# INTRODUCTION TO AEROSPACE SYSTEMS II FLIGHT STABILITY

**PREPARED BY**

**ABASHE TOKAN**

**AEROSPACE ENGINEERING DEPARTMENT**

# INTRODUCTION

**Flight stability** is basically defined as an aircraft's ability to maintain/return to its original flight path when its equilibrium is disturbed flight stability allows an aircraft to

- Maintain uniform flight conditions
- Recover from disturbances
- and minimize pilot workload.

**TO DISCUSS STABILITY** we must first define what is meant by equilibrium.

***If an airplane is to remain in steady uniform flight, the resultant force as well as the resultant moment about the center of gravity must both be equal to 0.***

An airplane satisfying this requirement is said to be in a state of equilibrium or flying at ***a trim condition.***

On the other hand, if the forces and moments do not sum to 0, the airplane will be subjected to **translational** and **rotational motion**.

Simply stated: **thrust** equals **drag** and **lift** equals **weight**, but more appropriately stated:

- ***The sum of all upward components of forces (not just lift) equals the sum of all downward components of forces (not just weight)***
- **The sum of all forward components of forces (not just thrust) equals the sum of all backward components of forces (not just drag)**

- When an airplane is in **straight-and-level flight** at a constant velocity, all the forces acting on the airplane are in equilibrium.

- If that straight-and-level flight is disrupted by a disturbance in the air, such as **wake turbulence**, the airplane might pitch up or down, yaw left or right, or go into a roll.

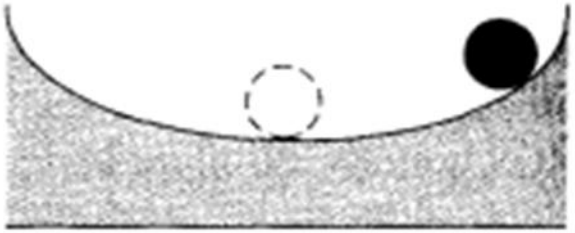
- If the airplane has what is characterized as stability, once the disturbance goes away, the airplane will return to a state of equilibrium.

# TYPES OF AIRCRAFT STABILITY

There are two types of aircraft stability which are **STATIC and DYNAMIC** stability, which are further divided in to:-

- Positive static stability
- Negative static stability
- Neutral static stability
- Positive dynamic stability
- Negative dynamic stability
- Neutral dynamic stability

**STATIC STABILITY:** Static stability is the initial tendency of the aircraft to return to its equilibrium state after a disturbance.

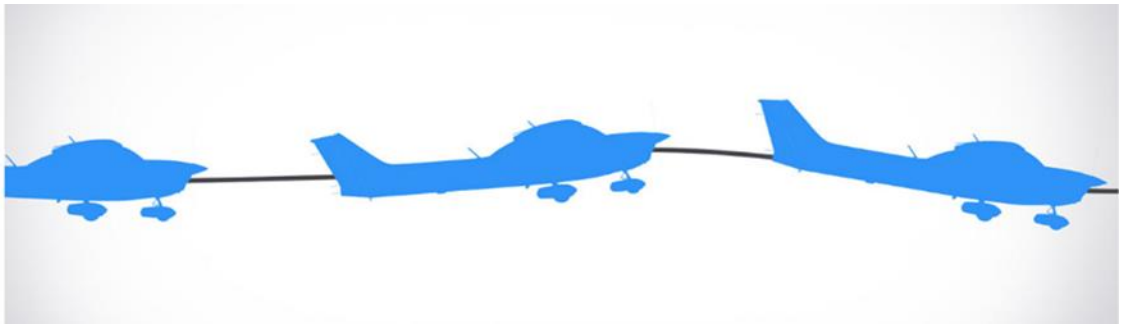


If the ball were to be displaced from the bottom of the curved surface by virtue of the gravitational attraction, the ball would roll back to the bottom (i.e., the force and moment would tend to restore the ball to its equilibrium point). Such a situation would be referred to as a **stable equilibrium point.**

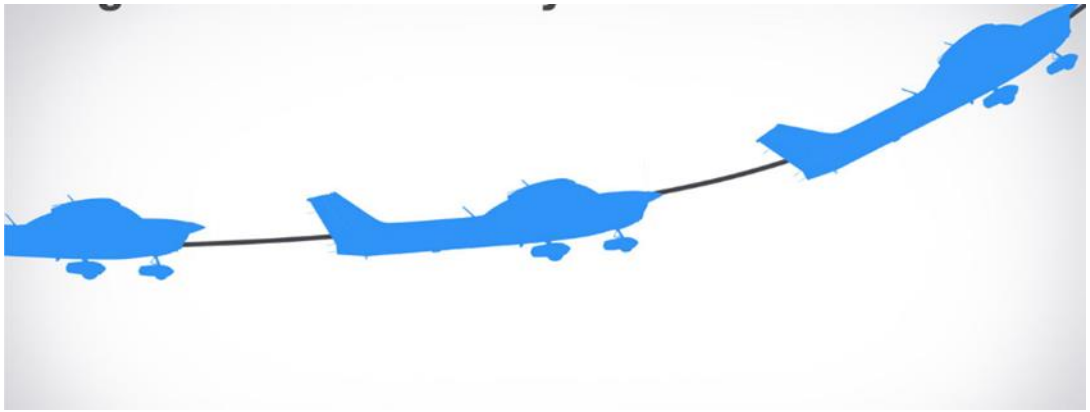
**Examples** of aircraft with static stability are **Cessna**, **piper training aircraft**, making them easy to trim and fly hands off .

