# How Does a Sail Work?

## *Not like you are told*

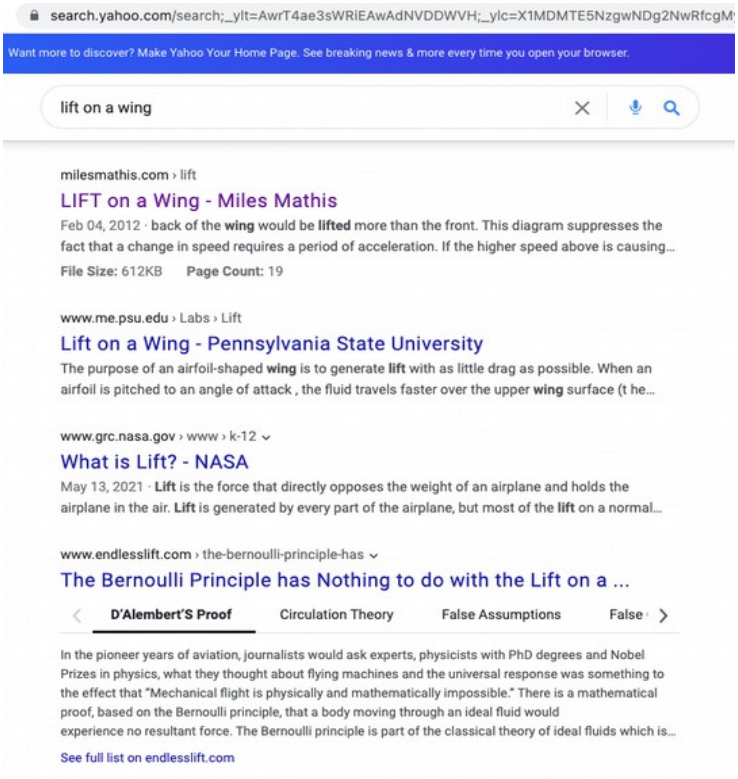
*by Miles Mathis*

*First published April 22, 2022*

My Dad was a CPA, but a serious woodworker in his spare time. After working out of the garage for many years with his saws, he built a shop in the backyard. His favorite project was building fancy furniture, like antique replica grandfather clocks, slant-top desks with curved and carved legs, highboys, things like that. But in about 1975 he build a small, all-wood sloop—I think it was 14 ft. Even the mast and rudder were wood. We would take it out on the local lake, which I have to admit was not highly scenic. The nearest lake to Lubbock, TX, that isn't a hog wallow is White River Lake, about an hour east, and from a tourist's standpoint even it isn't worth the drive. But it is out in the middle of nowhere and so is fairly clean and uncrowded, or at least it was then. I was about 12 at the time, so my point is I have been familiar with sailboats since then. I soon learned about tacking into the wind, not getting too close to the wind, and so on. A friend of ours had a small Hobie Cat, and I also got to steer that a couple of times. That boat was a lot of fun, since you spent about half your time in the water.

I have to admit I never found sailing into the wind a big mystery. I intuited the basic mechanics of it from the start, so I guess I just assumed they were known to all.

As my readers know, I wrote a big paper called *Lift on a Wing* in 2012, which currently ranks number one at Yahoo,* after a promoted link to stackexchange. It ranks number three on a Bing search on that question, just above NASA. Other engines also rank it on the front page, though Google has censored it completely. Which is illegal, by the way: it is called suppression of trade. Anyway, that ties in here, because—as it turns out—the mainstream uses the airfoil to explain how a sail works.




I also remind you that I have achieved that ranking *while* Google is censoring the paper. Google fields 90% of all searches, and yet somehow my paper still ranks number one! I am 90% censored, while NASA and Penn State are not censored at all, and yet my paper still outranks them.

You will say that after publishing that paper, it is incredible I have waited a decade to address this sail question, and I admit it is a bit incredible. As I say, the answer was so obvious to me from the age of 12 I didn't even research the mainstream answer, and wasn't aware of it until yesterday. When I finally did, I was thrown completely off balance. I watched the three top-ranked videos in utter disbelief, and I am still walking around in somewhat of a daze.

