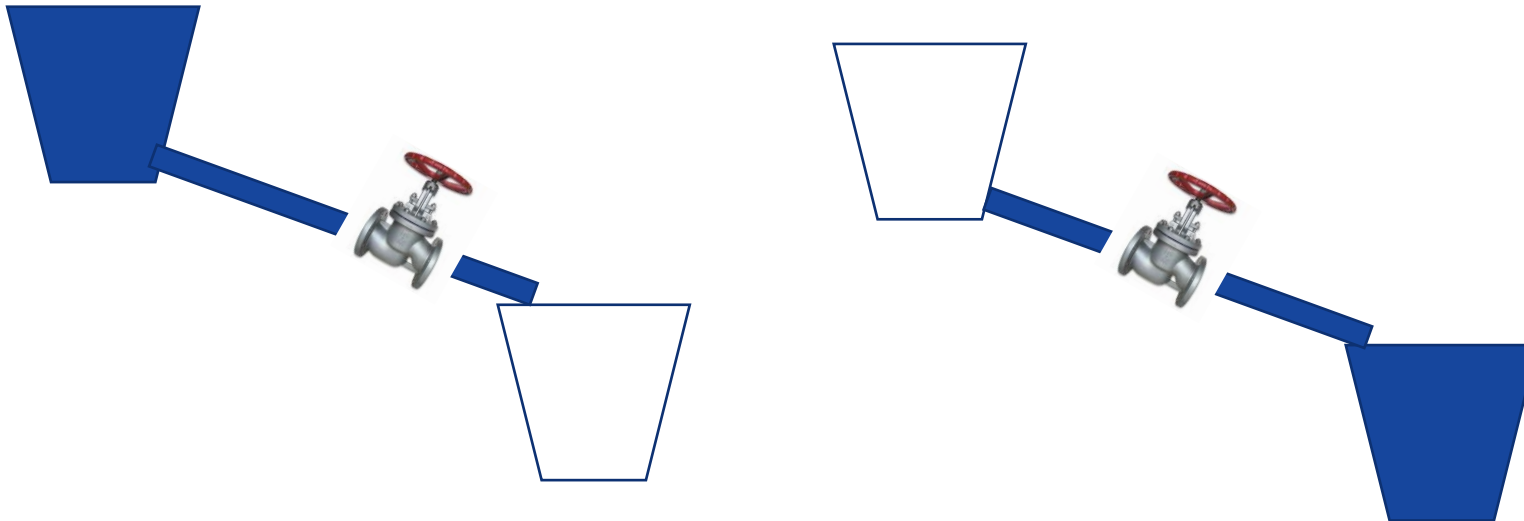


Technical Course for Coaches Level 3 – Basic Aerodynamics



What is pressure?

Let's see what happens to a bucket full of water.



Velocity

Velocity.....

What happens if you squeeze the end of the water hose ?

The water goes in more distance and that means that it gets more

Velocity.

Pressure

Velocity

Bernoulli

Bernoulli

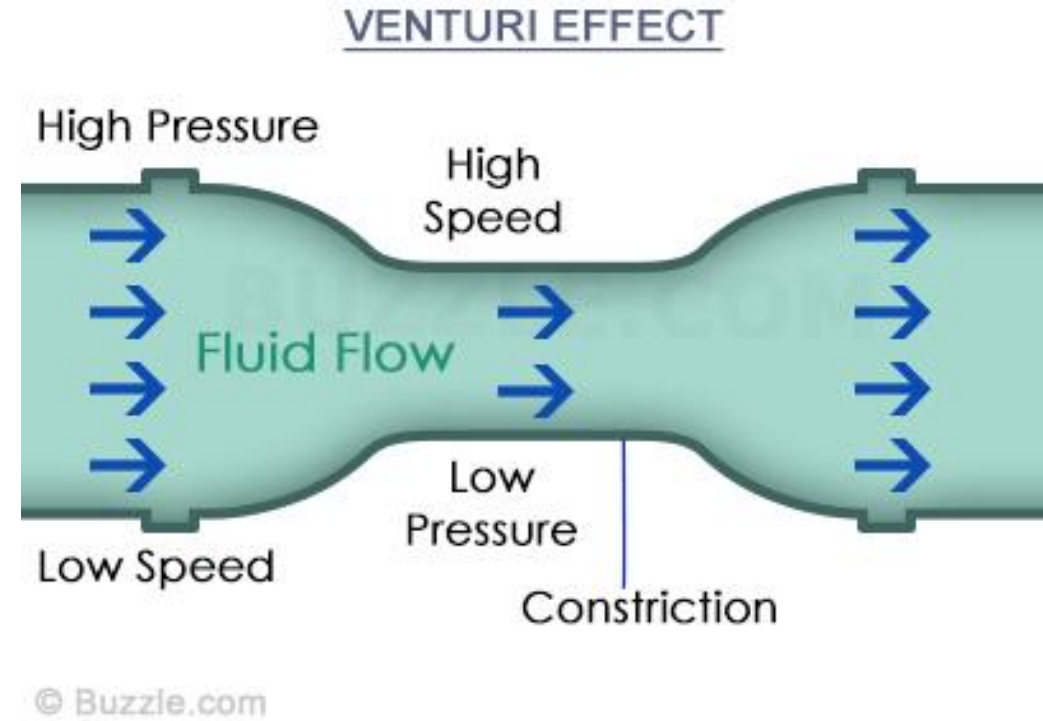
Bernoulli says that when the velocity increases the pressure drops.



