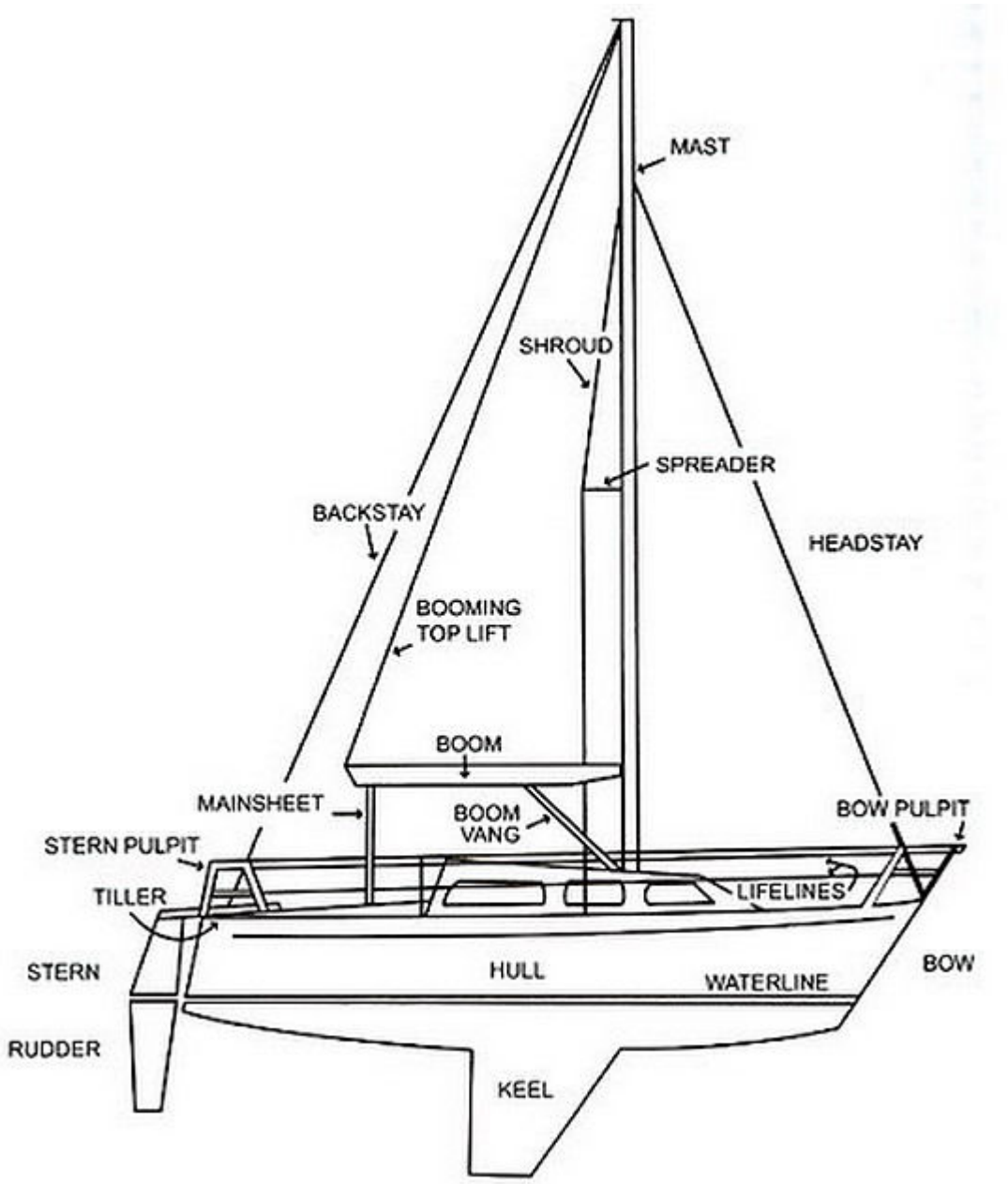
A Sailing Primer

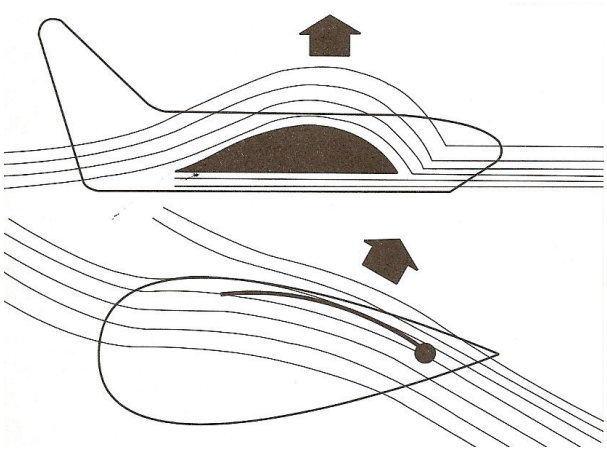
1. Parts of a sailboat

The following diagram shows the basic parts of a cruising sailboat.

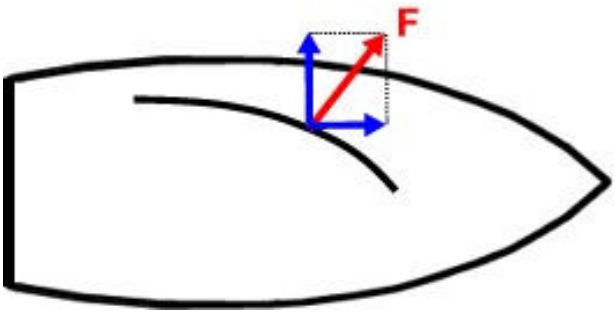


2. How a sailboat moves

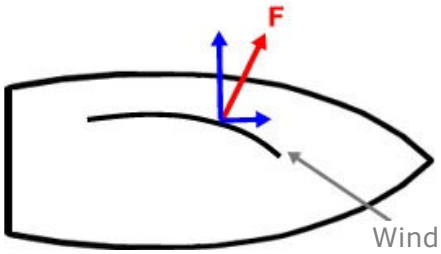
Sails are airfoils, similar to airplane wings. On an airplane, the speed of the air passing over the top of the wing is faster than the air on the bottom of the wing. This causes "lift". In the same way, air flow over a sail causes "lift" as shown in the diagram below. When sailing toward the wind (not directly into it), the boat is being pulled along by the force on the sails. When the wind is coming from behind, it is simply pushing on the sails and there is no lift.



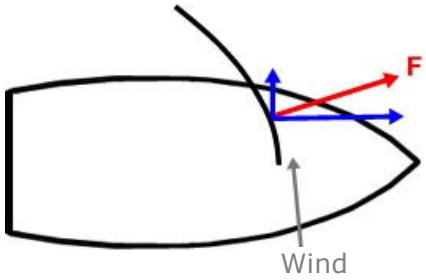
The force **F** on the sail consists of a forward component and a sideways component. The forward component pulls the boat forward while the sideways components cause the boat to heel (tilt). The keel and rudder counteract this sideways component.