We will get to those videos in a moment, but I want to pause to give you a better idea how disorienting this is to me. A similar thing happened today, when I went to True Value hardware store to buy some turpentine. I couldn't find it so I asked one of the young men if they had it. He looked at me like I was speaking a foreign language and said, "come again?" He didn't know the word turpentine. My blood ran a bit cold, as I wondered if I had transferred into a parallel dimension. But in this case there was an explanation: I am now in California and California outlawed turpentine years ago. So this young person had never even heard of it. A True Value worker who hadn't heard of turpentine!

That was how I felt researching this current question of the sail. I am apparently living in a world where no one understands how it works. Possibly a deeper dive on the internet would show me someone else giving the explanation I am about to give you, or maybe it is in some old book. I don't know. But I didn't find it on a normal search on the question. I find this somewhat eerie, because—unlike the question of how planes fly—this one is easy. That question required knowing of my charge field (I say mine, though a few before me like Tesla knew of it). But this question doesn't. It has nothing to do with charge or with new explanations of lift. It is what I would consider first-year physics.

Before we get into it, I will pave the way by reminding you that a few years after my lift paper came out, the mainstream admitted—in *Scientific American*, no less—that it didn't really understand how lift on a wing worked. That paper from 2020 was called *No One Can Explain Why Planes Stay in the Air*, and it was by top author Ed Regis, quoting John Anderson, curator of aerodynamics at the National Air and Space Museum. Amazingly, it is still up. What they should have said, though, was that no one besides me could explain it. They just didn't want to give me any more press, so as usual they failed to mention my top-ranked paper. My personal opinion is that the paper at *Scientific American* was aimed specifically at me, and that they thought it might be worth admitting they didn't know if they could imply I also didn't know. That is why they started their title with "No one". No one, including Miles, knows, they want you to believe.

Eight years after publication, my paper—ranked number one on Yahoo, Bing, etc.—was getting such traction they were desperate, and desperate people make big mistakes like admitting that centuries of mainstream theory is just unsupported bluster. Even before my paper came out, they were admitting the old theory propped up by Bernoulli and wings curved on top and unequal times had been disproved in wind tunnels. So they ditched that and put all their chickens in angle of attack or the Coanda Effect. After I destroyed that in 2012, they had nothing and they have nothing now. The whole architecture has collapsed into a pile of smoldering sticks.

Which takes us to the sail. All the videos and other explanations of sailing into the wind rest on either the old airfoil explanations—which have since crashed—or on the Coanda Effect—which is even worse. But these videographers pretend not to have gotten that message. I guess they don't keep up with the news of physics since the 21st century started. In fact, the top-ranked video has a period feel, and appears to be from the 1970s or 80s. It is a segment of the *Curiosity Show*, and is by the same guy showing you how they put toy ships in bottles. So, cutting edge science. A search confirms it was a TV show in Australia in that time period, which is why it has an *HR Pufnstuf* feel to it. Which begs the question: why does the internet—the number one educator of everyone these days—lead with a 1970s pop video for kids from Australia on this question?

Just so you know, he explains it—if at all—as something to do with the Coanda Effect. He says that if you blow lengthwise on the *outside* of a curved sail—the convex side—the rear of it will move toward you. Then all you need is a centerboard on your boat to keep it from moving sideways, and voila! You are sailing into the wind. But any child watching this demonstration would have this as his first question:

**OK, so the centerboard or keel keeps the boat from moving sideways. But since the wind is coming from the front, why doesn't the boat move backwards? The Coanda force seems to be sideways on the rear of the sail, so I don't see how the centerboard turns that force to the bow or forward, somehow propelling the boat forward instead of back. Plus, this talk of blowing on the back of the sail is a bit ridiculous, given that we know the wind is filling the *front* of the sail. The front being the concave side of the sail facing the wind. The sail has to fill in order for the boat to move in any direction, and if the sail is filled, then obviously the main force is from that wind pushing on the front of the sail. So talking about the Coanda Effect on the back of the sail appears to be the most dishonest sort of diversion imaginable, hardly worthy of shoveling into the heads of us kids.**

I think you are already seeing why I was saying I was disoriented by all this. It is even more awful than what normally passes for science, and you can't help looking around to see if you are being

gaslighted once again. If you are my age, you might say, “Am I on Candid Camera?”