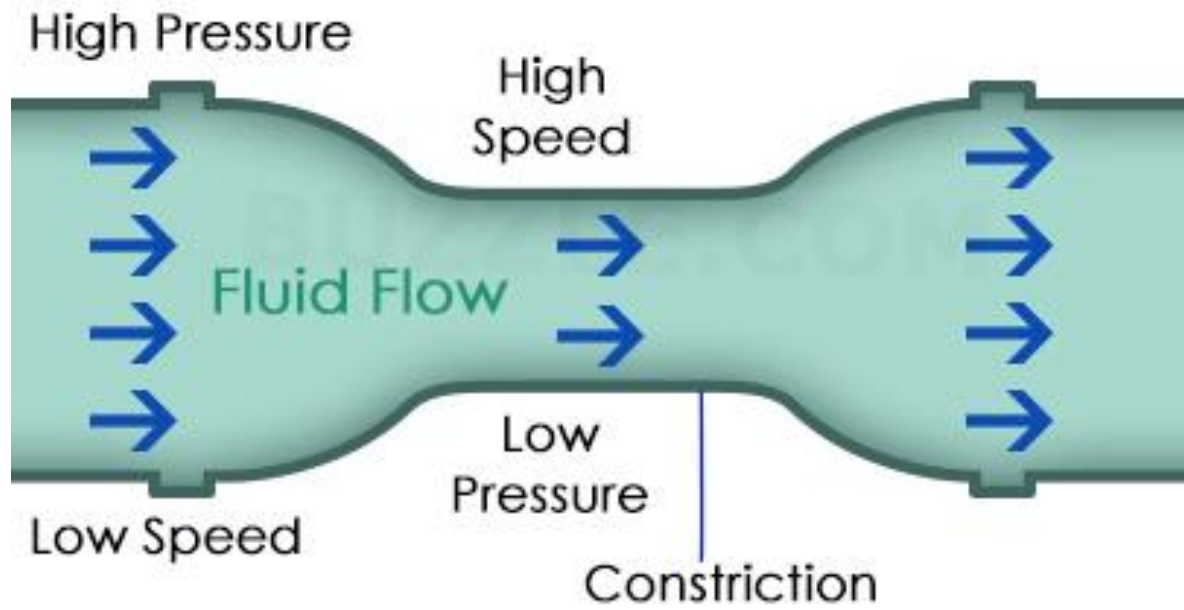
Velocity increases



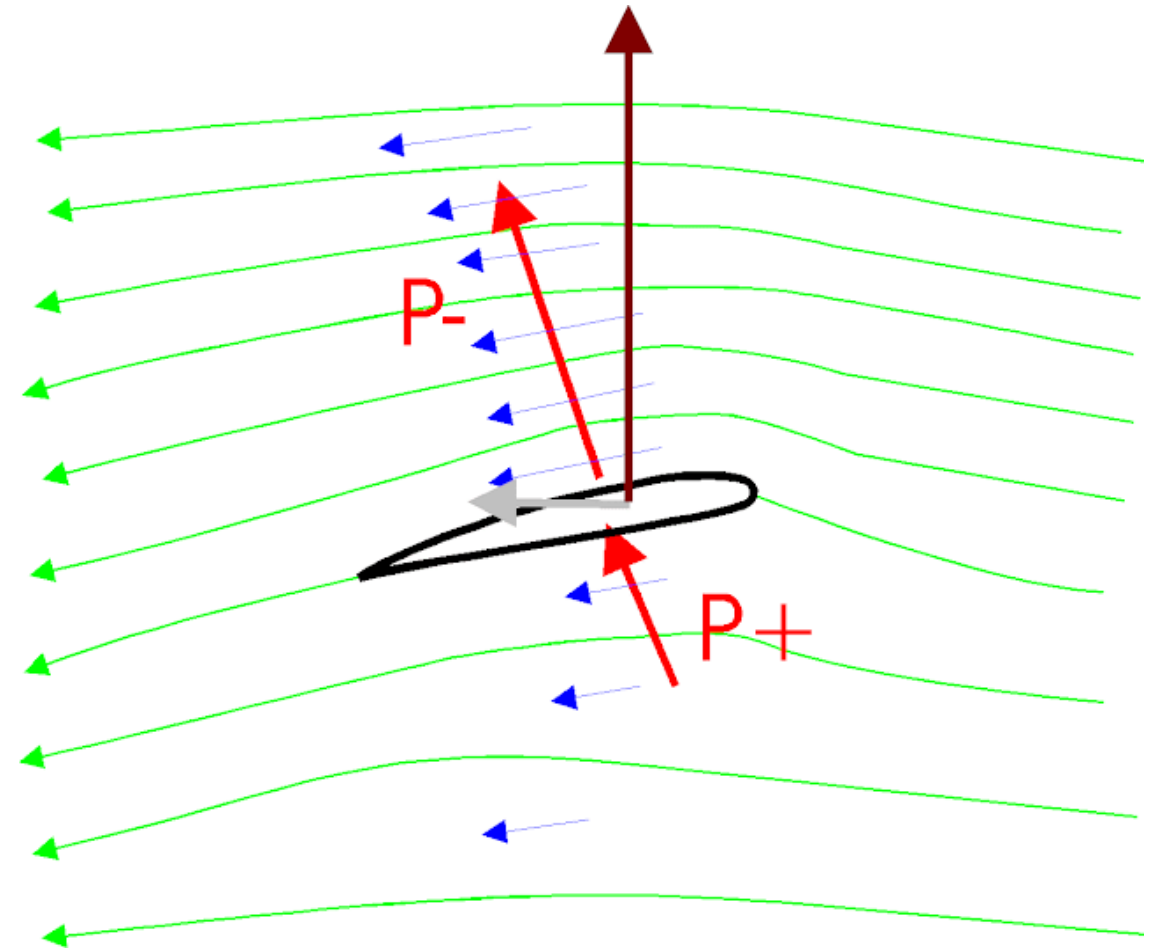
Pressure decreases



VENTURI EFFECT

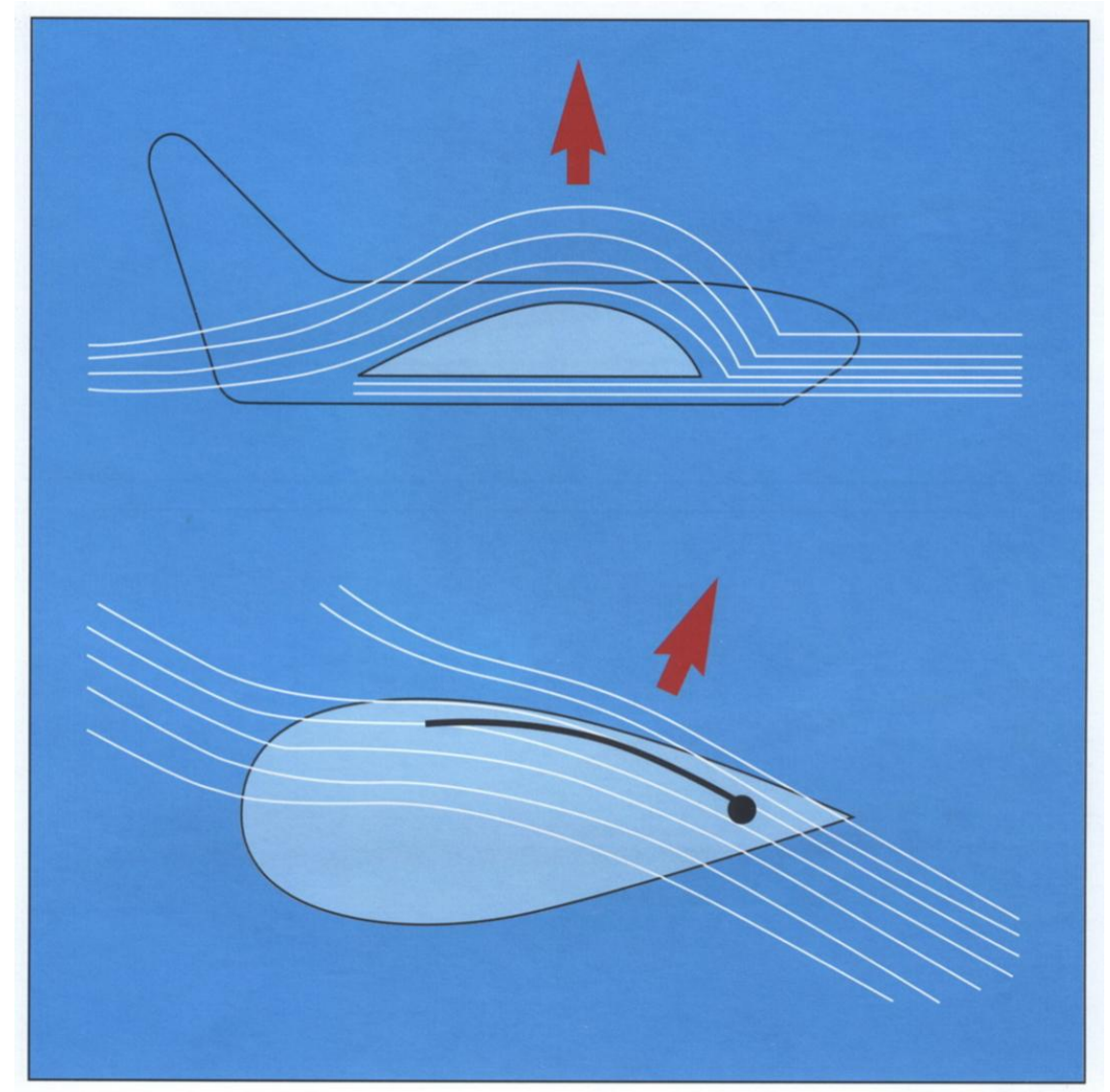


