Turning

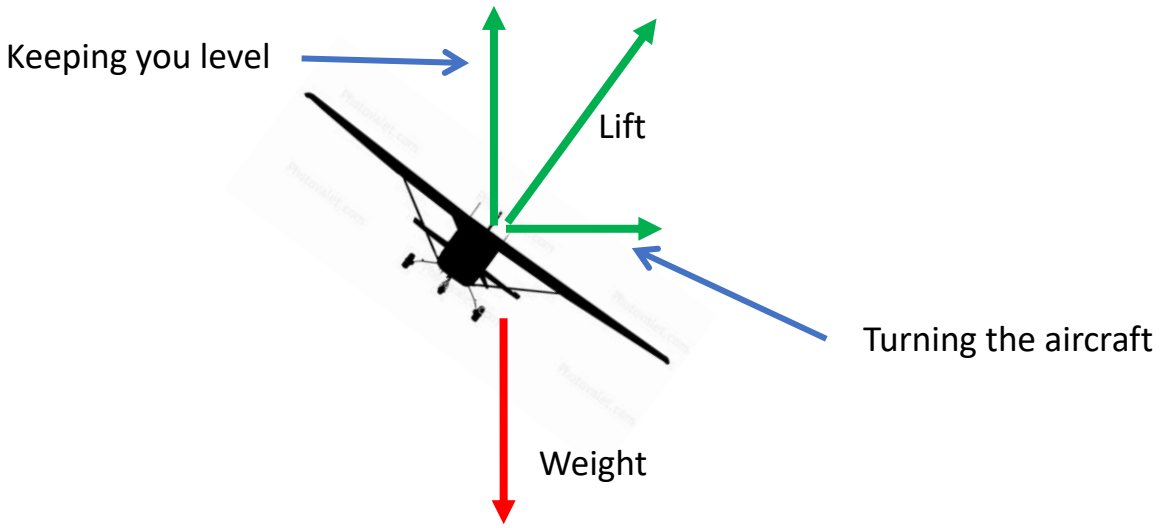
CASA's latest *Flight Safety* magazine contains (as usual) an article by US contributor Thomas P. Turner. His previous couple of articles, about checklists and weather, are well worth looking up, as is his latest one about rudder and ailerons in turns and stalls. If you get a wing drop in a stall, an aeroplane like PGL doesn't bite you if you use aileron, but some aeroplanes will. He describes it very well (except that using rudder in a stall doesn't pick a wing up; it just stops the wing drop becoming a spin).

But since I feel like starting an argument, I'm going to disagree with one of his diagrams, on a theory topic that I think most instructors teach very badly, which is the forces in a turn.

Back in the 1500's a very smart bloke by the name of Isaac Newton came up with some laws of motion. When I used to teach Physics to pilots, and we got to Mr Newton's three laws, I'd always start with "What's Newton's third law?" The reason, as you'll no doubt understand, is that no matter which law I asked for first, and which student in the class I picked, I'd always get "Every action has an equal and opposite reaction." So a bit like a smart student, who gives the right answer to the question, I'd ask the right question for the answer I knew I was going to get.

But we'll get back to the third law. Newton's first law says that an object will keep going in a straight line at a constant speed (which may be zero) unless it's acted on by an external **unbalanced** force. What that means for an aeroplane is that it won't speed up, slow down or turn unless the forces are unbalanced. For instance, taking off, thrust exceeds drag, you accelerate and you eventually gain enough speed to go flying.

Applying this to the forces in a turn: in a level turn, you bank and tilt the lift force. If it's a level turn, the upward portion of Lift equals Weight. The horizontal part of Lift is the unbalanced force that produces the change of direction.