Here is another top-ranked video that comes up on page one. There, the answer is that the sail is like an airplane wing on its side, and the Coanda Effect is included for good measure. Strangely, this video claims the keel or centerboard also acts like a wing—though it is shaped wrong to do that. It is not curved like the sail, nor is it curved more on one side than the other. It cannot possibly create reverse “lift”, and even if it did it wouldn't explain the boat moving forward instead of backward. Even if the keel and sail did create opposite vectors, the video doesn't explain how the vectors add to create a forward vector. Since they oppose, why don't they cancel? It is simply claimed that the forces, taken together, provide propulsion forward.

To see how this utterly fails, go to minute 2:00, where the keel is being treated like an airfoil. Notice that they draw the water coming in from the top left, to act as a counter to the wind coming from the bottom left previously. This seems to create balance. But in practice, that isn't where the water is coming from, is it? They just made up that vector, because when the boat is moving through the water, the water is coming straight from the front, isn't it? The boat is moving straight forward to the left, not to the top left in the illustration. So you have just been fudged. The keel isn't pushing the boat bottom left, it is just keeping the boat from drifting up in the illustration.

LiveScience is also ranked on the first page on this question, but fails to answer it. All we get is a general description, saying we need a keel, a sail shaped like an airfoil, and so on.

So let's see what Wikipedia says. This is the top-listed answer at Bing. Surprisingly, it has an even shorter page with almost no information. This is as detailed as they get:

**Sailing into the wind is possible when the sail is angled in a slightly more forward direction than the sail force. In that aspect, the boat moves forward because the keel (centreline) of the boat acts to the water as the sail acts to the wind. The force of the sail is balanced by the force of the keel. That keeps the boat from moving in the direction of the sail force. Although total sail force is to the side when sailing into the wind, a proper angle of attack moves the boat forward.[1]**

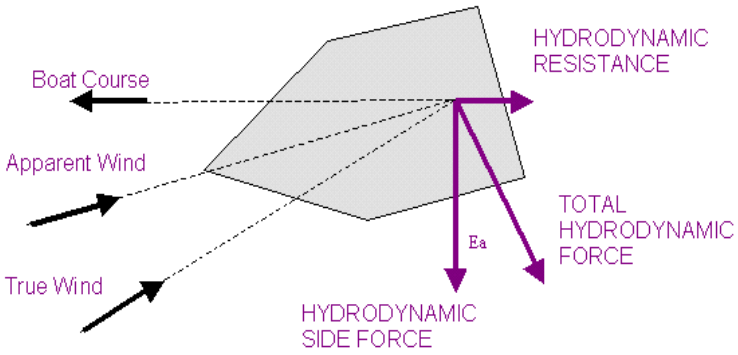
**The more the sail is angled from the centerline of the hull, the more the force points forward rather than to the side. Combine that slight adjustment in forward force with the opposition of water to air, and we have a boat shooting windward because it is now the course of least resistance.[1]**

What? That's like what you wrote on a test when you were in junior high, when you hadn't read the book and had no idea what the answer was. It sort of follows the mess we saw in the second video, but it has even less rigor or logic. And notice how they get the angle of attack in there, though it isn't clear what they are doing with it. The whole page just proves my point: either no one knows how a sail works, or they have decided to hide the right answer for some reason. I honestly can't fathom it.

On page two of our search, we get the first university site, which is MIT. This is a “Report on how things work”, by Robin C. Evans. The first thing we learn is that people have been sailing against the wind since 900AD, so apparently I am the first who has understood how it works in 1100 years. Robin certainly doesn't. She can't even subtract 900 from 2000, since right after telling us that this has been going on since 900AD, she then tells us that was 2000 years ago. So I guess she thinks she is living in the year 2900. She then says two competing theories of the airfoil exist, so she is going in that direction. She gives us full equations from Bernoulli and Euler, obviously to soften us up with some math she thinks we won't understand. She then shows us the old picture of the wing, curved on top and straight on the bottom. So I guess she hasn't been reading her *Scientific American* or other trade