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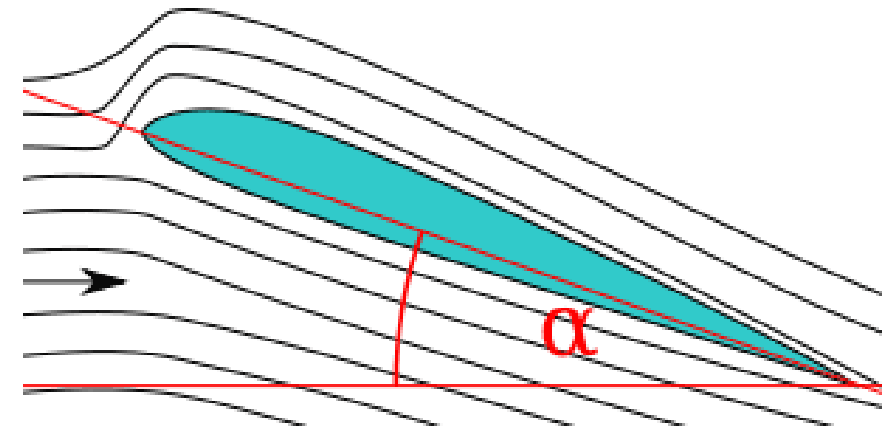
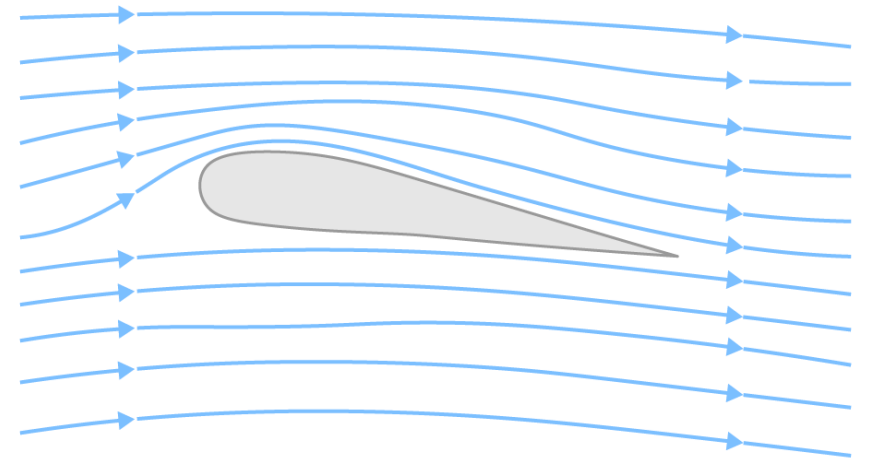
Let's do a little experiment

What happens when the wind meets a curved object?



