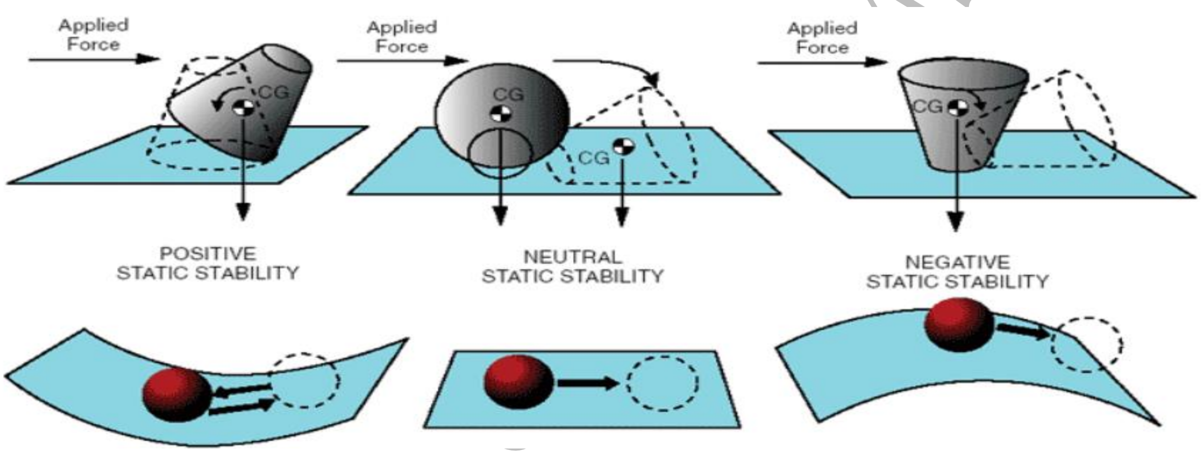
**GATE Aerospace Coaching By IITians GATE CLASSES**

## Aircraft stability

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

If the system does not react to the disturbance and maintain it's new position as an equilibrium state, then the system is said to be "Neutrally stable".

If the system react to the disturbance and keep moving from its original equilibrium state, then the system is called "unstable system".




Stability:-

Stability are mainly classified into

(A). Static stability

(B). Dynamic stability

(A). Static stability

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

(B). Dynamic stability:-

Here, system response is considered with "time".

**GATE Aerospace Coaching By IITians GATE CLASSES**

A system can be statically stable without being dynamically stable. That is, a statically stable system may not be dynamically stable.

