Creating lift and avoiding drag

This section explains the basic principles of how sails work, including airfoils, lift and drag, sail depth and twist, and overall trimming goals.

Creating Lift with Airfoils

Before you start looking at sail shape, you must first understand a little of how sails work.

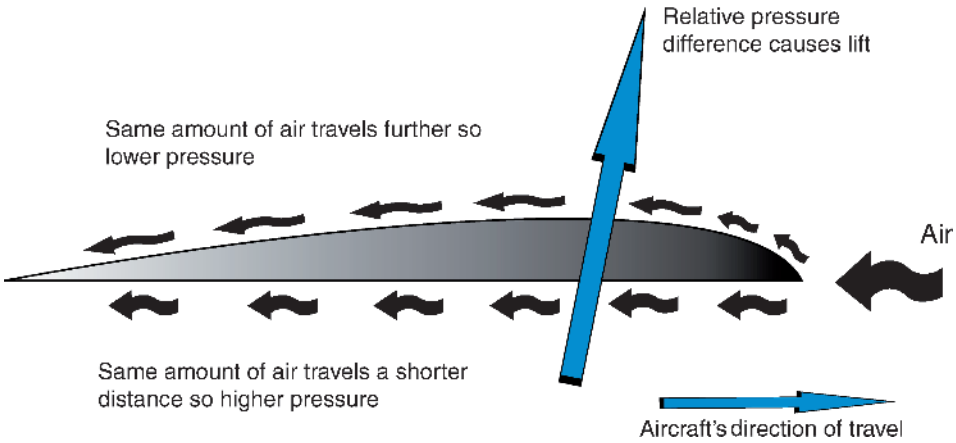
- When a boat is sailing, its sails are its engines. Sails use wind energy to create driving force. This force is harnessed to move a boat through (and sometimes over) the water.
- Sails can be used as airfoils or air dams. When the mainsail is used for upwind sailing it's used as an airfoil. Downwind sailing means the sail is used as an air dam. The crossover point is, approximately, when you're sailing on a broad reach (see Appendix C).
- Airfoils are special shapes that create lift and drag. Lift is the useful force that we use to make the boat go forward. Drag represents the forces that slow the boat down. Good sail trimming is about maximizing lift and minimizing drag.

Having promised not to blind you with science, I will however, be giving you a little bit of theory you can't do without if you're going to understand lift and drag. It's pretty straightforward though!

- Higher pressure air tries to move towards lower pressure air. Anything between high and low pressure experiences a force towards the lower pressure too. For example, when you burst a balloon, the higher pressure air inside the balloon escapes. As it does so, the outside of the balloon is blown away – towards lower pressure air.
- The same principle applies to airfoils such as airplane wings or sails.
- Airfoils are used to create a pressure difference. This pressure difference generates lift. Lift is a force that we harness in sailing to make a boat move forwards. In aviation, this force is harnessed to elevate aircraft.