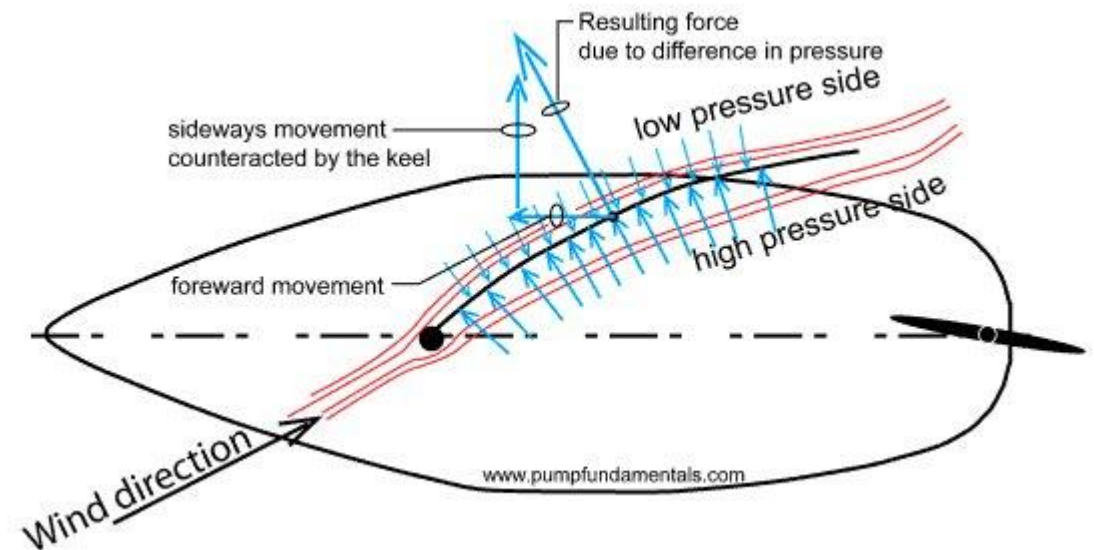
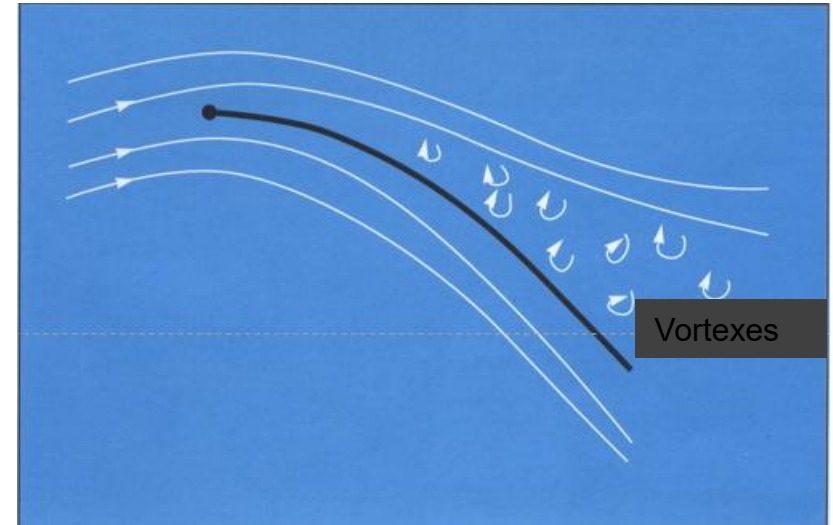
Aerodynamic force on the sail

- By having an aerodynamic shape in a stream of fluid according to Bernoulli's law the velocity on the curved area is increased and therefore we have lower pressure.
- When the shape is inclined, then one force due to the suction is lifting and one force from the windward side is pushing the subject.
- Suction is contributing the 60% and the pressure the 40%



Aerodynamic force on the sail

- The sail is an aerodynamic shape so on the leeward side of the sail there is suction and on the windward side there is pressure.
- Suction is created when the wind follows the leeward side
- Less vortices maximum suction



The main sail in proper position

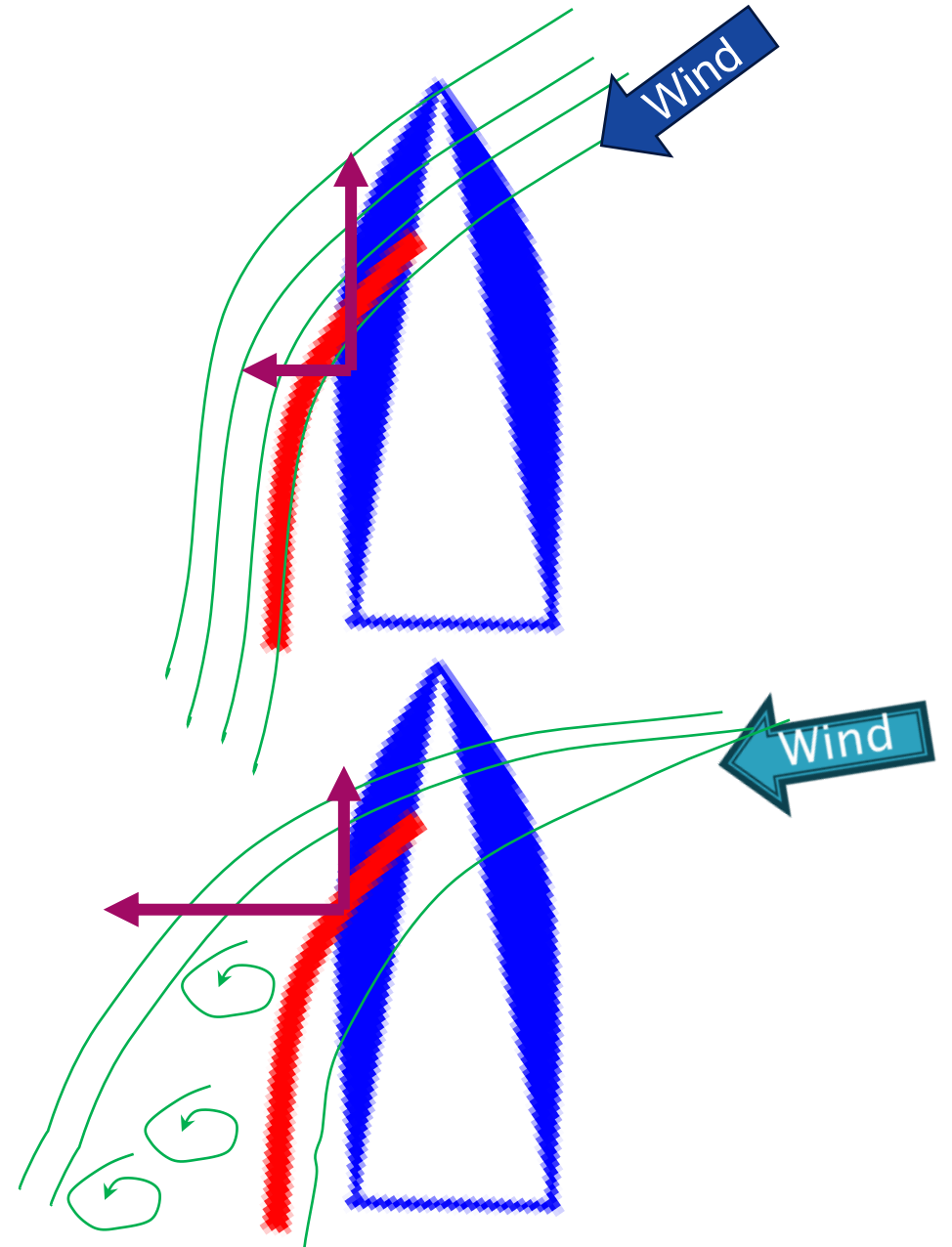
In this case there is small side force and big forward force so ..