**Dynamic stability:-**

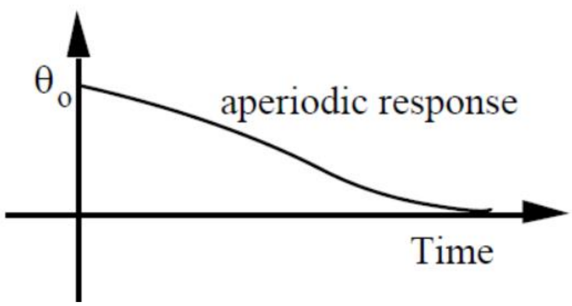
(i). Positive stable

(ii). Neutral stable

(iii). Negative stable (or) unstable

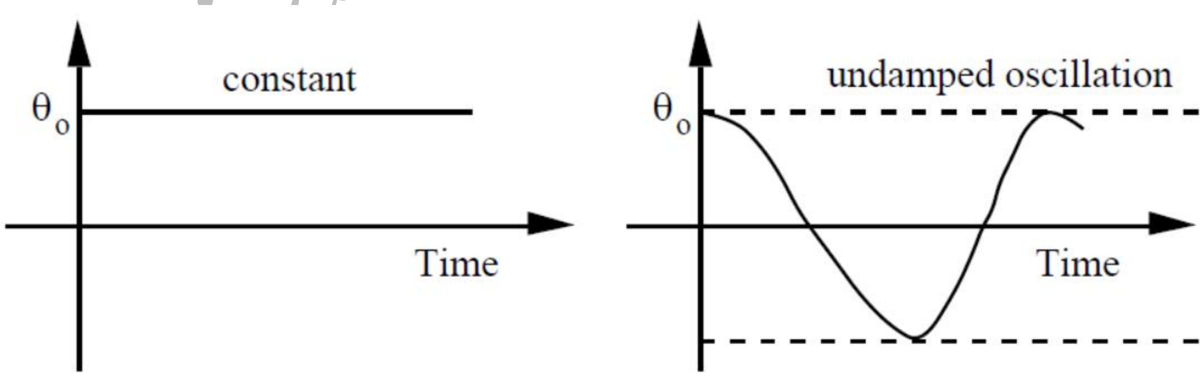
(i). positive dynamic stability

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



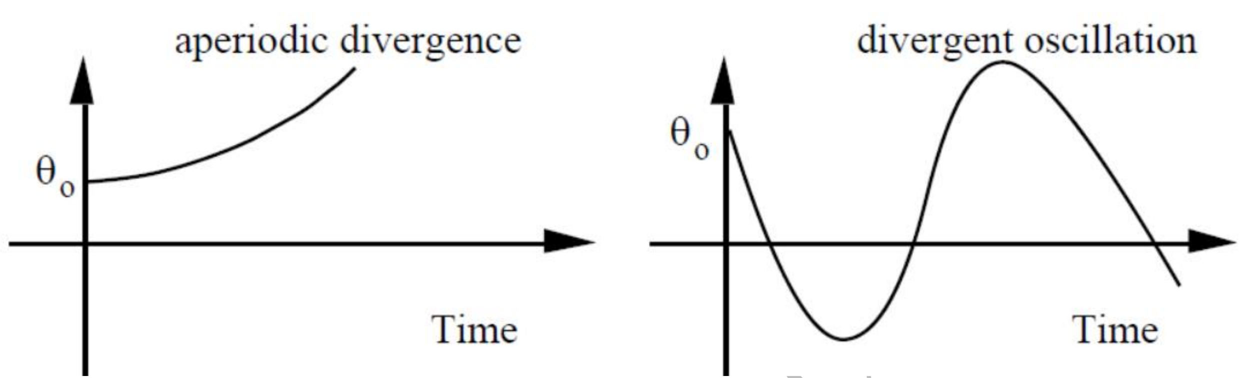

(ii). Neutral dynamic stability

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

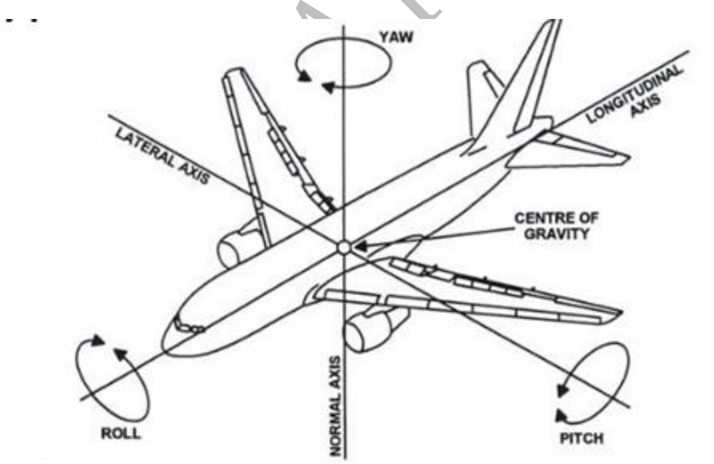


(iii). Negative dynamic stability

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




## Parameter notation




| Stability | Axes | Motion about the Axis |
|---|---|---|
| Longitudinal | Lateral | Pitch |
| Lateral | Longitudinal | Roll |
| Directional | Normal | Yaw |

Sign notation:-

With respect to center of gravity of an aircraft

**GATE Aerospace Coaching By IITians GATE CLASSES**

For Pitching,

Nose up (+ve)

Nose down (-ve)

For Rolling

Right wing (star board side) down (+ve)

Right wing (star board 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 ability point. (i.e). leading edge, trailing edge or aerodynamic center of the wings.

**Moment at aerodynamic center:-**

As per definition of aerodynamic center the pitching moment coefficient remains constant with all angle of attack.

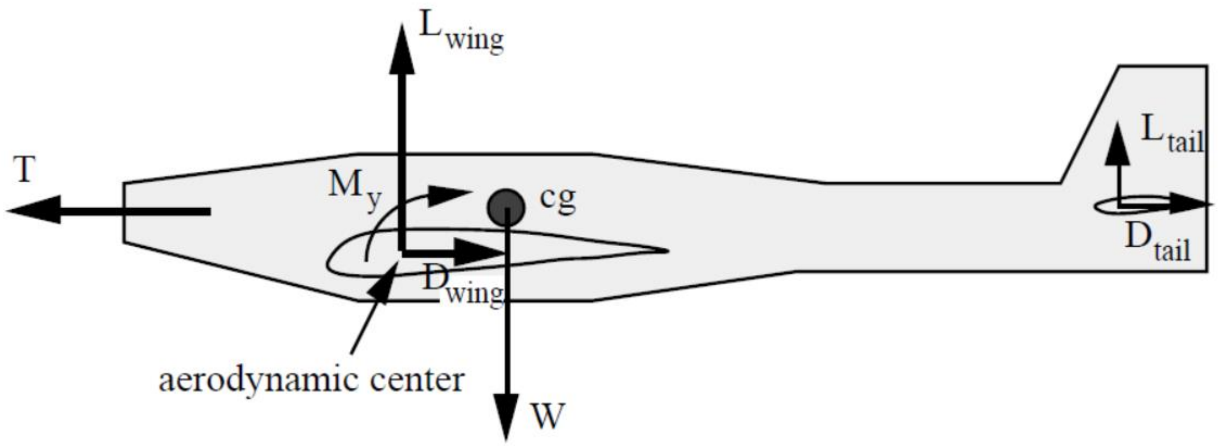
$$C_{Mac} = \frac{M_{ac}}{q_\infty S_c} = \text{constant}$$

Now at zero lift condition for a flying wing,

$$C_{Mac} = \left(C_{m,c/a}\right)_{L=0} = C_{m,anypoint\ L=0}$$

Hence $C_{Mac}$ can be obtained from the value of the moment coefficient about any point when the wing is at 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 $M_{ac}$ of the wing, thrust of the aircraft, lift of the tail, and aerodynamic forces and moments on other parts of the aircraft.

$$M_{cg} = f\left(L, D, T, L_{Tail}, other\ forces\right)$$

Here,

weight of the aircraft will not be considered for obvious reason.

$$C_{Mcg} = \frac{M_{cg}}{q_\infty S_c} = \frac{f\left(L, D, T, L_{Tail}, other\ forces\right)}{q_\infty S_c}$$

All the discussion of the stability of an airplane will be done by considering $C_{Mcg.}$