Stability

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- Example: longitudinal stability
  - an aircraft is in straight and level flight
  - the aircraft is upset by a wind gust from underneath the aircraft
  - this causes the aircraft to pitch up
- Static stability is the **initial** reaction to the pitch up
- There are three possible types of static stability
  - positive or stable
  - neutral
  - negative or unstable
- An aircraft that has positive static stability encounters the upset pitch up and responds by pitching down.
- If that same aircraft with positive static stability encounters a pitch down upset, it will respond by pitching up.
- An aircraft that has neutral static stability encounters the upset pitch up will respond by staying where it is, pitched up.
- An aircraft that has negative static stability encounters the upset pitch up and responds by continuing to pitch up further.
- Some aircraft are designed to have negative static stability, such as fighter jets, with the benefit of manoeuvrability.
- Some aircraft are designed to have positive static stability, such as a training aircraft like a Cessna 172.
- Dynamic stability is the aircraft reaction to the upset **over time**.
- There are also three possible types of dynamic stability
  - positive or stable
  - neutral
  - negative or unstable
- For an aircraft to be dynamically stable in any of the three states, it *must be positively statically stable*.
- An aircraft may have positive static stability, and positive dynamic stability.
  - This aircraft will first respond to the upset pitch up by pitching down.

    - It will then respond to the pitch down by pitching up.
    - Since it has positive dynamic stability, the oscillations (or pitchoids) will **decrease in size** over time.
    - This aircraft will eventually return to its original state of flight in straight and level.
- An aircraft may have positive static stability, and neutral dynamic stability.
    - This aircraft will first respond to the upset pitch up by pitching down.
    - It will then respond to the pitch down by pitching up.
    - Since it has neutral dynamic stability, the oscillations (or pitchoids) will **stay the same size** over time.
    - This aircraft will not return to its original state of flight in straight and level.
- An aircraft may have positive static stability, and negative dynamic stability.
    - This aircraft will first respond to the upset pitch up by pitching down.
    - It will then respond to the pitch down by pitching up.
    - Since it has negative dynamic stability, the oscillations (or pitchoids) will **increase in size** over time.
    - This aircraft will not return to its original state of flight in straight and level.
- Stability is determined by 3 factors in aircraft design
    - the location of the Centre of Gravity
    - the location of the Centre of Pressure
    - the location of the downward force on the tailplane
- On a typical training aircraft, the CG is forward of the CP
    - On its own this configuration would cause the aircraft to pitch down
    - A counteracting downwards force from the tailplane further back on the aircraft prevents this, stabilising the aircraft
    - This force does not need to be the same magnitude, since it is at a greater distance from the CG [^1]: https://www.youtube.com/watch?v=mGG_LVO5Tis