The boat is healing less with maximum speed

The main sail is pulled more

In this case due to the turbulences there is big side force and small forward force so ..

The boat is healing a lot without speed

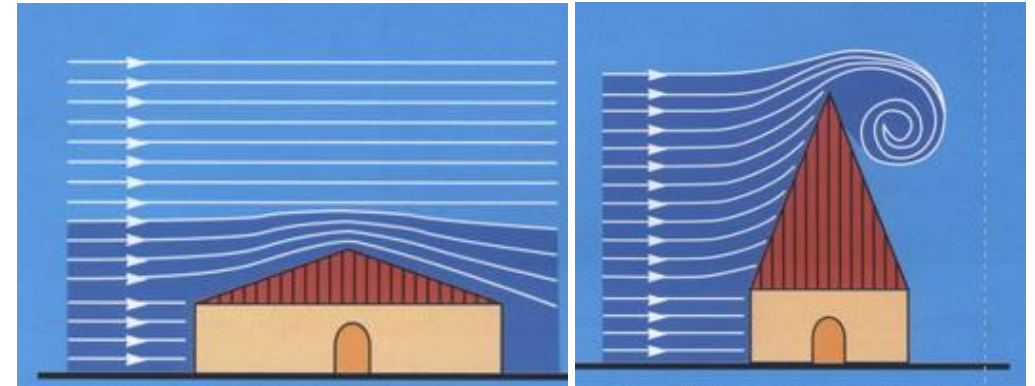


Bearing Away

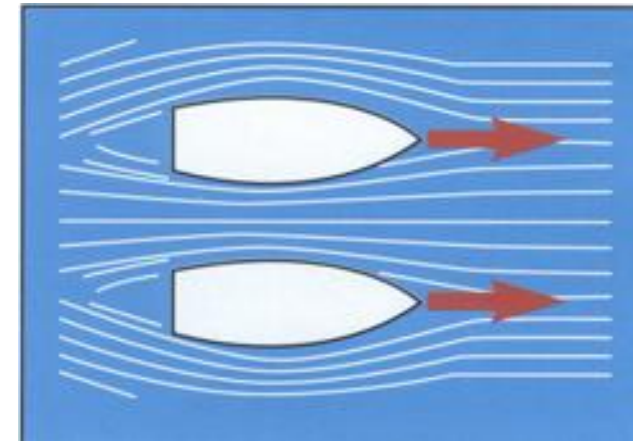
Now take a look at the video from WB-Sails, showing a Star bearing away.

<https://www.youtube.com/watch?v=8iRj6aLeCBQ>

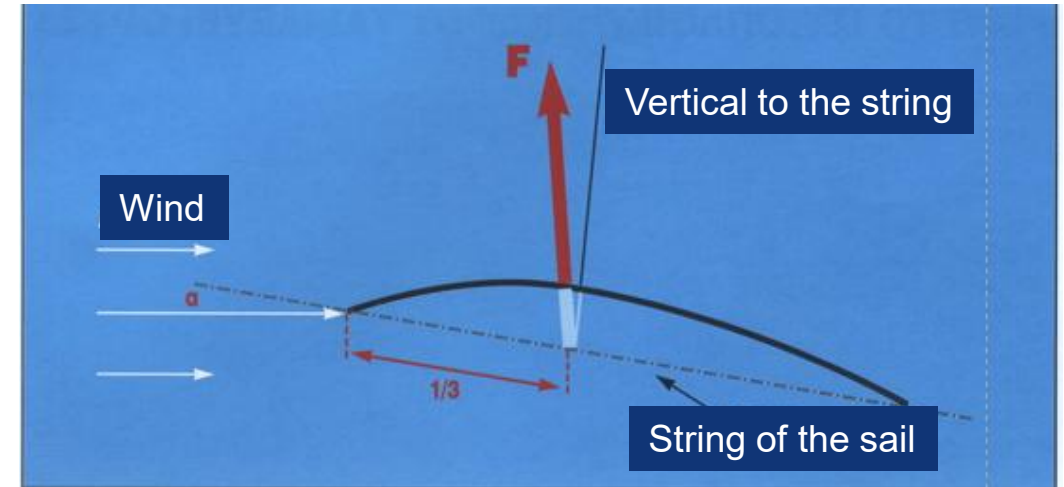
The Roof on the left has a better shape and suction is created, 60 % suction pressure. The roof on the right receives pushing pressure 40%. So the roof on the left is more possible to be lifted by the wind



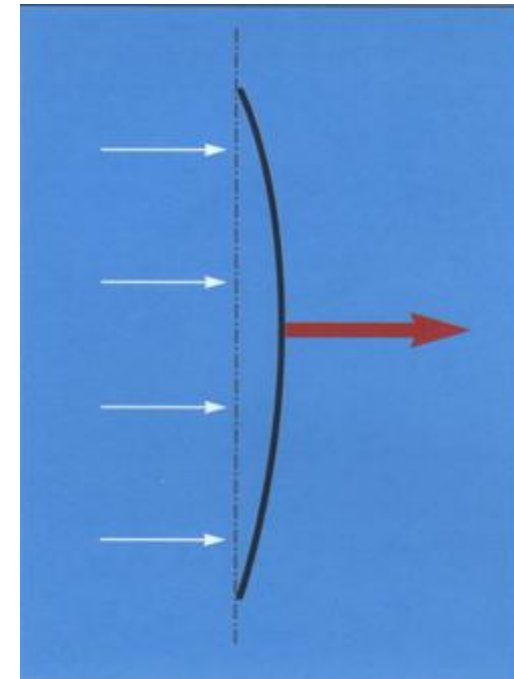
When two boats are sailing in parallel very near, the suction created will push the boats towards each other