3. How the sails work



Close hauled

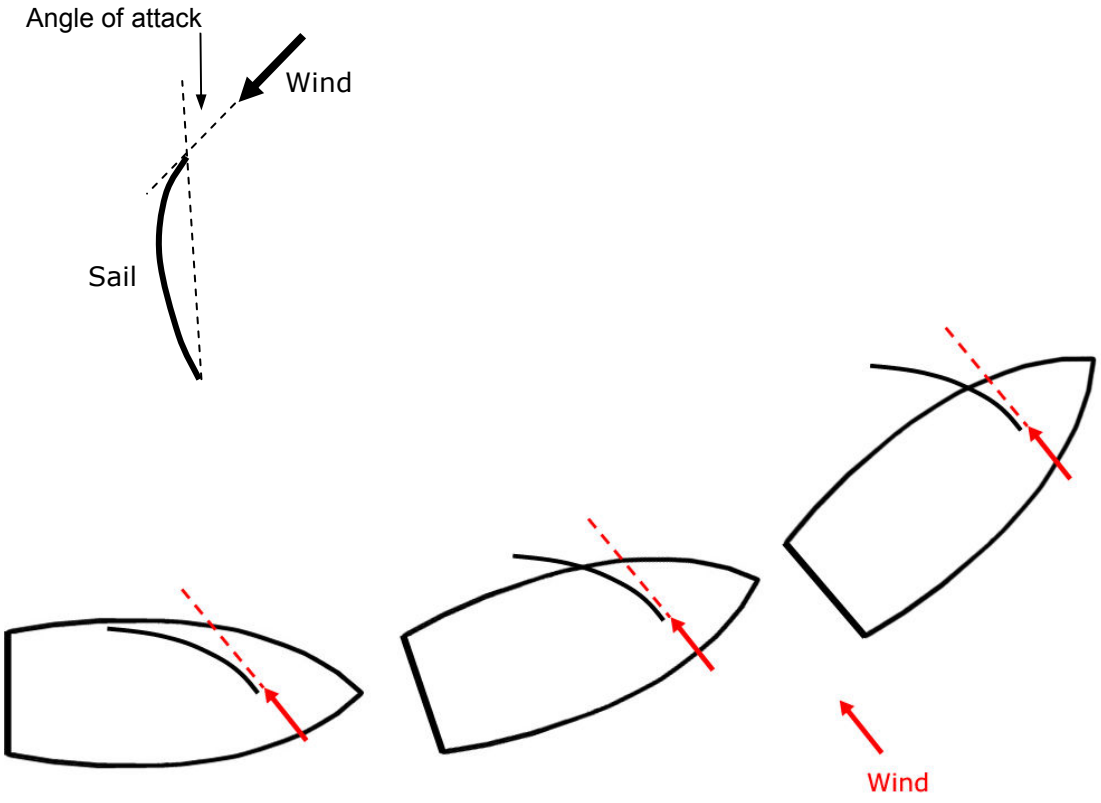


Beam reach

When a sailboat is sailing roughly 30 degrees off the wind, it is *close hauled* (see Points of Sail). The sideways component of force F is the greatest on this point of sail, which means the boat will heel most when close hauled.

When the sail is let out and wind is at roughly 90 degrees (beam reach), the forward component of the force on the sail is much greater than the sideways component. You are sailing on a "beam reach" and experience little heeling. This is the fastest point of sail (see Apparent Wind).

As shown in the diagrams, a sail can be pulled in close or eased out almost to where it is at right angles to the boat. Notice that the angle of the wind with respect to the position of the sail stays constant. This angle that the wind makes with the sail is called the angle of attack, and is one of the most important factors in maximizing the efficiency of a sail. In the following diagram, as the boat turns the sail has to be let out to maintain the correct angle of attack.



4. Apparent Wind

If you are in a stopped car with the wind blowing at 5mph from directly in front of you, and you put your hand out the window, you will feel the force of a 5mph wind. If you now start driving at 10mph, the force you feel will be the force of a 15mph wind. This is apparent wind, and it is this phenomenon that allows a sailboat to sail faster than the wind.

Imagine you are standing on your boat and you feel the wind as shown in fig a. With the boat stopped, what you feel is the true wind. Like the forces on the sail, we can break the wind into its components as shown in fig b. When the boat starts moving forward, we add the wind caused by this forward motion (green) as shown in fig c, and the resultant wind we feel is apparent wind (red). Notice that this wind is greater than the true wind and is coming from a slightly different direction.

