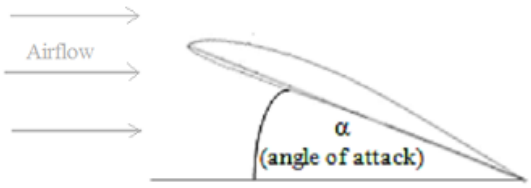
BUILD-A-BOAT!

How do you think a sail boat is similar to a bird? A wing is quite like the sail of a boat. So let's look at a wing more closely. This shape is called an airfoil, and it can be used to more simply analyze the forces on a wing (from a bird or a plane). Air will flow around the airfoil (both above and below). The air will follow the shape of the airfoil; since the airfoil is curved, the air is pushed downward by the airfoil.

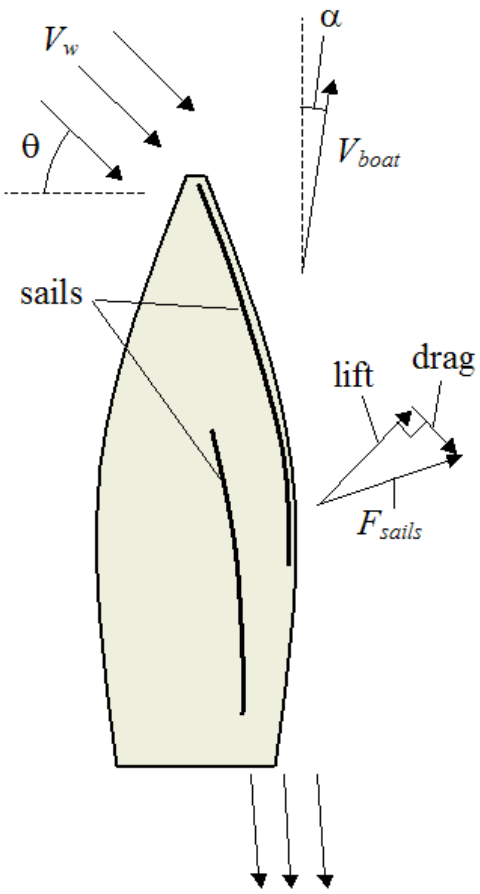
There is a law (called Newton's 2nd law) that says if the air is pushed down by the airfoil, then the airfoil is pushed up by the air. You may have heard this being said…"for every action, there is an equal and opposite reaction". In other words, every force exerted has an equal and opposite force exerted back. We can demonstrate this by using a skate board and a basketball. Can anyone guess how we would demonstrate this law? If you stand on the skate board with the basketball, then throw the basketball in the direction of the skate board wheels, then you and the skate board will move in the opposite direction. Equal and opposite. What do you think you can change so that you move faster? The faster you throw the ball, the faster you'll move.



Do you think any force is generated if air rushes past a flat plate (that is parallel to the air flow)? What can we change so that air is pushed down by the paper and force is generated? We can put it at an angle – this angle is called **Angle of Attack**. The angle of attack is the angle that the plate makes with the direction of airflow. The force generated is perpendicular to the plate. This force has two parts, one perpendicular to the airflow direction, called the lift, and one parallel to the wind, called the drag (this force will slow down the bird).

SAILING A sail can act in different ways. It can catch the wind straight on which causes the boat to be dragged along, like holding a bag in front of a fan. Or it can catch the wind at an angle of attack. This makes the sail work like a wing. The wind causes a force on the sail that is perpendicular to the

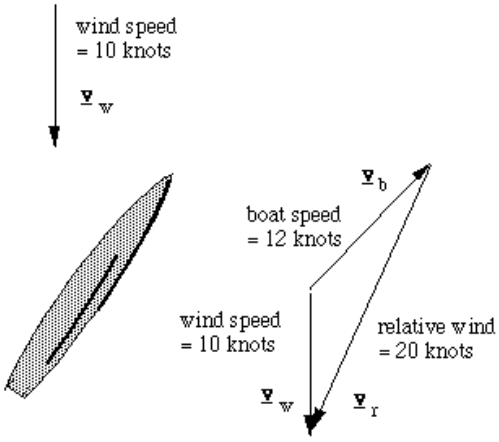
sail. Just like on a wing, this force has two parts: lift, perpendicular to the wind direction Vw, and drag, acting parallel to the wind direction Vw. The lift will pull the boat. So the lift can be used to move a boat in a direction different to the way the wind is blowing (on the picture the velocity of the sailboat (Vboat) is in a direction skewed slightly to the right of the center line of the boat.)



Do you think a boat can sail faster than the wind?

YES! If the boat moves in a different direction than the wind is coming from, the sail will "feel" an apparent wind that is the combination of the wind due to the movement of the boat and the true wind. This wind is called "relative wind" or "apparent wind. As you can see in the drawing, this wind can be larger than the actual wind and therefore it can "push" the boat faster than this actual wind.

MATERIALS Styrofoam container, skewer, construction paper, tape, scissors per participant. 1-2 fans for testing.



EXPERIMENT Have participants spend 15 min designing and building their sail car model, 10 min testing it and 5 min reflecting on what worked.

REFLECTION

1. How should you angle the sail so that the sail car goes the furthest?
2. What are you proud of learning?