# Types of static stability

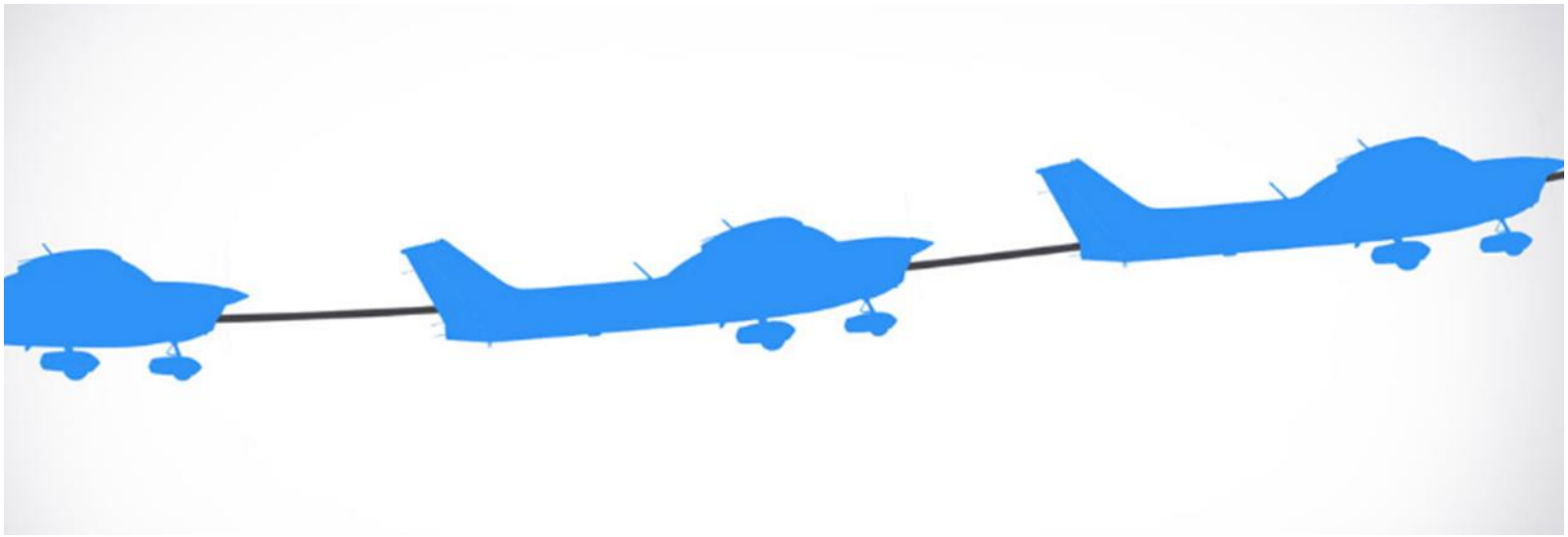
**Positive static stability:** An aircraft that has positive static stability tends to return to its original attitude when it's disturbed. Let's say you're flying an aircraft, you hit some turbulence, and the nose pitches up. Immediately after that happens, the nose lowers and returns to its original attitude. That's an example positive static stability, and it's something you will see flying an airplane like a Cessna 172.



**Negative static stability:** an aircraft that has negative static stability tends to continue moving away from its original attitude when disturbed. For example, if you hit turbulence and your nose pitches up, and then immediately continues pitching up, the airplane has negative static stability. For most aircraft, this is a very undesirable thing.



**Neutral static stability:** An aircraft that has neutral static stability tends to stay in its new attitude when it's disturbed. For example, if you hit turbulence and your nose pitches up 5 degrees, and then immediately after that it stays at 5 degrees nose up, your airplane has neutral static stability.