journals lately. She doesn't realize wind tunnels have disproved all that unequal time garbage, nullifying all of both Euler's and Bernoulli's equations. Next she repeats what we have already seen above, as in the second video, about the hull (keel, centerboard) acting as a hydrofoil. Or, more likely that video was repeating her analysis, which they all got from the same source. She footnotes Michael Evans from 1998, who may be a relative, and also C. A. Marchaj 1979, so I guess we can blame them instead of her for most of this. But again, Marchaj was living in the time of *HR Pufnstuf*, before they had to admit none of this airfoil/hydrofoil stuff actually works. I just showed the main reason the hydrofoil can't work (see minute 2:00 of the above linked video): they have faked the vectors. It requires drawing the water vector coming in from the leeward side of the boat, which is ludicrous. When the boat is in motion, the water can only be drawn coming from the bow.

She also brings in the old angle of attack, but does nothing but name-drop it. She does not use it to actually explain how a side force is translated into a forward motion. The analysis here is further mucked up by talking about the true wind and the apparent wind, which they hope will confuse you enough to accept all this. With the apparent prestige of MIT and enough talking in circles, Evans hopes she will be able to fool you into thinking someone knows what they are talking about. I really encourage you to study that page closely. It should be highly embarrassing for them, since it is clear they haven't got a clue of the actual mechanics.




So you can laugh along with me, I reprint that diagram from MIT of the hydrodynamic forces. According to that, the total hydrodynamic vector is backwards to the boat's course, caused by the hull or keel. So, as I said above, if we combine that with any aerodynamic total vector from the sail, we should get a differential or subtraction. How can that vector combine with the sail vector to cause forward motion? As we have already seen in the videos, the lift vector from the sail being treated as a wing would give us a vector about 180 degrees from that total hydrodynamic vector, which, according to the rules of vector addition would give us a wash. A zero total vector and no motion. You would expect a second diagram of the sail vectors on that page at MIT, but nothing is forthcoming, and now you see why.

I should also point out that this page at MIT doesn't even once get near suggesting what I am about to show you. Neither did Wikipedia or LiveScience or any of the other sites I visited.

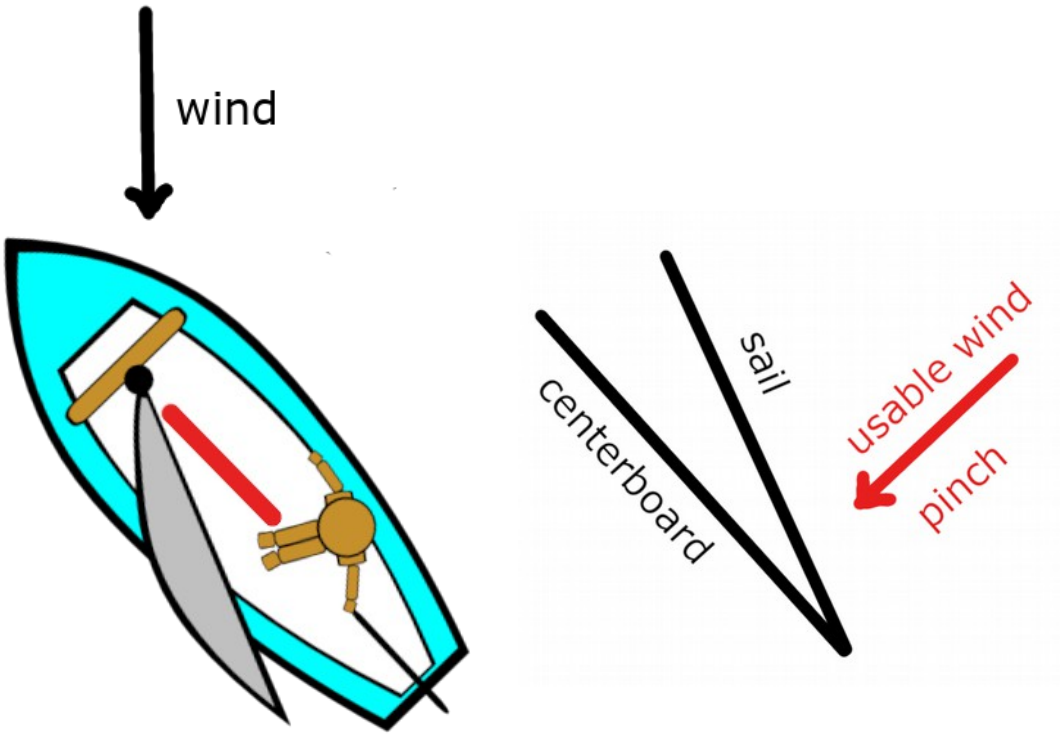
But I won't waste any more of your time. How does a sail allow you to sail near the wind? For those who know nothing of the question, I will get you started. You can't sail right into the wind. You have to be at an angle of 22 degrees or more either way. That vector is called a tack. To sail into the wind you sail for a while on one side of the wind, then come about and sail on the other side, zigzagging forward. That's because if you point right into the wind, the sail won't fill. The wind goes on both