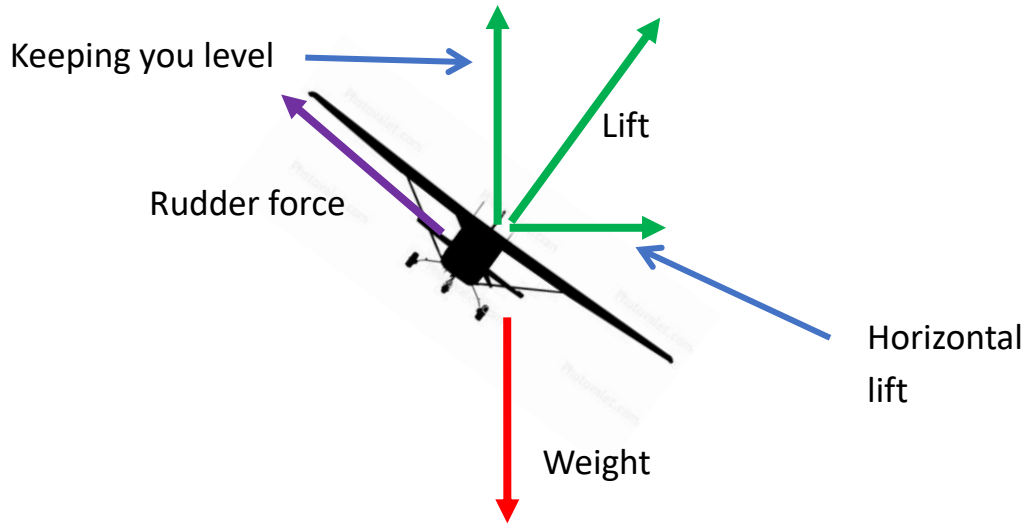


If there was another horizontal force balancing the horizontal part of lift, the aeroplane would not be turning.

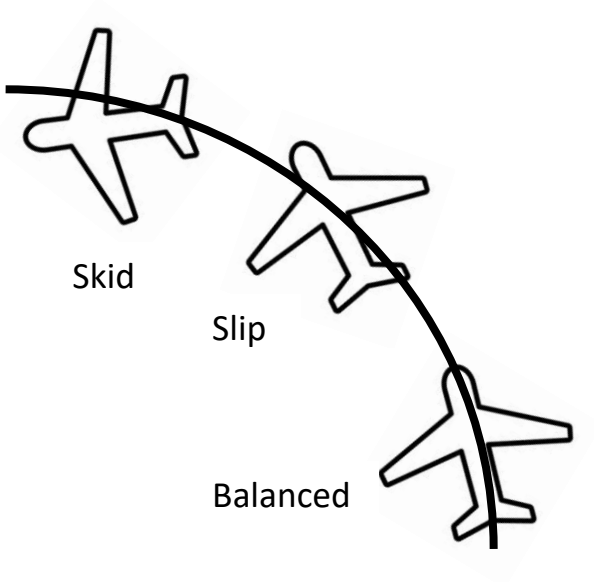
But consider what your body tries to do. Because it has inertia, it tries to keep going in a straight line. But the seat, being part of the turning aeroplane, pushes your backside into the turn. Back to Mr Newton's third law: your backside exerts an equal and opposite reaction on the seat, and you feel as though you're being pushed into the seat. It's an apparent force, but unfortunately most aerodynamics textbooks show it as a real force balancing (ie. cancelling out) the centripetal (inward) force that the wings produce. In my not-so-humble opinion, the reason is a misguided idea that all the forces have to be in balance.

Slipping and skidding

So what happens if your passenger wants to open the windows and take some photos? You roll right (imagine the diagram is looking from behind the aeroplane) and you apply enough left rudder to keep the aeroplane straight. The sideways part of your rudder force is countering the sideways lift, and you don't turn.



This is a slip. One definition of a slip is that it's a turn with not enough rudder, the result being that the rate of turn is not enough for the angle of bank (in this case, a bank with no turn at all). A skid, on the other hand, is the result of too much rudder, and too much turn, for the angle of bank. The tail is not following the nose, but is on the outside of the path of the turn. The diagram below shows what a skid, a slip and a balanced turn look like from above (or below for that matter).



Let's go back to the second diagram. Right bank, enough left rudder to stay straight. What are the instruments telling you?

- AH – right bank;
- Skidball – out to the right, telling you to balance the turn with right rudder (or less left rudder);
- Turn coordinator – wings level, because you're not turning.

So what does the turn coordinator tell you? It doesn't tell you your angle of bank; it only tells you if you're turning. The example you probably see more often is when you do instrument checks on taxi: turning left, AH erect with wings level, skidball right, turn coordinator showing a left turn. The TC of course looks like it's showing you a left bank even though your wings are level.

A key point here is that the TC does not reflect your angle of bank unless the ball is in the middle. In the right bank-left rudder scenario above, you're banked but your TC is wings level. When you do taxi checks, your wings are level but the TC's little wings are not.

That's very useful in night or instrument flying training when you learn unusual attitude (UA) recoveries on limited panel. Take away the AH and you only have the turn coordinator to help you level the wings. But that only works if you first put the ball in the middle.

But with any luck, your vacuum pump failure happens in VMC by day and you still have the most important instrument in the aeroplane, which is of course the front window!

Kevin