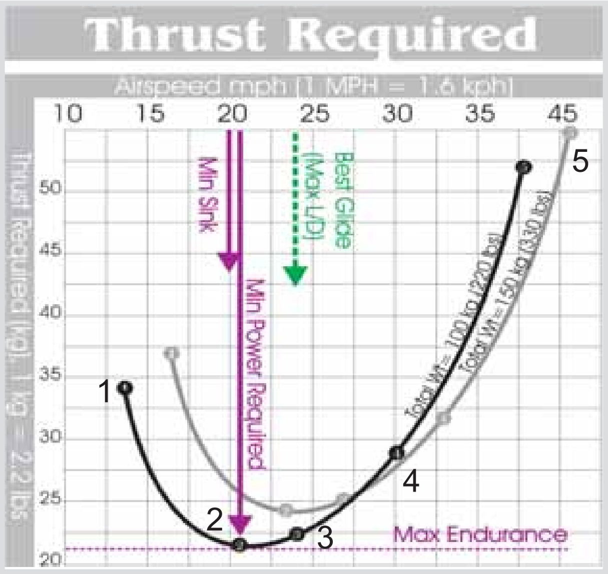
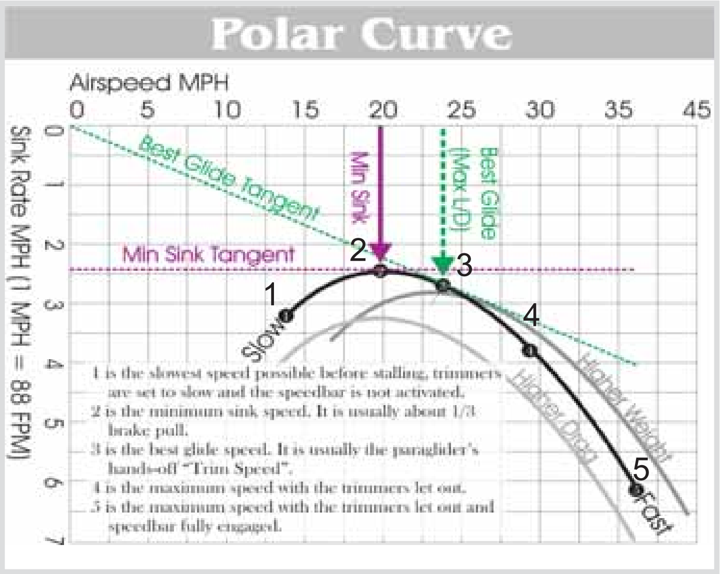




1 is the slowest speed possible before stalling, trimmers are set to slow and the speedbar is not activated.
2 is the minimum sink speed. It is usually about 1/3 brake pull.
3 is the best glide speed. It is usually the paraglider's hands-off "Trim Speed".
4 is the maximum speed with the trimmers let out.
5 is the maximum speed with the trimmers let out and speedbar fully engaged.

Thrust Required

This graph shows how much thrust is required to hold level flight at various airspeeds. Each labeled point has some significance. The gray line represents the thrust required for a heavier pilot flying the same wing. You can see that a weak motor, with trimmers fast and on full speedbar may not have enough thrust to keep him level with trimmers out and full speedbar.

The point's significance:

1 is the slowest speed possible before stalling, trimmers are set to slow and the speedbar is not activated.

2 is the minimum thrust required point. On most wings it is the slowest trimmer setting and brake pressure 1.

3 is with the trimmers slow (or neutral) and no brakes which is normally very close to the best L/D speed.

4. is with the trimmers fast but no speedbar.

5. is with the trimmers fast and full speedbar.

Stalling

A wing stalls when airflow over the top separates into a turbulent, random flow. It happens at the *critical angle of attack* and, although technically not related to speed, high angles of attack stem from heavy brakes and flying slow. If you're already flying slowly, it doesn't take much of a gust to cause a stall. A spin happens when only one part of the wing stalls and the flying part enters a rapid turn.

What is frequently called a full stall, when the pilot stuffs the brakes below his seat, is really more of an aerodynamic aberration than a stall—and far more violent, too. The wing does indeed go through the stall AoA, but then essentially becomes a luffing sail—flapping wildly in a hurricane force wind as you fall. Raising the brakes allows it to re-inflate, returning normal aerodynamics with an unpredictable bang (*see Chapter 18*) and surge.

The Polar Curve

Polar curves (see above) graph a glider's sink rate plotted against flying speed. It is a great way to understand many relationships between control settings, speed, sink rate, glide ratio and endurance. The next chapter has a discussion of power vs thrust but know that *power* must take into account airspeed.