sides of the sail and it “lufts” or flaps. This tells us that it is the sail filling that provides the force, as you would expect. It has little or nothing to do with the Coanda Effect or the sail acting as an airfoil. A sail in a tack is providing a force from the *inside* of the sail, just as when the sail is used downwind. The only way the Coanda Effect even gets close to being true is that due to the angles, the rear of the sail in an upwind tack carries more of the force—but from the inside of the sail, not the outside. You can tell just by looking at how the sail curves in that position: more wind is in the back of the sail than the front. That's why, without a centerboard or rudder, the boat not only drifts sideways, it drift backwards and even wants to spin. The wind is “pinching” the rear of the boat, in a way. But nothing resists the pinch, so the boat just slides.

So, we have a pinch at the rear of the sail or boat. How does adding a centerboard make the boat go forward instead of backward? To understand it, let us study a simpler set up. Take a rectangular block and place it lengthwise against a smooth wall or other immovable surface. That will be your boat. If you now push it against the wall, it won't move either forward or backward, because everything is square. You are pinching it against the wall, but there are no acute angles, so the pinch doesn't lead to any motion. But now cut your boat in half, but corner to corner, so that you now have a long triangle or wedge. If you grease your boat and the wall, and now push on it, it will squirt out forward, forward being the large end of your triangle. Your boat has squirted out the front, like toothpaste out of a tube. Your pinch has turned into forward motion, hasn't it?

If you aren't following me here, I suggest you actually get a block and a wedge and do it.

I probably don't have to tell you why, it is pretty intuitive, but it has to do with applying equal forces to an unequal object. You are pushing the same on the front and back of your wedge, but the wedge is not responding equally, because there is less of it in the rear. So the rear feels more force, driving the boat forward. That is what a pinch is. Notice that it won't work if you push only on a point. You have to push over a width. That's because it relies on an unequal force, and you can't offer an unequal force across a point, by definition.



You will say the boat is not a wedge, but a wedge is created by the angle of the centerboard to the sail. The centerboard acts as the wall side of your wedge and the back of the sail acts as the other side. It becomes the other leg of the triangle. I guess people have missed this because the triangle is in the diagram, not in the boat. Or, technically it *is* in the boat, but in boat+sail. The wind is providing the pinch at the back of this wedge, and that drives the boat forward. This also explains why sailboats sail fastest on a beam reach, with the wind coming in from one side or the other. The maximal wedge is created in that position, since fat wedges respond better than thin ones to the pinch, in most cases. You have a quicker change in the response to the force.

This is confirmed by the known forces in a close haul, which not only make the boat without a centerboard slide sideways or back, but also spin. The pinch is increased at the rear of the sail when closest to the wind, by the sail facing the wind better back there, which, without a rudder, would make the boat spin.

The only thing left to explain is how boats tacking into the wind can sail faster than the wind. For some reason this is also treated as a grand mystery, though it isn't. It is because the speed of the boat is determined by a cumulative or continuous force of the wind, not just one gust. In other words, the boat gets to add up a bunch of little pushes from the wind, older pushes carrying over. The boat is still moving from the wind five seconds ago and two seconds ago, not just the wind now. Go push a toy car on a track. If you give it one little push, it continues to roll for a few seconds, right? It doesn't stop rolling as soon as you stop pushing. So if you push, then stop for a second, then push again, then stop for second, and so on, the car will build up speed. Most likely you won't find this supernatural, thinking the car is magic because it is going faster than each one of your little pushes. It is the same with the wind. The speed of the wind is just a measurement of its power at each moment. It is not a measurement of the wind's cumulative power.