In small angle of attack $\alpha=12^\circ$ - 25° the point of action for the driving force is approximately $1/3$ from the forward part of the string and the force is inclined forward



When the angle of attack is getting bigger the point of action is moving towards the center of the string.
So when going downwind the angle of attack is 90° the aerodynamic force is vertical to the string and the point of action is in the center



Let's have a look at Elena's Jam pot



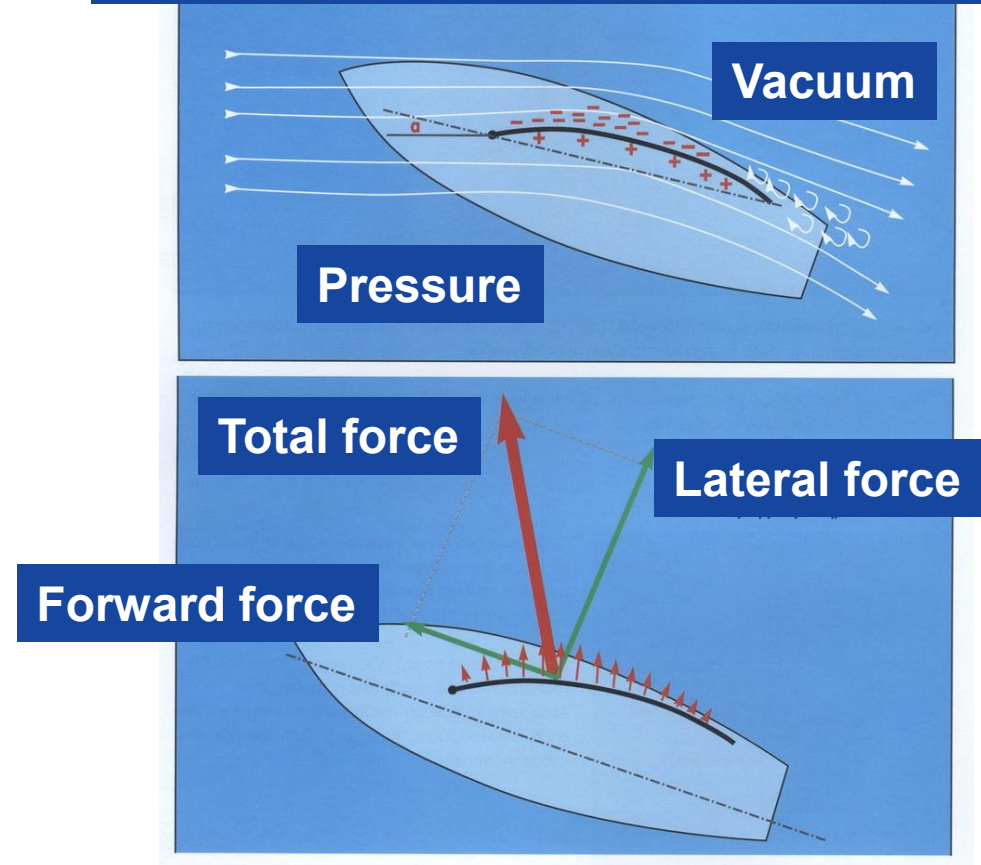
Why Pavlos is hiking?



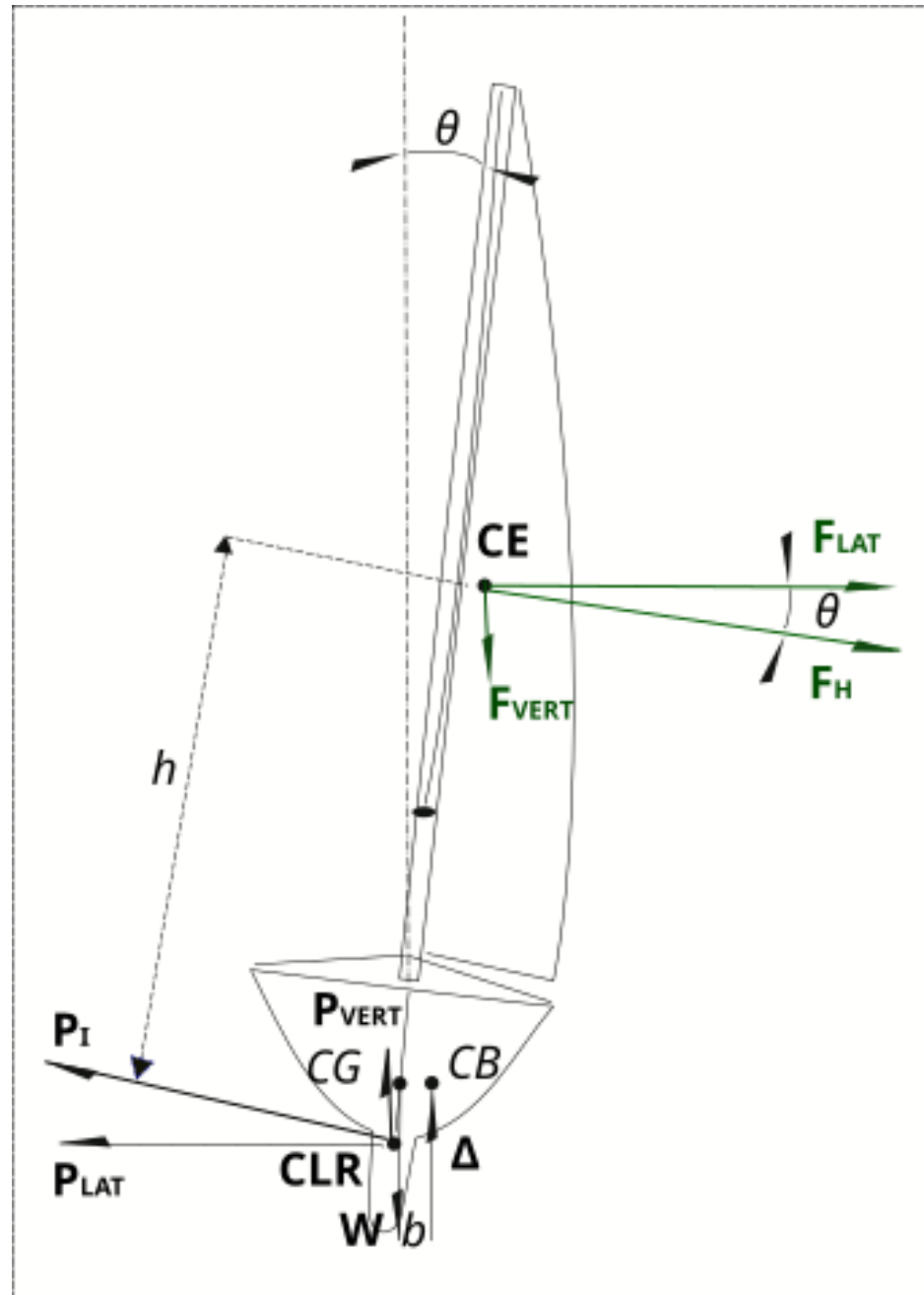
That's right !! To counterbalance the lateral force

How does a sailing boat travel upwind?