The polar curve shows sink rate as speed changes. At your slowest speed, just before stalling, the sink rate is quite high. As you speed up the sink rate improves until reaching the "Min Sink" speed. Then sink rate increases again as you speed up. The tangent line to the curve from 0,0 is the best L/D (glide). Where it touches the curve is the speed and its slope is the best glide ratio itself. Being heavy doesn't worsen the glide *ratio;* it just increases the speed and descent rate where it occurs.

The Aerodynamics of Downwind

It's well established that flying upwind or downwind is no different in terms of power required and that's *almost* true. There is one obscure situation where you can actually require more power to fly downwind than upwind: in a wind gradient.

It stems from having the thrust line hang so far below the wing. In a wind gradient, it is possible for the motor to feel different relative wind than the wing.

First, understand that our motors have to work harder when they're operating in a slipstream. Since thrust is a function of accelerating a mass of air from one speed to some higher speed, when you're standing still with no forward airspeed, the motor works less to generate thrust. But as you accelerate, the prop must spin faster (more power) to generate the same amount of thrust. The higher rpm is required to accelerate the inrushing air by the same amount as when you were standing still. That rpm increase is our most obvious sign of this phenomenon.

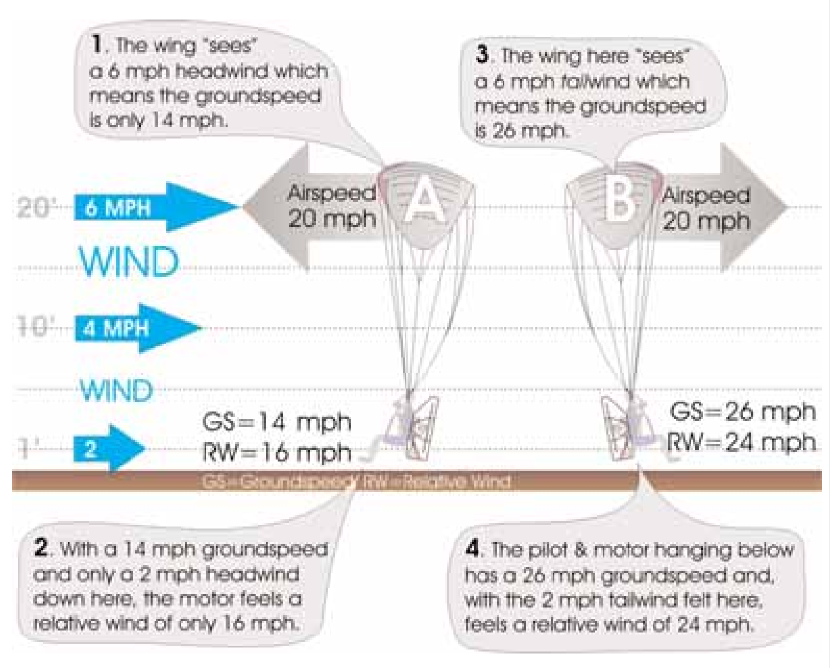
When flying into a gradient, the wing above you is experiencing a stronger headwind than what you're feeling. Sitting down there in the relative calm, you're going slower. Picture the extreme: lets say that, at wing height (15 feet or so), the breeze is blowing 20 mph, but at the ground where you hang, it's calm. You'll be hovering yet feel no airflow past your face whatsoever. Your motor would be happily producing static thrust which it's very good at. In the other extreme, if you turn downwind in such a gradient, your wing would be flying it's 20 mph with a 20 mph tailwind. *You,* on the other hand, would be feeling 40 mph breeze on your face! What's worse is that your prop would have to spin at a much higher rpm to generate the needed thrust to keep you aloft.

When It Can Take More Power to Fly Downwind

The only time more power is required to fly downwind is in a significant wind gradient, where the wind at the surface is much less than the wind at 15 feet high. That condition is most prevalent in the mornings and evenings when thermal mixing is minimal. The effect is usually minor, requiring only a few RPM more in a 4 mph windspeed difference. It is also fairly rare for it to be that significant over that small a height range.

The pilot pictured below will not likely experience the effect because, although he's down low where it would be most pronounced, beach sites don't get much gradient owing to a more consistent airflow.

The diagram below right shows the key difference between upwind and downwind flying: effective wind on the pilots face which is *relative wind*.



Drag & Power

Flying downwind in such a gradient saps more power on two fronts—1) there is more drag because your body is moving faster, and 2) the prop has to spin at a higher rpm to generate the same amount of thrust. The effect will be be most evident on your tachometer.

Rare

Even for us this is a rare scenario because the gradient is usually much higher than 15 feet. But it can be noticed, especially when it's otherwise very smooth. Be careful testing it, though, hitting something while scooting along downwind is most undesirable.

by Sheila Bouten

Early mornings or late evenings are the best time to feel wind gradient effects.