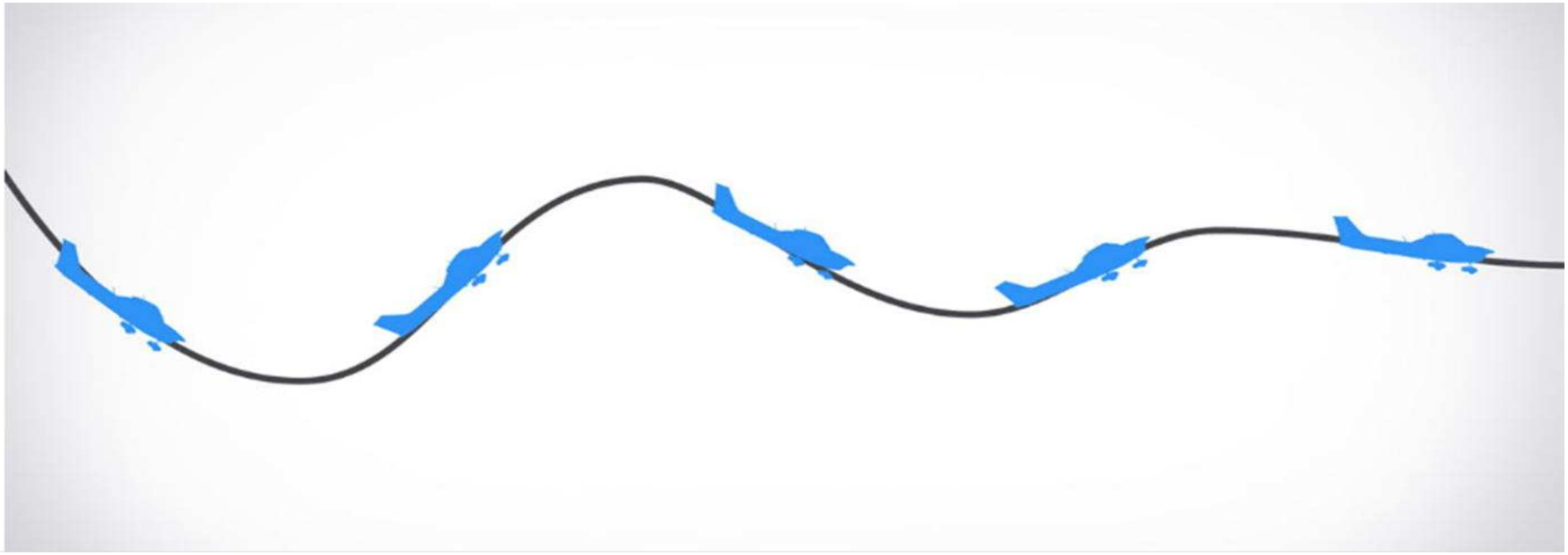
# DYNAMIC STABILITY

Dynamic stability is how an airplane responds over time to a disturbance, a dynamically stable system will eventually recover its equilibrium .

