Airspeed – All you didn't know you wanted to know

Airspeed is what makes the world go-round …. at least the aviation world.
Without airspeed you "ain't going anywhere". Airspeed comes in three flavors, Indicated airspeed, Calibrated airspeed and True airspeed.

Before we talk about airspeed let's talk about physics, specifically, the physics that makes an airplane get off the ground and fly. I'm not an aeronautical engineer and don't really know the details about what makes an airplane fly, but I do get the big picture. To get an airplane up into the air requires something pushing up on the bottom of the wings with a force sufficient enough to lift the weight of the plane off the ground.

This force is created by moving the wings <u>through the air</u>. The air moving across the top of the wing speeds up, which causes a "lowering" of the air pressure on top of the wing and by comparison, the air pressure on the bottom of the wing is now "higher". The higher pressure "pushes up" on the wings with enough force to make the plane fly. The faster you move the wind through the air, the more "lift" you create.

Once more to emphasize, lifting force is created by the movement of air across the wings of the plane and if you move the wing through the air fast enough it'll create sufficient lift to fly.

Notice it said "movement of air across the wings" and "move the wings through the air fast enough…". It's important to note it didn't say anything about speed across the ground. So the trick is to move the wing <u>through</u> the air <u>fast</u> enough. How fast is fast enough? Depends on the aerodynamics of the wing and the weight of the plane. We're all familiar with measuring speed across the ground, our cars do it all the time, but speed through the air is a different concept, the important part here is "through the air".

When the wind is blowing and the plane is on the ground pointed into the wind air is already flowing across the wings and part of the air flow (lift) requirement is already met setting still. This is important to know and is why we always takeoff and land going into the wind, Mother Nature is helping us with the "fast enough" part of creating lift.

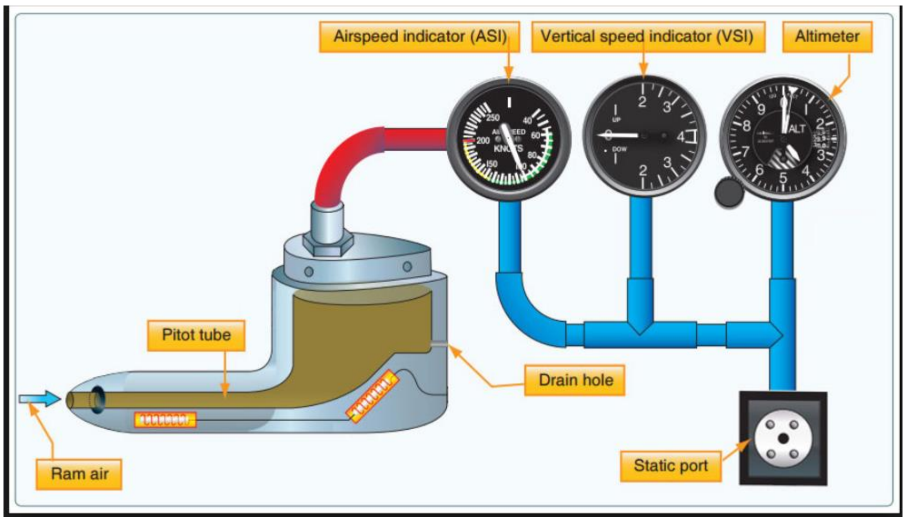
Let's say we need an air flow across the wing of 60 MPH to lift off the ground, the wind is blowing 10 MPH and we takeoff directly into the wind. We have air flowing across the wings at 10 MPH setting still and only need an additional 50 MPH of "airspeed" to create the required lift. The 10 MPH the wind is blowing across the wings and the additional 50 MPH were moving adds up to 60 MPH airspeed and away we go at a ground speed of 50 MPH.

However, if we took off "down wind" we would first have to catch up with the 10 MPH wind before any air would be flowing across the wings, then still need an additional 60 MPH airspeed to create the required lift. All together we would be going 70 MPH across the ground to get 60 MPH air flowing across the wings. That's 20 MPH ground speed more than if we took off into the wind. Not good. This applies the same when landing a plane. You always take off and land into the wind, your takeoff and landing rolls will be shorter, your ground speed will be slower and it just feels better.

All we have to do to fly is make the airplane wings go fast enough <u>through</u> the air and we're on our way. But, how can we tell when we're going fast enough? --- enter the Airspeed Indicator.

Here's a good place to talk about "units of speed". Most airspeed indicators are calibrated in nautical miles per hour (Knots), however some are calibrated in miles per hour (MPH). It doesn't matter which it is, if the Pilot Operating Handbook (POH) says the plane is ready for liftoff at 60 Knots when the pointer on the airspeed indicator says 60, take off. Same is true if the indicator is calibrated in miles per hour, whatever the POH for this airplane says that's what you do. Be careful however when doing cross country flight planning, you must use the same units of measurement everywhere. You can't use knots per hour for speed and statue miles for distance, it won't work.

To make the airspeed indicator - indicate airspeed, you need three things. A Pitot tube, an airspeed indicator and a static air pressure vent.