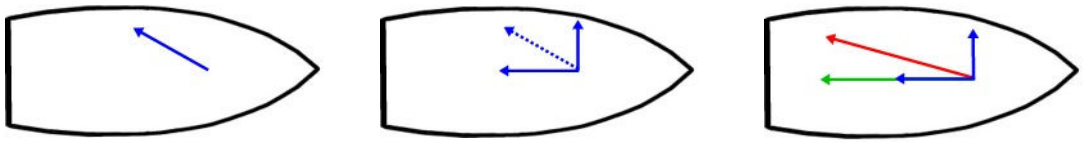


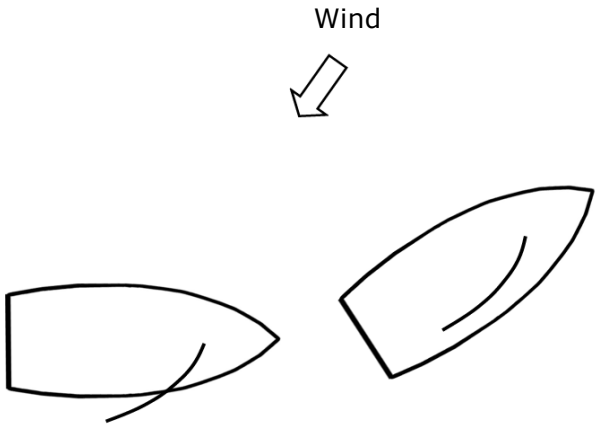
Fig a Fig b Fig c

Now because the wind the sails "feel" is stronger, the boat goes faster. As the boat goes faster, the apparent wind keeps getting stronger. The boat will continue to gain speed until it reaches its limit due to the drag of the hull through the water or the angle of attack decreases to the point where the sail simply does not operate as an air foil anymore.

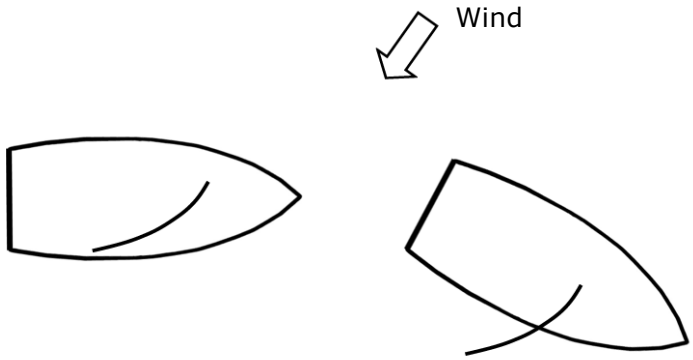
5. Changing course

A sailboat can change course in four ways: Heading Up, Bearing Away (or Falling Off), Tacking, and Jibing.

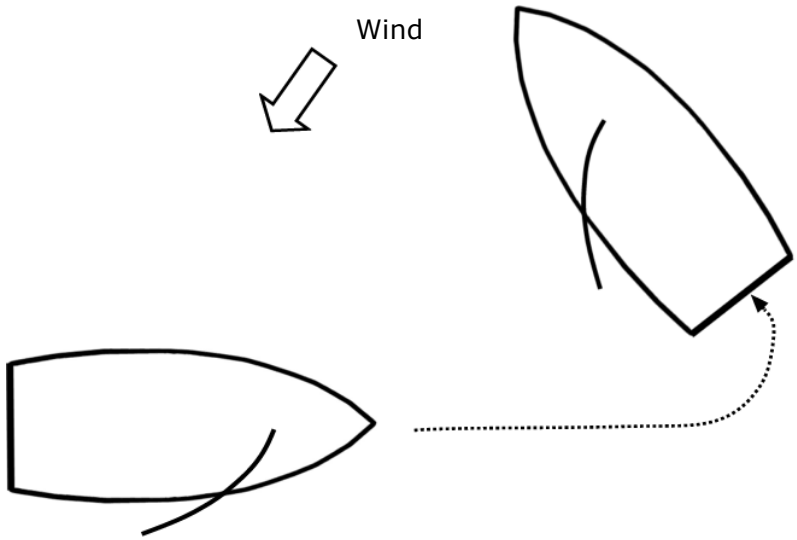
Heading Up refers to changing course to sail closer to the wind, but not passing the boat through the wind. In this case the sail will have to be "trimmed" (pulled in).