So why doesn't the sailboat keep adding up windpower, going faster and faster until it flies off into the sky? That is also pretty obvious: it is resisted by the water and the air.

You can see how simple that is, so is it possible I am the only one who knows it? I don't see how. But why would they hide it and make themselves look stupid?

Some will claim I am saying the same thing as the mainstream, just simplifying it. No. Not even close. Never once do the mainstream explanations mention a pinch, a squeeze, a squirt, a wedge or anything like it. Never once do they pull that important triangle out and highlight it. They mention an angle of attack, but that angle has nothing to do with my wedge angle. That is the angle of the sail to the wind, and they use it to refer to the airfoil analogy and little else. And their forces are all wrong to start with, since they rely on Coanda Effects or airfoils or hydrofoils that simply aren't important here. The sail isn't mainly acting as an airfoil here, it is acting AS A SAIL. That is, it is catching wind. The wind is blowing directly on the inside of the sail, so they don't need to be talking of airfoils at all. It isn't pressure differences causing this, *it is wind blowing directly*. How hard is that to figure out? People who know nothing about airfoils or Bernoulli can figure out what is happening in the first instance here, since they can see or feel the wind entering the sail and filling it. The wind is pushing directly against the sail, so as soon as the mainstream starts talking about Coanda Effects or airfoils, you should know you are being conned. They are trying to overcomplicate the problem beyond your comprehension, so that they can sell you one of their ugly fudges. This is what they specialize in, not science. Any real scientist, engineer, or sailor should look at that MIT page for a few moments and just shake their heads in pity. It is clear at a glance the whole thing is a bad snowjob. Even if you can't

intuit the right answer, you should study their answer and realize it doesn't answer the question at all. It is an impenetrable mess, and it is an impenetrable mess *on purpose*, because they know that if you begin to penetrate it, like I did, you will see them for the shameless fudgers they are. Their only hope is to confuse you and browbeat you. They are sitting in a chair at MIT and have various initials after their names, therefore they must right and you must be wrong. They must be smart and you must be stupid. In other words, it is just one more part of the Big Bluff. That has been their only response to me over the years, but I am unbluffable. I bow to no authority but Nature.

You will say that even if I am right, it isn't necessary to attack these mainstream people with such relish. But I think it is. They have been nothing but nasty to me from the beginning, and not just me. They have been suppressing open science for centuries, it went into overdrive after about 1920, and it is still getting worse every decade. So I am not the problem here. It is not my attitude anyone should be complaining about. It is the entrenched attitude of the mainstream, which is fiercely protective of its position, to the point of outright fascism and censorship. You can see why they would need such protection, given the sad state of their theories. If they allowed anyone to speak but their own spokespeople, the whole house of cards would fall in short order. They know that, which is why the levels of fascism are rising across the board now, not just in science. If you think I am making it up, go look for my *Lift on a Wing* paper at Google. Where is it? Why do the spiders at the other major engines think it is the most popular paper on its subject in the world, ahead of NASA, but Google has never heard of it? What possible reason could they give for hiding my paper from you? Google is selling you an open internet while providing you a closed one. They have already morphed into a Chinese-style internet without admitting it.

At whose behest do you think Google is censoring me? Mainstream science of course, which has asked for their protection against me. Pitiful.

One final point: do you really think that physicists who can't tell you how a sail works can tell you anything about black holes, the first three second of the universe, or the interior of the atom?

*You may not realize the importance of my rankings, so I will just tell you that it had never happened in the history of the internet, and no one else but me has achieved it. Many of my papers rank on the first page, some of them number one, and they are PDFs with zero promotion. This was not even thought to be possible, which is why Google finally had to step in and nip it in the bud. It may soon be a thing of the past, and in a hundred years only the oral tradition of it may survive, passed on in the halls of the rebellion, where they tell the tale of the guy who—in the early years of the internet—beat Wikipedia, Facebook, the Encyclopedia, and the Dictionary, on real numbers, with no help from hackers or coders or even keywords.