The picture shows the Pitot tube connected to the airspeed indicator and the static air pressure vent port connected to the airspeed, vertical speed and altimeter, which is correct. Right now we're just interested in the airspeed indicator.

The Pitot tube is mounted at the front of the plane usually under a wing. Its job is to feed a "reference" air pressure to the airspeed indicator. Air is made up of atoms and molecules of stuff. As the plane moves through the air, these air particles are rammed into the Pitot tube creating "pressure". The faster you go the higher the pressure. The Pitot tube funnels this dynamic pressure to the airspeed indicator.

It's the job of the airspeed indicator to convert this dynamic pressure into numbers on a dial that we can use. It does this by comparing the dynamic pressure from the Pitot tube to the current atmospheric pressure outside the airplane, which it obtains from the "Static Vent Port". The static vent port is a small, almost pin head size hole located on the side of the plane near the front. Through this vent the airspeed indicator can "feel" the current atmospheric pressure around the airplane.

When the plane is setting still on a calm day the Pitot tube pressure and the atmospheric pressure are the same, the airspeed indicator compares the two, sees no difference in them and shows the airspeed as zero. Once the plane starts moving air is "rammed" into the Pitot tube, dynamic air pressure builds up and by comparison with the static pressure the airspeed indicator sees an increase in airspeed and moves the hands on the dial accordingly.

Indicated Airspeed:

The speed shown on the airspeed dial is called Indicated Airspeed and it's REAL important, it's what we use to operate the airplane. It's important to know that the speed we see on the airspeed indicator is NOT the speed we're moving across the ground, it's the speed we're moving through the air. (Well, sort of – more on that later).

Why is Indicated Airspeed important?

Indicated air speed is how we fly the plane, takeoff speed, landing speed, climb speed, glide speed, stall speed are all Indicated airspeeds. Indicated airspeed is indirectly a measurement of how many air particles are moving across the wings of the plane, per unit of time, creating lift. Lift is our friend and indicated airspeed tells us how many friends we have. We operate the airplane based on the same Indicated airspeeds regardless of how fast the wind is blowing, the altitude we're at, or what the temperature might be. Indicated airspeed is king!

As noted, Indicated airspeed and ground speed are NOT the same thing. If we were flying a J3 Cub at an Indicated airspeed of 40 MPH into a strong head wind, the ground speed might be zero.

How can that be?

Indicated Airspeed is in a round-about way an indication of how much lift we have. Give the J3 Cub enough lift and it will fly. Once we're up in the air we become part of the air mass around us and if the air mass is moving (the wind is blowing), it moves us along with it. At that point we're no different than a leaf blowing in the wind. The J3 Cub is very happy to fly at an indicated airspeed of 40 MPH, but if we're pointed into a 40 MPH headwind (air mass in motion), that's blowing us the opposite direction (like a leaf), then our ground speed is going to be --- zero. You've seen big birds do this while they're looking for a mouse on the ground. They're flying forward through the air giving them lift, but the wind is pushing them back and the net result is they're hovering.

There's some other business about Pressure Altitude and True Airspeed that may be involved, but ignore all that for now, at the moment we're happily flying our J3 Cub, going nowhere. (Wonder what would happen if we slowed the Cub down to 35 MPH indicated airspeed?)

Calibrated airspeed

Airspeed instruments are mechanical gadgets that have small mechanical errors. Also the attitude of the airplane in flight can have an effect on the air flow into the Pitot tube, which can cause an error in the Indicated airspeed. Calibrated airspeed is Indicated airspeed corrected for these instrument & position errors. The correction table is published in the Pilot Operating Handbook located in the plane somewhere. Technically, we should be operating the plane using Calibrated airspeed, but because the calibrated airspeed correction table is in a book, not on the instrument panel, we use the Indicated airspeed instead. However, so that you'll be familiar with FAA terminology, this write-up will refer to Indicated airspeed as Calibrated airspeed.

Note: The Calibrated airspeed correction table for the clubs C-172 shows that for each Indicated airspeed the corrected Calibrated airspeed is always a couple of MPH faster, meaning we're always going just a little bit faster than the airspeed indicator says we are, which is a good thing.

True Airspeed

Calibrated Airspeed is a measurement of dynamic pressure cause by air particles being rammed into the airspeed indicator through the Pitot tube and is in a way an indication of how much lift we have.

Atmospheric pressure is the weight of the air particles in the column of air directly over the airplane. If atmospheric pressure goes up, there are more air particles, and the air is *more dense*. If pressure goes down, it's because there are fewer air particles directly overhead, and the air is *less dense*. When the air is less dense, there's less air particles per unit of measure, and it's harder to get the required air flow across the wings to create the lift needed for takeoff. There's also less air particles being rammed into the Pitot tube, so there's less Calibrated airspeed for the same ground speed. To make up for this we have to go faster through the air to achieve the Calibrated airspeed/lift needed for liftoff.

