I feel the need, the need for speed!

Entry speed for a loop 160 knots. 23 inches MAP and 2300 RPM will give you 130 knots. 40 miles at 120 knots will take 20 minutes. Get the nose down; that attitude won't give you 75 knots in the climb you invalid!

Those statements are all about speed, but they're not all the same kind of speed. So how many different kinds of airspeed are there? For completeness, let's include the ones everyone knows – the ones you learnt in your PPL training.

Indicated airspeed (IAS)

IAS is not a measure of how fast you're going through the air or over the ground. It's a measure of dynamic pressure, or in simple terms, how many atoms of air per second or per minute are going down the throat of the pitot tube. It's the one the ASI shows, and it's the one that matters for anything aerodynamic. Your rotate speed, climb speed, maximum flap or gear speed, stall speeds, and entry speed for a Cuban eight, are all indicated airspeeds.

Calibrated airspeed (CAS)

CAS is IAS corrected for instrument and position errors. Small errors are inherent in most instruments, just like an old wind-up clock that loses two seconds every week. Position error refers to the position of the static vent, it and comes about because the static pressure on the aircraft's surface is not necessarily exactly the same as the static pressure remote form the aircraft. Remote in this case means far enough away to not be influenced by aerofoils and Bernoulli's principle.

In practice, the errors are so small that we usually consider CAS and IAS to be the same.

Equivalent airspeed (EAS)

This is one we don't usually worry about at a country aero club. EAS takes account of compressibility of the air, and it's the CAS at ISA sea level that would produce the same dynamic pressure that the aircraft is experiencing in flight. It's usually slightly lower than CAS.

You don't need to worry about it below about 200 knots, so if EAS is relevant to the aeroplane you're flying, you're probably not flying at Northam because the runway's too short for you.

True airspeed (TAS)

This is EAS (or because we usually don't bother with CAS and EAS, we can say it's IAS) corrected for density, which of course means temperature and pressure. At sea level in ISA (pressure 1013 hPa, temperature 15°C) they're the same, but if you calculate it based on temperature and pressure at altitude, it will be higher than IAS. The differences are not huge down low, but at Flight Level 350, 300 knots IAS is in the order of 500 knots TAS.

That big difference is one of the reasons jets fly high. A jet engine at idle is at 40-50% of maximum thrust, and idling means the power produced by the turbines is just enough to keep the compressors going. What that means is that at lower power settings, say, 60% of maximum, most of the power generated is just turning the engines over and not actually producing thrust, so the engines are not very efficient. Jet engines are most efficient at high RPM. The problem is 95% of maximum thrust may produce 500 KTAS at sea level, and that's 500 KIAS, which is way above V_{NE} for a typical big jet (but not for military jets like, say, an F-14 whose pilot chooses to ignore "Negative Ghostrider, the pattern is full".) But at FL350, that same thrust will produce a similar TAS, but at an IAS that is within structural limits.

Groundspeed

IAS matters for aerodynamics, and GS is the only other speed that we really care about, We only care about TAS because it's the one we combine with the wind to calculate GS, and from that some other important numbers such as ETI, fuel required, and what time we need to leave to arrive home at Northam by bar o'clock.

Mach number

This is named after the Austrian physicist Ernst Mach, and because he spoke German, he pronounced his name "Mark", which is the way we generally pronounce it. MN is a simple ratio between your TAS and the speed of sound.

The speed of sound in a gas is directly related to the temperature, and any formula to calculate it depends on the absolute, or Kelvin, temperature. In knots, it's 39 × the square root of the absolute temperature. So at sea level in ISA, where the temperature is 15°C (288K), the speed of sound is $39 \times \sqrt{288} = 662$ knots. At FL400 at the ISA temperature of -56.5°C, it's only 574 knots.

One of the interesting speed relationships is between CAS and Mach number. At any pressure altitude, a certain CAS will equate to a certain Mach number. For instance, at FL370, 260 knots CAS is M0.8. That relationship doesn't depend on temperature. If your CAS stays the same and the temperature suddenly increases by 10°, the TAS will increase, but the speed of sound will increase by the same ratio, so the MN won't change. 260 KCAS at FL370 will always be M0.8. Airliners generally fly at planned Mach numbers, which obviously allows them to stick to schedules, but probably more importantly, for separation. If you're on an air route at FL390 doing M0.8, and the aircraft behind you is at FL390 and also doing M0.8, you'll maintain separation.

The relationship between IAS (or CAS), pressure altitude and Mach number is important in determining climb and descent profiles for most jets. If a jet takes off from sea level and climbs at, say, 280 KIAS, that's just over M0.4. In the climb, as the density reduces the TAS will increase, and because the temperature reduces the speed of sound will reduce. So if Mach number is TAS ÷ speed of sound, and the TAS is increasing and the speed of sound is reducing, it follows that MN will increase as you climb.

A typical climb profile of 280/M0.7 (often expressed as 280 into 0.7) means you'll climb at a constant 280 KIAS, with your MN increasing from about 0.4, and at FL270 it will reach 0.7. From there you'll climb at a constant MN, with your IAS gradually reducing. By the time you reach FL350, your CAS will be below 240 knots. Incidentally, to climb at 280 KIAS, you'll require ATC to dispense with the standard speed limit of 250 KIAS below 10,000 ft. That's what they're referring to when they say "Cancel speed restriction" to a departing jet.

Descent will be similar. A typical descent profile may be M0.7/280/250. To do that, you'll start your descent at M0.7, your IAS will gradually increase, and from FL270 you'll maintain 280 KIAS with a reducing MN, until you get to 10,000 ft, below which you'll maintain 250 KIAS unless ATC tells you otherwise.

Happy flying, and since we're coming into the windier time of year in Northam, with the associated gusts and windshear, keep your speed up on finals!