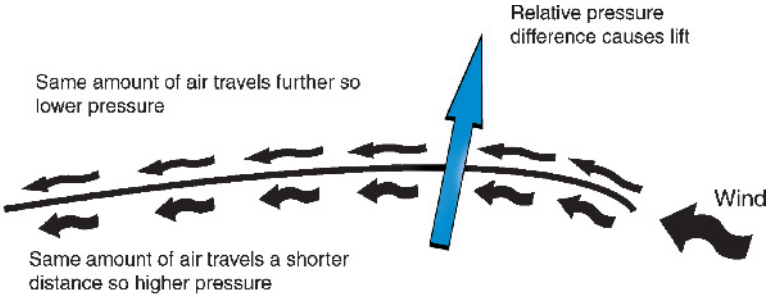
Airfoil: Airplane Wing

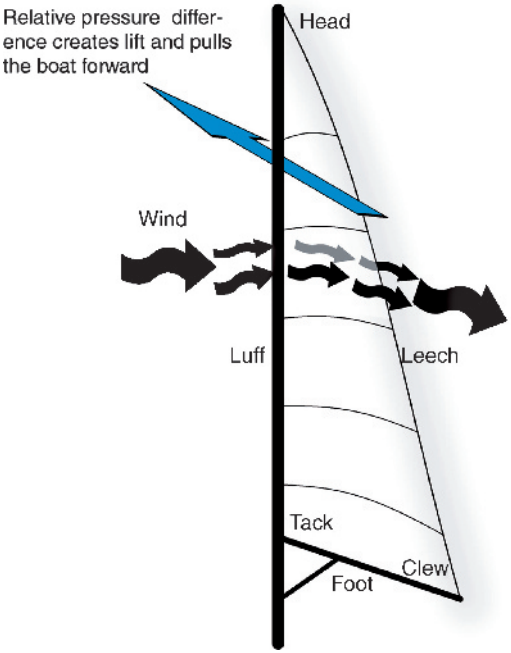
The engines on an airplane move the plane forward. This causes air to flow over the wings. There is a relative difference between the speeds at which the same amount of air travels over the wing compared to under. This is because the air traveling over the wing has further to travel. This relative difference in speed causes a pressure difference that lifts the wing, and with it the airplane.



Airfoil: Sail

As the wind flows around a sail, the relative difference in the speeds that the air moves causes a pressure difference that lifts the sail forward, and hence the boat too. Note that an airplane's wing is horizontal and a yacht's sail is vertical which is why lift on a yacht forces the boat forward, and lift on an airplane forces the airplane up.





Avoiding Drag with Airfoils

Now that you understand lift, let's look at drag.

- Drag sounds bad – and it is bad. Too much drag will cause the boat to become less controllable and as a result, it will go slower.
- Drag is created as a side effect of lift and it primarily causes a boat to be knocked over. This is called heeling. While a bit of heel is often good, too much slows the boat down. The more a boat heels, the more the helmsman will have to compensate with the rudder. The more the helmsman uses the rudder, the slower the boat goes because it ends up acting like a brake.
- On a windy day out on the water, many boats will have much too much heel, i.e. over 20 degrees. Many will have over 60 degrees of heel and some will almost be flattened. This is bad sailing and is entirely avoidable. As a mainsail trimmer, you are primarily responsible for balancing lift and drag.
- When a boat is sailing well, it is because we have created the right balance in the sails between lift and drag. The following sections explain the fundamentals of mainsail shape. It is essential for you to understand what mainsail shapes there are and how you control them. With practice, you will be able to see immediately whether the sail is the right shape for the conditions.

Overall Mainsail Trimming: Goals and Means

Now that you've covered the basics of lift and drag, it's time to understand the fundamentals of mainsail trim.

Goals:

- To develop as much power as possible to go as fast as possible.
- To control drag so the boat is manageable and going fast.

- To enable the helmsman to steer in the right direction.

Therefore, the correct sail shape is the best compromise between lift and drag.

Means:

The power in the sails is controlled in two ways: rig set-up (i.e. shroud tension and backstay tension) and mainsail trim (sheet, halyard, outhaul, vang and cunningham).

1. Rig Set-up

- Rig tension is controlled by the skipper, though the job of making changes to the rig may have been delegated – perhaps even to you! The purpose of changing the rig tension is to control the overall power that the sails can develop.
- You're in big trouble if your rig's out by very much. Racing in light winds with a rig set-up for big winds will see you wallowing at the back of the fleet. Your sails won't be powerful enough. A rig set-up for light winds but sailed in heavy winds will make your day very hard indeed. Your sails will be too powerful and so it will be difficult to maintain control.
- When you're racing, the rules tend to limit the changes you're allowed to make to the rig. Changes to the rig can only be made before the preparatory period of a race.
- Importantly though, the backstay can be changed throughout a race.

What does this mean to you as the mainsail trimmer?

- However well you trim your mainsail, you cannot develop more lift from the sails than is available from the rig. Since your job is to help make the boat

sail well, you need to be aware that poor performance may be coming from somewhere else on the boat. If the boat is going slower than expected, and perhaps the blame is being leveled at you or the jib trimmer, you need to ask the following question: is the rig too tight for these conditions?

- For a rig set tight, however much you ease the backstay and outhaul, you will never be able to get more lift from the sails beyond the limit set by tight rig.
- Conversely, for a rig set too loose, however hard you tension the backstay and outhaul, you will never be able to reduce the drag from the sails below the limit set by the loose rig.

Although the difference between a loose and tight rig is hard to see, the effect is significant in terms of the overall power the sail generates. A quick and easy way to check the rig's tension is its effect on the forestay.

Firstly, make sure the backstay is off completely. Then, grab the forestay and push against it.

- A tight forestay will hardly yield and indicates a tight rig.
- A loose forestay will move appreciably and indicates a loose rig.

Apart from the effects of rig tuning, the subject of rig tuning itself is not discussed in this book.

