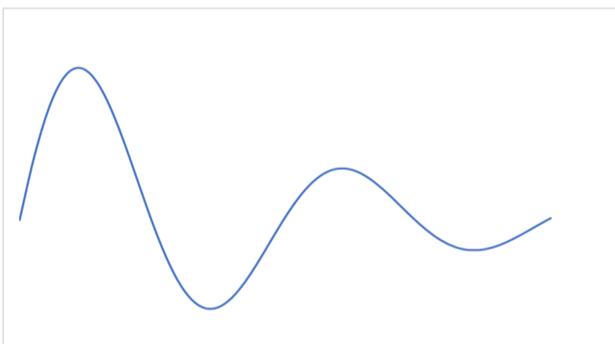
Stable or unstable? Good or bad?

Depending on how much attention you paid to your early aerodynamics lessons all those years ago, you may think it's always a good thing for an aeroplane to be stable. As with a lot of what we do, the answer to the question "Is stability good?" is more nuanced than a simple yes or no, because to a large extent, the opposite of stability is controllability.

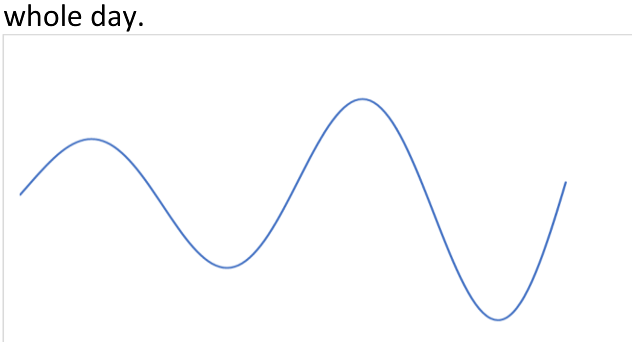
Static and dynamic stability

If an aeroplane's flight path is disturbed by, say, a gust of wind and the nose pitches up, static stability refers to the aeroplane's immediate response. If the nose returns straight away to where it was, the aeroplane is statically stable. If the nose stays where the wind pushed it, that's neutral stability. If the nose continues to pitch up, even after the disturbance, that's statically unstable.

Dynamic stability is about how an aeroplane responds over time. If, for example, an initial pitch up is followed by a pitch down to slightly nose low, then a pitch up again, and eventually the oscillations dampen out and you're back to where you started, that's positive dynamic stability. The oscillations will look like the figure below.



If an initial pitch or roll or yaw is followed by oscillations that get bigger over time, that's dynamic instability. The oscillations would look like the figure below, and would probably spoil your whole day.



What affects stability?

Most factors that determine whether an aeroplane is more or less stable are design features, but there are a couple of things you can do to make things better or worse.

Pitch stability

The main factors that affect longitudinal (pitch) stability are the size of the tail – a bigger tail can provide a bigger force to restore the nose to where it was – and the distance between the tail and the centre of gravity. You can influence this by loading your aeroplane properly. If the CG is too far forward, the aeroplane will be too stable, and hard to control in pitch, and if it's too far aft the tail surfaces may not be effective enough. Neither of these is a good thing.

Roll stability

Factors that affect lateral (roll) stability include (but are not limited to):

- High wings – that's why many training aeroplanes have high wings;
- Dihedral – the wingtips being higher than the roots, which may low-wing aeroplanes have;
- Sweepback (This is not the main reason airliners have swept wings – that's more about delaying the onset of supersonic effects and reducing their severity, but since supersonic flight is uncommon at Northam, we'll leave that discussion out!)

Yaw stability

Some of the factors that affect directional (yaw) stability are:

- The size of the fin;
- The distance between the fin and the CG which, as for pitch stability, you can influence by loading the aeroplane properly;
- Design features such as a sweptback leading edge of the fin, which increases the distance between the fin's centre of pressure and the CG. The Mooney has the opposite – a swept forward trailing edge so it's not too stable in yaw.

If you think about which aeroplane types have high wings or dihedral or big tails or fins, and the effects on stability, it's easier to understand why different types handle differently. For instance, PGL has a nice big fin, which makes it directionally stable, but it means that straightening it out when landing in a strong crosswind takes a Size 10 bootful of rudder, whereas Dave Kerr's Parrot, with a smaller fin and a much shorter distance between fin and CG, doesn't take as much effort to straighten it out.

The interaction between types of stability

Directional stability is good. It means it's easy to hold a heading. That's why a 172 has a big fin. It also explains the large sweptback fin on that magnificent piece of kit that the RAAF retired in 2010 – the F-111. If it was relatively easy for the pilot to hold a heading, that meant he and his colleague could devote more time to carrying out a mission, such as converting terrorists to heat and light.

Lateral stability, on the other hand, is good in moderation, but too much is a bad thing, because it makes an aeroplane too hard to turn. For this reason, most aeroplanes are more stable in yaw than in roll. Considering each type of stability in isolation, that's all good – easy to hold a heading and easy to turn.

The potential problem with directional being stronger than lateral stability is spiral instability. If you drop a wing and start to sideslip, directional stability tries to point the nose towards the relative airflow, which is now partly from the side. This means the aeroplane wants to yaw in the direction of the roll. Lateral stability, on the other hand, wants to pick the wing up and restore everything to normal. In most aeroplanes directional stability wins, which means a wing drop results not in the wing picking itself up, but in yaw, then more roll, more yaw, and eventually a spiral (or a spin if you're stalled). So when you're not trained and current on instruments and you fly into cloud, and a wing drops, the stronger direction stability will lead to a spiral dive, which on average will last the proverbial 178 seconds and get you on the nightly news for all the wrong reasons.

So out of all this, there's not a lot of actual flying advice. Make sure your centre of gravity is in limits, and don't fly at night or in cloud if you're not trained and current!