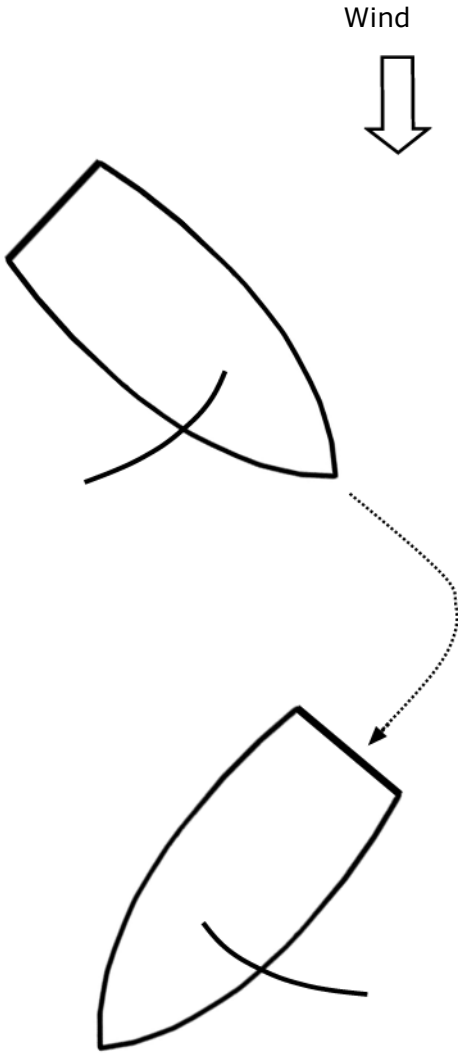
Bearing Away refers to changing course to sail further off the wind, but not passing through the wind. In this case the sail is "eased" (let out).