Important concept here! If we have to go faster through less dense air to attain the same calibrated airspeed, and if calibrated airspeed is indirectly a measurement of lift and if the amount of lift required to fly is the same, than it seems to me that in less dense air our TRUE airspeed has to be faster than our Calibrated airspeed.

Yep – that's right.
In less dense air we have to go faster through the air to achieve the lift needed to fly, True airspeed goes up, ground speed goes up, amount of runway needed to reach takeoff speed goes up, but Calibrated airspeed stays the same.

Airplane performance listed by the manufacturer is calculations made for operating the plane at sea level (most dense air) on an ISA standard atmospheric day. Any variation from that changes the performance of the plane. (For an explanation of the ISA standard see the write-ups on Altitude and Altimeters).

Airports located at high altitudes, such as ones in Colorado, have less dense air to work with just because of the altitude, consequently ground speeds are always much higher than airports at lower altitudes. Sometimes, during the summer the Density Altitude at these airports is so high and the air so thin smaller lower powered airplanes cannot get going fast enough to reach the minimum Calibrated airspeed for liftoff. In these cases the Calibrated airspeed required for takeoff DID NOT change, but the ground speed necessary to reach that airspeed increased dramatically. The increase in required groundspeed requires more runway and if "it ain't there, then you ain't taken off".

Again -- At high density airports the operational Calibrated airspeeds are the same as at sea level, but the ground speeds are MUCH higher, takeoff and landing rolls are MUCH longer and you'll need a LOT more runway. I know an airport in Colorado where the runway has a noticeable slope. The field elevation is 7,523 feet MSL and the runway is 7,351 feet long, about twice the length of Hicks. During the summer the Density Altitude can be over 11,000 feet. If the winds is not too much of a problem the local rule is to land going uphill and takeoff going downhill.

Another problem with operations at high density airports; it may be possible to reach takeoff Calibrated airspeed, liftoff and then not be able to climb. Be careful with high Density altitude operations, don't mess with the physics of Mother Nature, she wins every time.

So, what really is True airspeed? True airspeed is Calibrated airspeed adjusted for non-standard ISA atmospheric pressure and temperature. (One more time, see "Altitude and Altimeters" on the club website to learn about the ISA standard and Density altitude). True airspeed is how fast we're really going through the air, Calibrated airspeed is what our airspeed indicator says when adjusted for instrument and other small errors.

True airspeed is what the manufacturers talk about when they're telling us how fast their plane can fly. It's also the airspeed we use to determine ground speed when flight planning cross country trips. True airspeed fluctuates depending on atmospheric conditions, but operational Calibrated airspeeds stay the same.

Most of the time when we're flying the air mass is also moving and it's carrying us along with it. The speed of the moving air is called "winds aloft", but it's really just the air mass in motion and we're part of it. Nothing about the air mass in motion changes our airspeeds in any way, but it has a dramatic effect on our ground speed. Flying into a strong headwind plays havoc with estimated time of arrival and fuel consumption.

To calculate true airspeed you can use a type E-6B flight computer either old manual style, or newer electronic. To find True airspeed you must know three things, the pressure altitude, the outside air temperature and the calibrated airspeed.

Let's look at an airspeed indicator:

The picture is of a classic "steam gage" airspeed indicator that also has True airspeed scales, which is a little unusual. (The white scales). Neither of the club planes altimeters has the True airspeed scales.

Note: Now we switch back to calling it Indicated airspeed because we're looking at the face of the airspeed indicator, not a correction table.

The big numbers on the outside scale of <u>this</u> instrument is Indicated airspeed in MPH. The smaller numbers on the inside scale is Indicated airspeed in Knots. (Note: In some/most planes these are reversed) The green arc is the normal Indicated airspeed operating range for the airplane. The low speed end of the green arc is the stall speed with gear and flaps up (Vs1). The high speed end of the green arc is the maximum speed in rough air (Vno).

The white arc is the operating speeds with gear and flaps down. The high speed end of the white arc is the maximum speed you can extend the flaps (Vfe). The low speed end of the white arc is the stall speed in landing configuration, gear and flaps down (Vso).

The yellow arc is the "caution" air speed range where you cannot make sudden, or abrupt maneuvers, or operate in rough turbulent air. The red line is the never exceed speed (Vne).

This particular airspeed indicator also has scales to convert Indicated airspeed to True airspeed. You start by turning the knob setting the Outside Air Temperature (OAT) in degrees centigrade opposite the Pressure altitude on the top white scale, then reading the True airspeed on the bottom white scale opposite the indicator needle. The picture shows an Indicated airspeed of 176 MPH with a True airspeed of 203 MPH. (One last time – see "Altitude and Altimeters")

Note the various combinations of OAT and PA that result in the same True airspeed. An OAT of 0 degrees at PA 8,500, or an OAT of -10 degrees at 9,500 both give a True airspeed of 203 MPH. Kind of interesting….).

So now you know all there is to know about airspeeds and airspeed indicators.

Well maybe not, but at least you're on your way to passing the private pilot written exam and the airspeed conversation you'll have with the examiner on your check ride.