Why a sailing boat travels upwind ?



- Propulsion force
- Lateral Force
- Drag
- Lateral Resistance
- The boat resistance



So.....

When the lateral force is counterbalanced, the only force remaining is the force that forwards the boat.

That's exactly what happened with the jam pot.

The Physics of Sailing

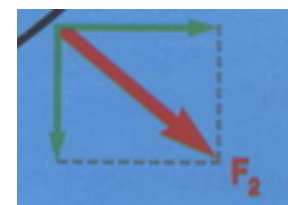
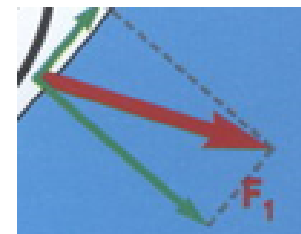
Lets take a look now at the video from the Massachusetts Institute of Technology, who introduces the physics of Sailing.

https://web.mit.edu/blossoms/videos/lessons/introduction_physics_sailing/

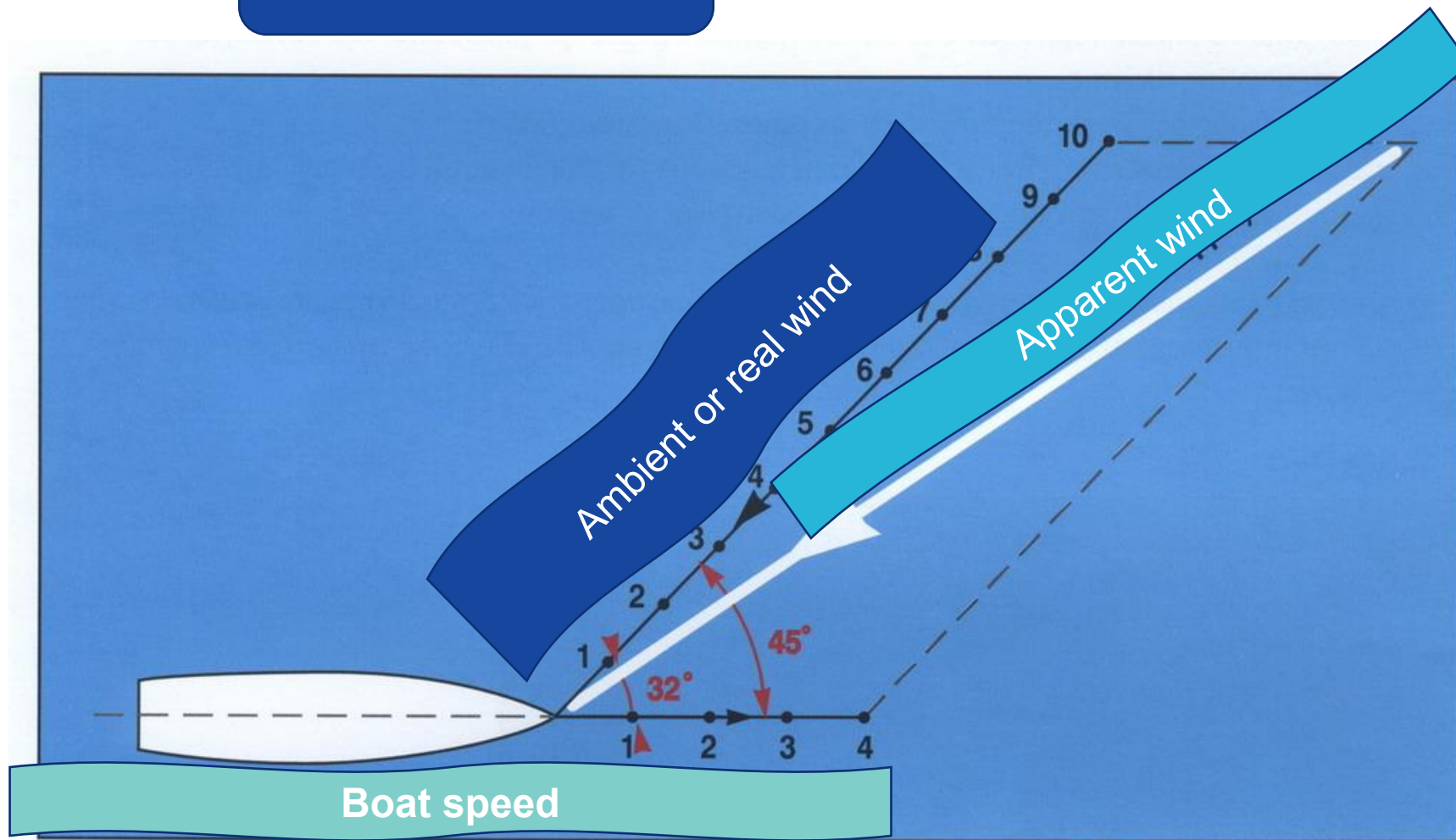
Let's see what happens in different courses

COURSE	Boat speed in kts	Apparent wind in kts
Upwind	6	17
Reach	7	15
Downwind	5	7