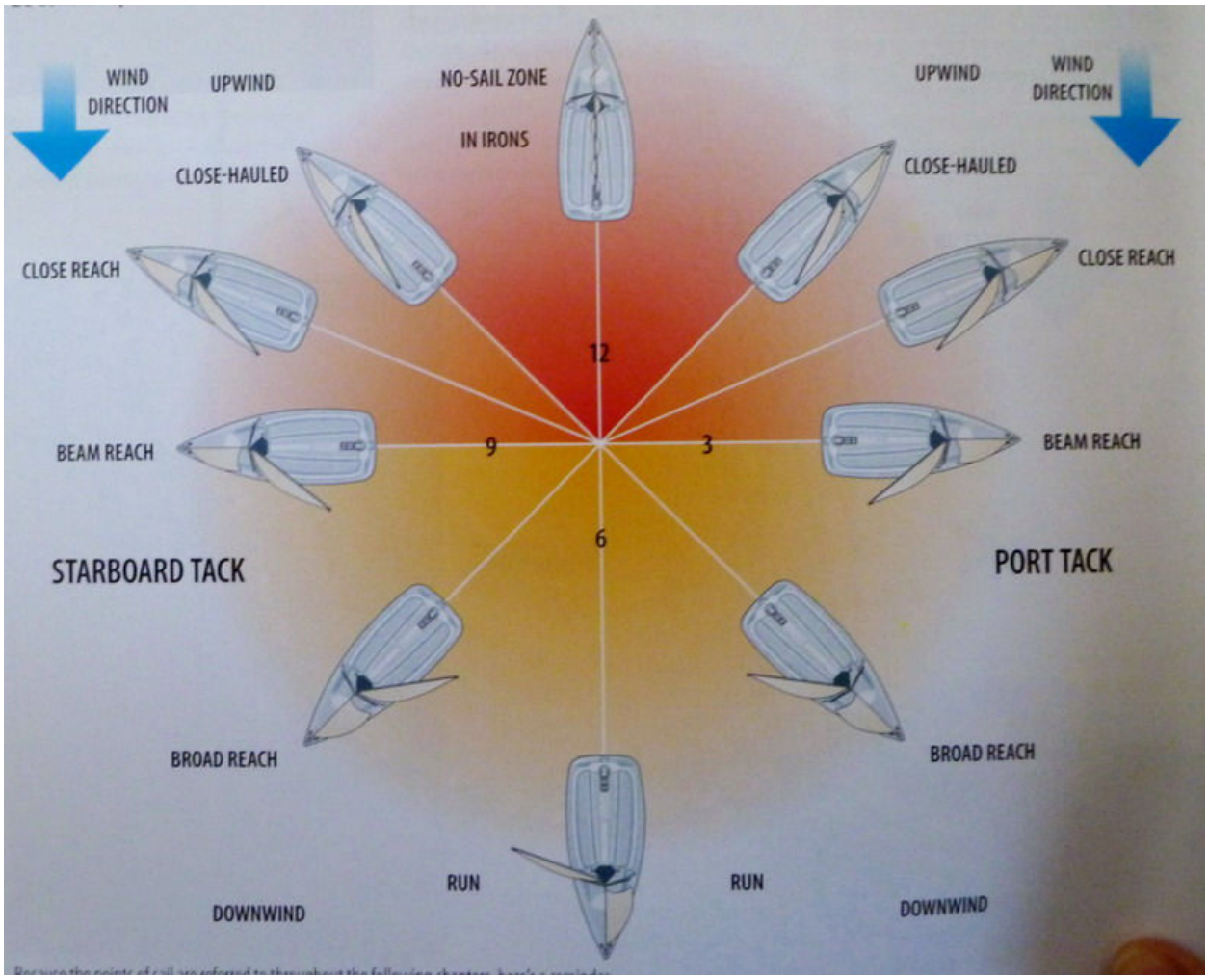
Tacking refers to changing course by passing the bow of the boat through the wind. Notice in the diagram that we change from a port tack (wind coming from the port side) to a starboard tack (wind coming from the starboard side).



Jibing refers to changing course by passing the stern of the boat through the wind.

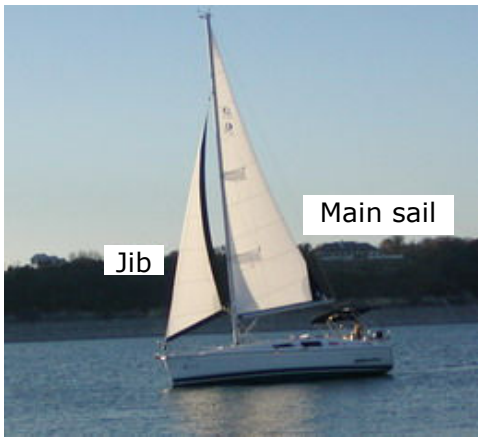


6. Points of sail



7. Controlling the sails

The most common sailboat is a sloop, which has a single mast and two sails: the mainsail and the jib which are controlled, primarily, by ropes called *sheets*. There is one sheet for the main sail, called the main sheet, and two sheets for the jib called jib sheets. Sails are raised and lowered by lines called halyards.



The things available to the sailor to control the sails are:

Main Sail
- Main sheet
- Main halyard
- Traveler
- Boom vang
- Outhaul
- Leech line
- Cunningham
- Back stay adjuster
- Topping lift

Jib/Genoa
- Jib sheets
- Jib halyard
- Leech line
- Sheet cars

These controls allow you to adjust three primary aspects of a sail:

1. Angle of Attack

2. Draft
   a. Depth
   b. Position

3. Twist

It is by managing these three aspects that you control the power of the sails, efficiency, and heel of the boat.