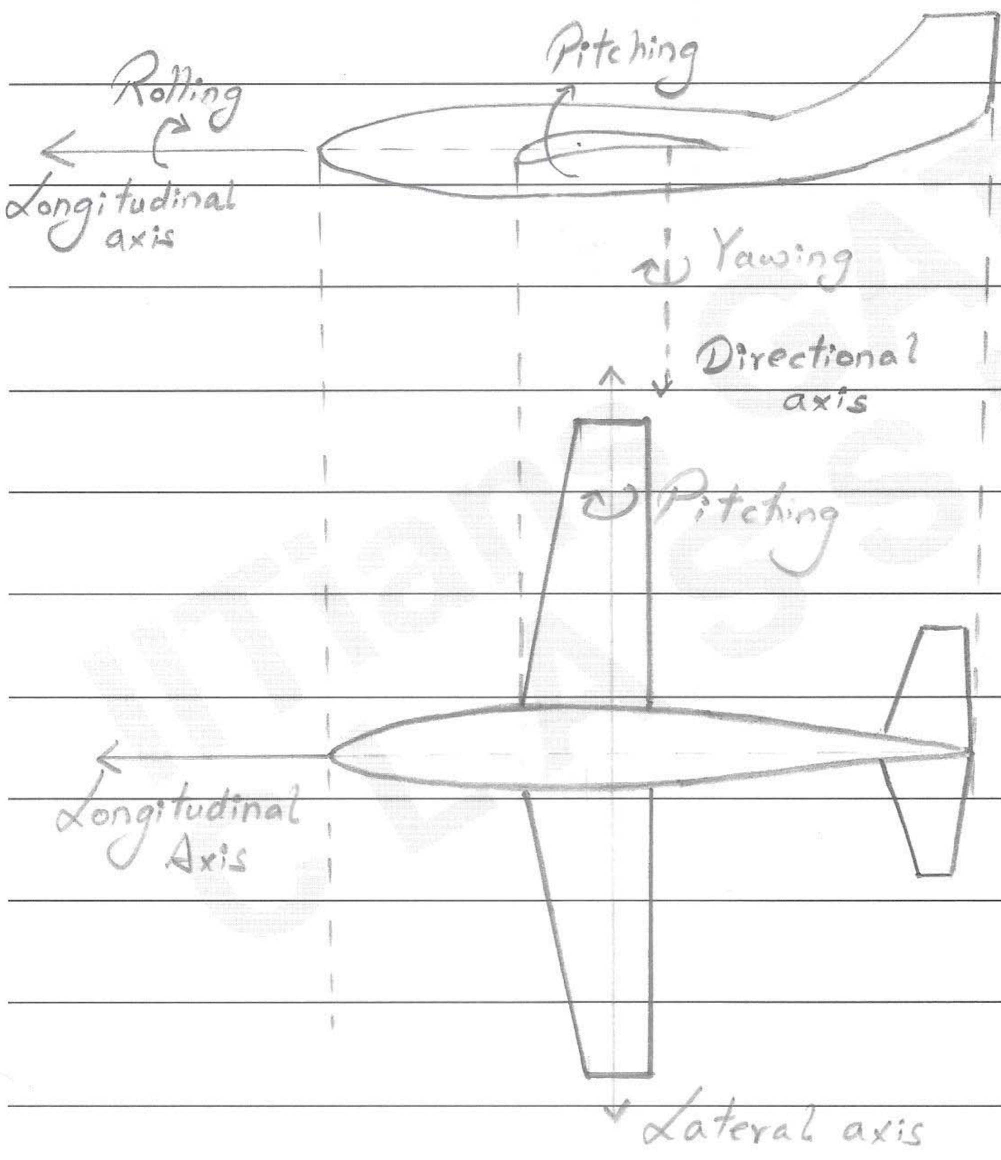


(iii) Negative Dynamic Stability

"A mechanical system which tends to acheive original equillibrium position but keep overshooting it by oscillating about it with "increasing" amplitude with time".


Amplitude
0
Time

Parameter Notation



Sign notation:

With respect to C.G. of an aircraft

→ For Pitching, Nose up → +ve

Nose down → −ve

→ For Rolling, Right wing (Starboard Side) down → +ve

Right wing (Starboard Side) up → −ve

→ For Yawing, turning towards right wing → +ve

away from right wing → −ve

Moments on the Airplane

"A study of stability and control is focused on moments".

→ The moment can be taken about any arbitary point, i.e., leading edge, trailing edge or Aerodynamic center of the wings.

Moment at Aerodynamic Center:

"As per defination of Aerodynamic Centre, the pitching moment coefficient remains constant with all angle of attack".

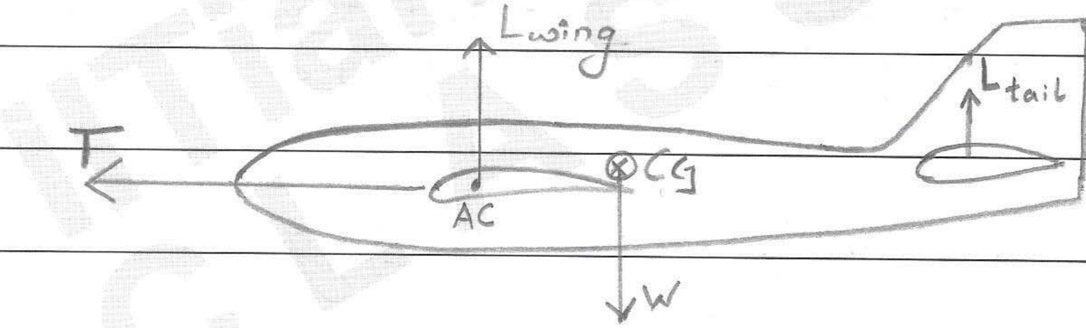
$$\therefore, \quad C_{mac} = \frac{M_{ac}}{q_\infty S c} = \text{Constant}$$

Now at zero lift condition for a flying wing.

$$C_{mac} = (C_{m,c/4})_{L=0} = C_{m,\text{anypoint}\;L=0}$$

→ Hence C_{mac} can be obtained from the value of the moment coefficient about any point when the wing is at the zero-lift angle of attack ($\alpha_{L=0}$).

→ Moment on Airplane



→ Consider the system of forces as shown in figure.

→ Moment about C.G. of an aircraft will be calculated for L, D and Mac of the wing, thrust of the aircraft, lift of the tail, and aerodynamic forces and moments on other parts of the aircraft.

$\therefore \quad M_{cg} = f(L, D, T, L_{Tail}, \text{other forces})$

Here, weight of the aircraft will not be considered for obvious reasons.

$$\therefore C_{M_{cg}} = \frac{M_{cg}}{q_\infty S c} = \frac{f(L, D, T, L_{Tail}, \text{Other forces})}{q_\infty S c}$$

→ All the discussions of the stability of an airplane will be done by considering $C_{m_{cg}}$.