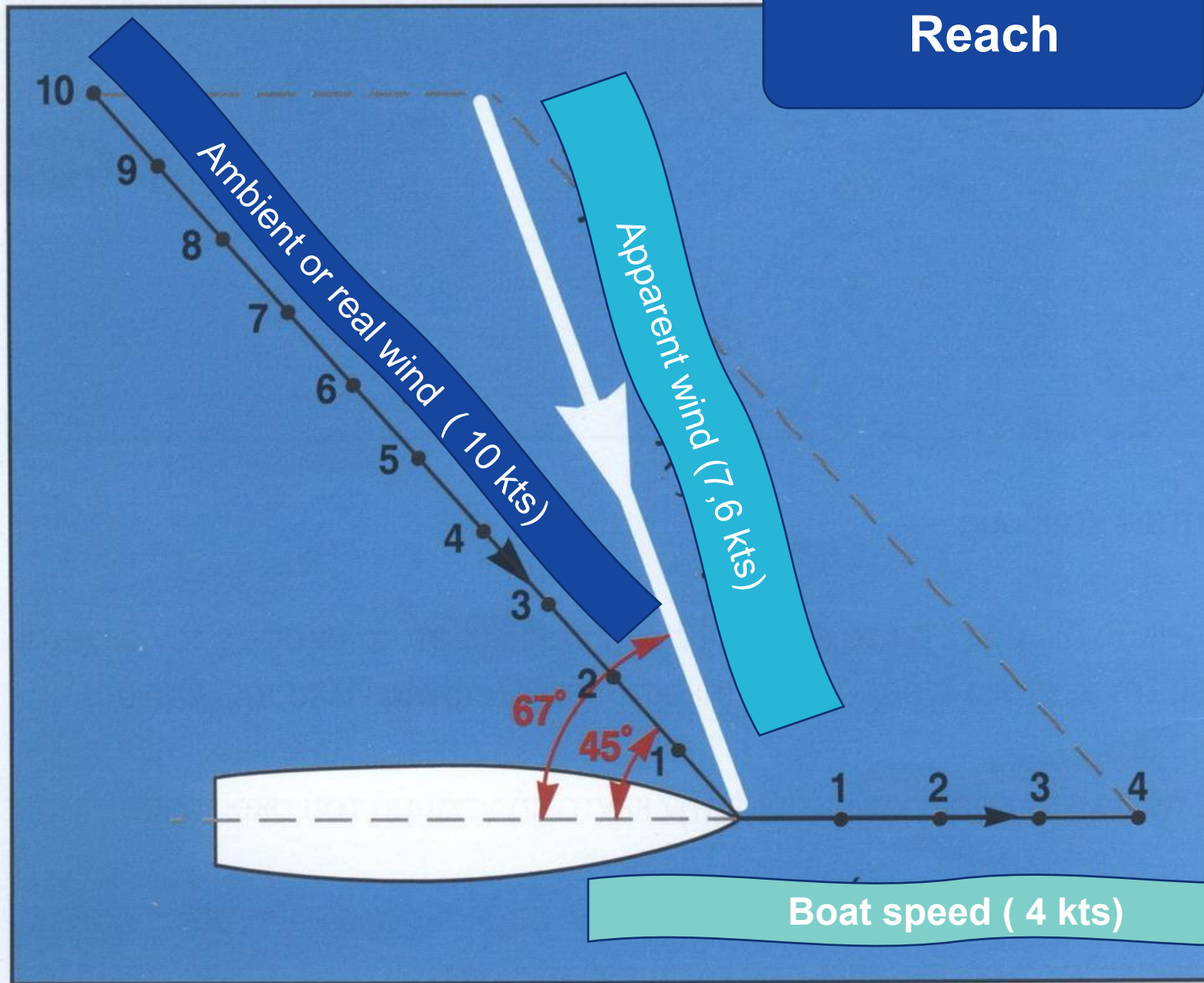
Real or ambient wind 12 kts



Upwind

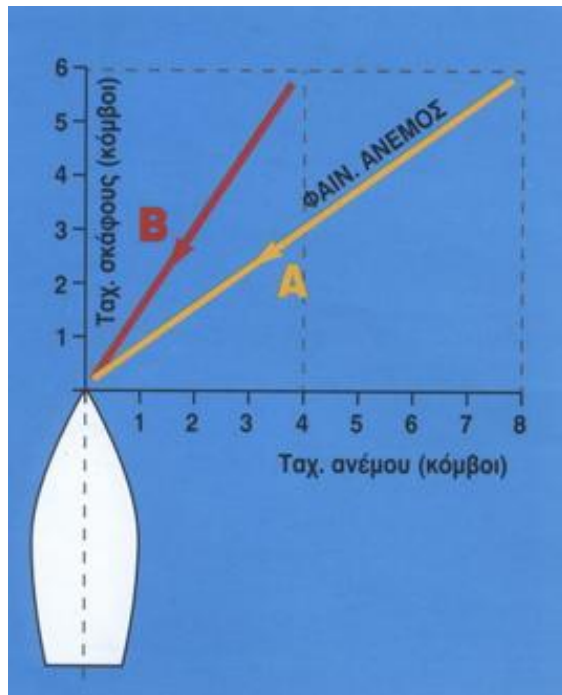
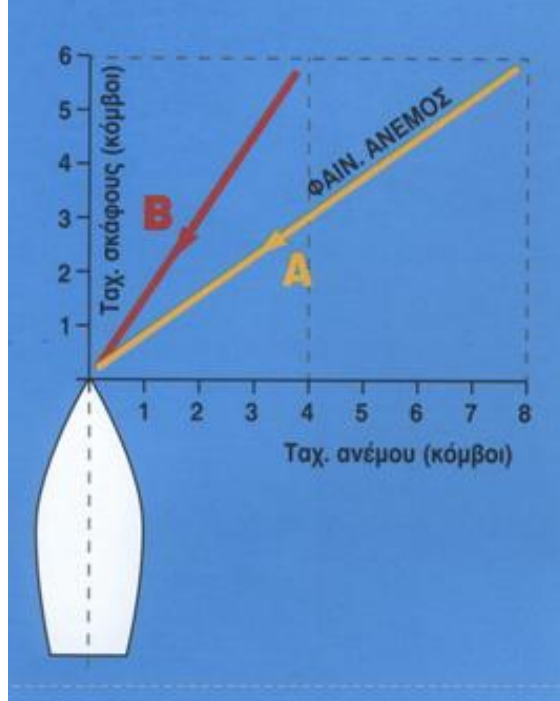


Reach



Let's see what happens in sudden wind strength change

When the wind suddenly drops from 8 to 4 kts you will feel like a header and therefore you need to bear away



When the wind suddenly increases from 4 to 8 kts you will feel like a lift and therefore you need to go closer the wind