UPWIND AND DOWNWIND TURNS

created by Nature, seen by Nikolay Tsarov, written by Nikolay Yotov

When I started paragliding 15 years ago, one of my first questions was "Which turn is faster - when I start it flying upwind or downwind?". Every ridge soaring beginner remembers his first turns downwind toward the slope and the hope of turning away in time before smashing into the hill. Why the paraglider seems more maneuverable when flying into the wind and less when flying downwind? "It doesn't matter" would fellow pilots say. "It's all relative" would experts write.

After surviving the beginner's traps, my eyes and judgements got better and turning close to the ridge was no longer problem for me. I almost forgot about this doubt, until recently, when I met an old teacher of mine. He's one of these types who dares to question the fundamends around. No wonder why the others at the air force school felt uncomfortable and avoided him. Luckily he got interested in paragliding and our trip begun:

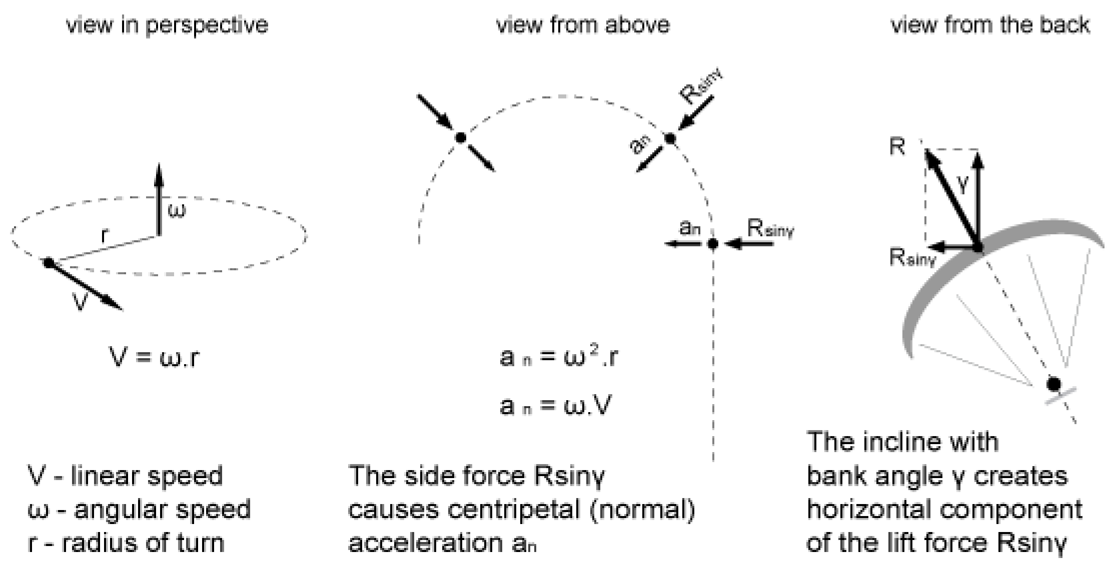
When we incline the paraglider at certain bank angle γ , then its lift force has horizontal component Rsinγ - the engine of the turn.

When a force acts upon a body, along it's trajectory of movement, then the body gains tangential acceleration and increases or decreases its speed.

When a force (Rsinγ) acts upon a body, perpendicularly to its direction of movement, then the body gains centripetal acceleration and changes its direction of movement but not its speed. The body turns.

To evaluate a turn we need to remind the basic physical laws: $\boldsymbol{V = \omega . r}$, where V is the linear speed, ω is the angular speed and r is the radius of the turn

The centripetal (normal) acceleration $\boldsymbol{a_n = \omega^2 . r}$



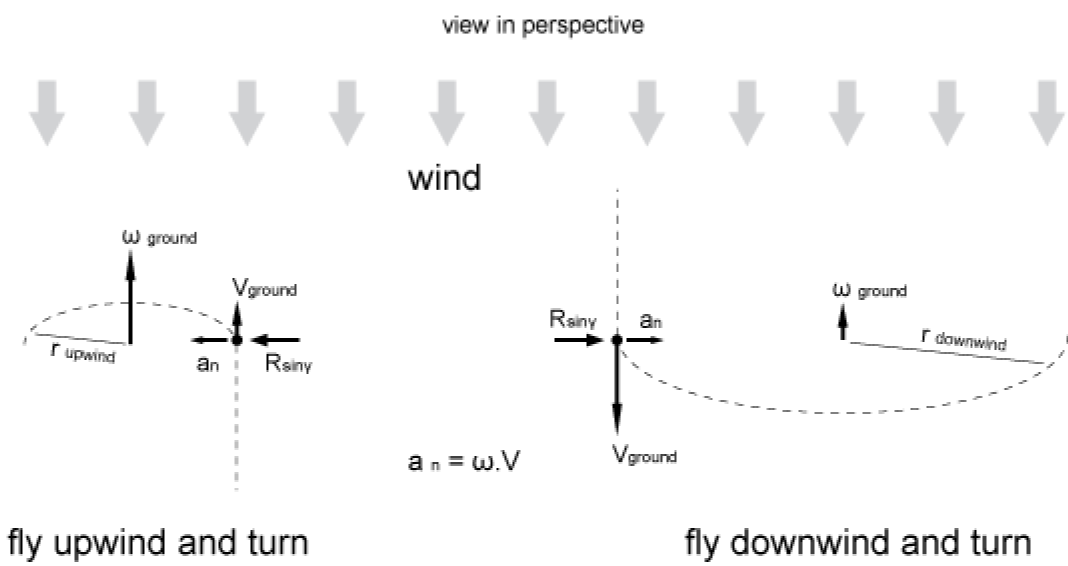
The centripetal acceleration is also $\boldsymbol{a_n = \omega.V}$

And here it's important to make the difference between air speed (V_{air}) and inertial/ground speed (V_{ground}). And also the difference between angular air apeed (ω_{air}) and angular ground speed (ω_{ground}) . Both are caused by a centripetal force, which causes centripetal acceleration. $a_n = \omega_{air}.V_{air}$ and $a_n = \omega_{ground}.V_{ground}$.

When the acceleration is once determined by a force, it's constant and when the linear speed is big, the angular is small and vice versa ($a_n = const = \omega.V$)

Thus when we fly against the wind, the initial ground speed is decreased and the turn is more intensive due to the increased angular ground speed.

When we fly downwind, the initial ground speed is increased and the turn is less intensive due to the decreased angular ground speed.



In both cases, the linear and angular airspeeds remain the same.

In both cases, the control imput is the same (γ=const, Rsinγ=const, a_n = const).

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I didn't have an opportunity to try it yet, but if you're an experienced pilot, then you can join this quest and check this theory in the following manner: Choose a day with wind speed similar to your trim airspeed. Fly against the wind for while, until maximum decrease of your ground speed, and make a standart turn with one brake (*remember the force you apply*). Then turn downwind, until maximum increase of your ground speed and make the same turn with the same brake and the same force. Repeat the test several times.

In both cases measure how much time it will take you to do a 90º turn by stopwatch. If it's the same, then the theory is wrong. If it's different, then .. hmm .. what's next?

I'll be happy to hear your results and comments. Fly safe!

n@skynomad.com