As a member of a team of sailors, you should ask the skipper before you start sailing what the rig tension is being set to. After all, it affects you as well as the rest of the boat. Setting the correct rig tension heavily influences the course of your day on the water.

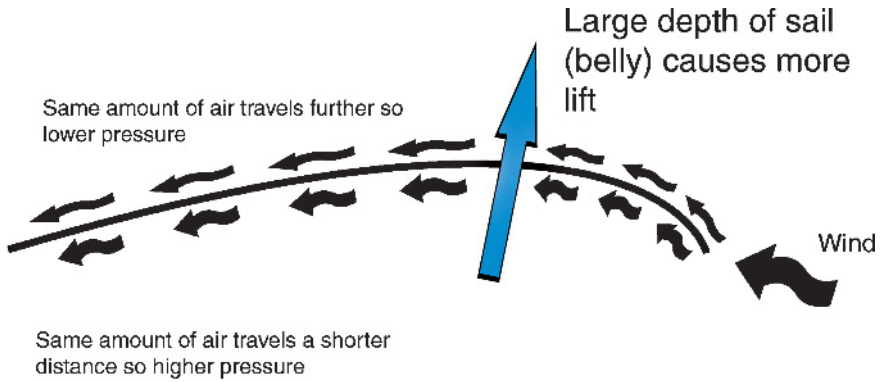
2. Mainsail Trim

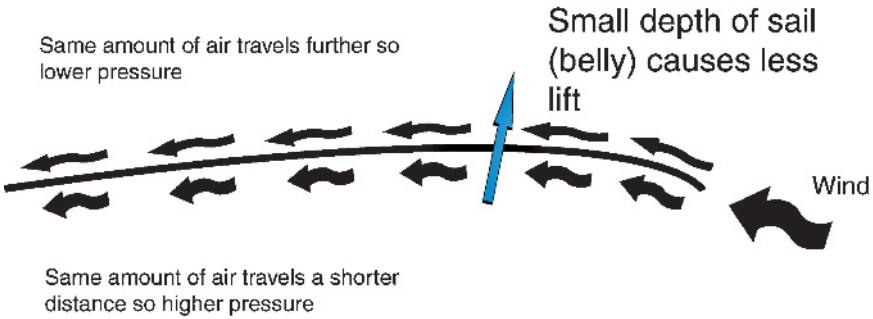
The other means of controlling power in the mainsail is the subject of the rest of the book.

Sail Shape: Belly (Depth)

Sail depth, or belly size, controls the power in the sail and hence how much lift and drag is created.

- The sail is at its most powerful, and creating most lift, when its belly is at its biggest setting. However, sailing with a big belly in high winds creates too much drag, which causes the boat to heel over, become uncontrollable and slow down.





- A big belly is suitable for light winds and a small belly is suitable for strong winds. You reduce the size of the belly as the winds get stronger but you only start reducing the belly as the forces of drag affect your performance and start to slow you down. As the wind drops in strength, you increase the belly again.

A deeper sail (bigger belly) produces more lift and drag. A sail with a smaller belly creates less lift and drag. Although the lift is welcome, in higher winds the drag over powers the boat and makes it uncontrollable and slow. Therefore, we vary the depth of the sail according to the wind strength.

Sail Shape: Leech (Twist)

The shape of the mainsail's leech is referred to as twist. If the leech at the top of the sail is angled further out from the boat than at the foot, we say it is open and therefore has twist. The amount of twist simply refers to how open, or closed, the top of the leech is.

- Understanding how much twist is in the sail is easy. Look at the angle the boom is pointing from the centreline of the boat. Now, at the same time, run your eyes up the leech to the top batten. The angle between the top batten and the boom is the amount of twist in the sail.

Twist is affected by the mainsheet, traveler and vang tensions. The tighter the mainsheet, the less twist, and hence the more closed the top of the leech becomes. Similarly, the tighter the vang, the more closed the top of the leech and hence the less twist.

- Different wind and sea conditions call for different amounts of twist. Light and very light winds require lots of twist. Medium and strong winds call for little or no twist. Heavy winds require you to reef the mainsail.

- Sailing in waves requires more twist and more power than sailing on flat water. Having more twist than you would on flat water helps keep the boat sailing as it is rocked around by the waves.

To prepare you for the rest of the book, Chapter 2 illustrates the mainsail, its place on the boat, the names of its controls and what they do.

Sail Shape: Twist