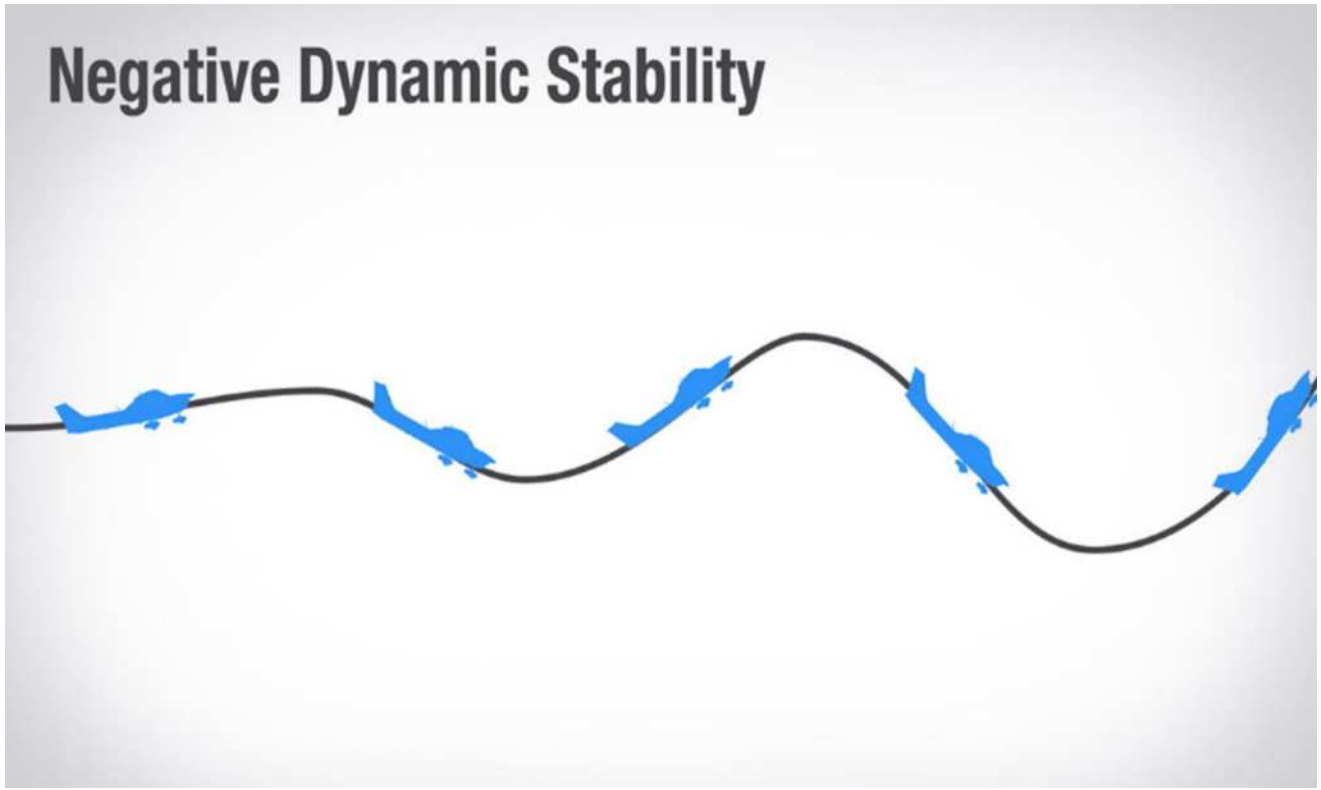
## TYPES OF DYNAMIC STABILITY

**Positive dynamic stability:** Aircraft with positive dynamic stability have oscillations that dampen out over time. The Cessna 172 is a great example. If your 172 is trimmed for level flight, and you pull back on the yoke and then let go, the nose will immediately start pitching down.

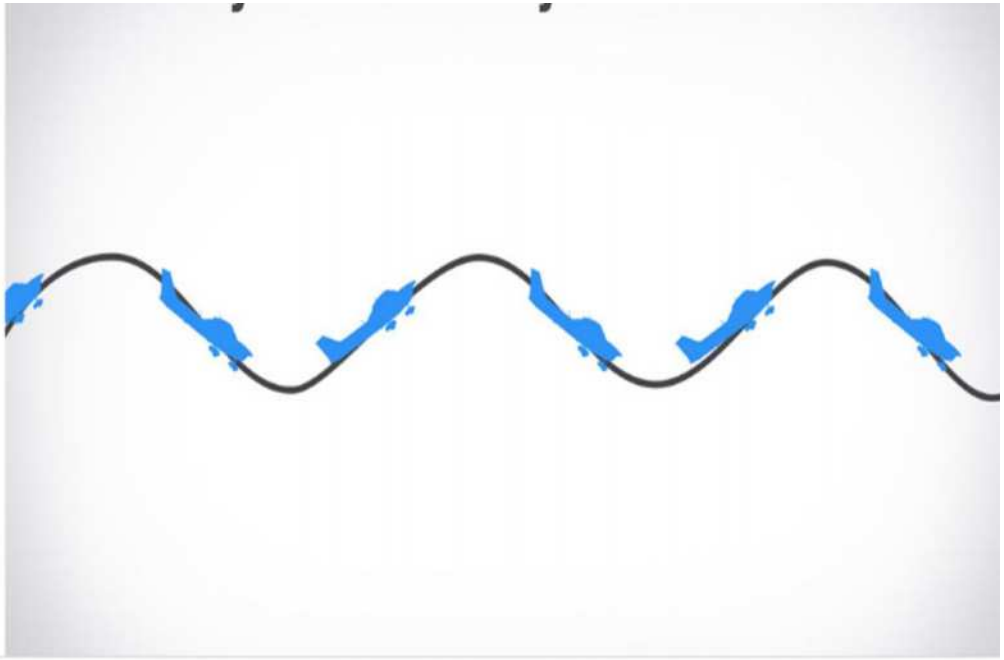
Depending on how much you pitched up initially, the nose will pitch down slightly nose low, and then, over time, pitch nose up again, but less than your initial control input. Over time, the pitching will stop, and your 172 will be back to its original attitude.



**Negative dynamic stability:** Aircraft with negative dynamic stability have oscillations that get worse over time. The diagram below pretty much sums it up. Over time, the pitch oscillations get more and more amplified.



**Neutral dynamic stability:** Aircraft with neutral dynamic stability have oscillations that never dampen out. As you can see in the diagram below, if you pitch up a trimmed, neutrally dynamic stable aircraft, it will pitch nose low, then nose high again, and the oscillations will continue, in theory, forever.



## Why Aren't All Aircraft Stable?

It really comes down to what your aircraft is built for. Stable aircraft, like Cessna and Piper training aircraft, are built to be statically and dynamically stable, making them easy to trim and fly 'hands off'.

However, jets like the F-16, are built to be unstable, making them highly maneuverable and easy to pitch, roll and yaw aggressively.