Forces of Flight

Has anyone ever told you to "go fly a kite"? What does that mean? Get out of here! Leave the heavy thinking to others while you pursue some easy-breezy fun. But making a wind-worthy kite and keeping it aloft are not mindless activities. They require practice and a basic understanding of the forces of flight.

Gravity

Gravity is the most obvious force. Ever since you first experimented with dropping a dish of baby food from your high chair, or your sister's doll into the bathtub, you have suspected that everything on earth that is heavier than air falls down. How, then, do you counteract gravity when you make and fly a kite? Use materials as light as wind conditions will allow.

Contemporary Kite Materials *Photo by Greg Kono*

For centuries kite makers have favored bamboo for spars and paper, cotton, or silk (in China) for the sail—all materials that are light, flexible, and generally available. Now they can add Tyvek®, mylar, ripstop nylon, and many other materials for sails. Spars can be made of plastic reinforced with glass (fiberglass) or carbon fiber, sometimes with both. Contemporary materials can be expensive, though. For example, airplane makers use lots of carbon fiber. Manufacturers who want to use that material in laptop computers, racing bicycles, tennis rackets, musical instruments, or kites must pay a high price for a supply that is limited by demand.

Lift

Once you have chosen light, strong materials from which to make your kite, lift is the force that will overcome gravity and send your kite aloft. The face of your kite angles into the wind, held in place by the bridle and line. This angle, the angle of attack, creates a difference in speed between the air moving above the kite and the air moving below. The different speeds create differences in air pressure, lighter above the kite where air moves faster, heavier below where the air moves more slowly. Greater pressure below the face of the kite lifts it into the air.

Angle of Attack *Photo by Kiyomi Okawa*

To create lift, aim to fly your kite at an angle between 20 degrees and 35 degrees into the wind. Establishing and maintaining that angle may require adjusting the kite's bridle for wind conditions. In a light wind a lower bridle (farther from the top of the kite) will create a larger angle and expose more of the kite's face to the wind. The kite will catch more of the wind available. Moving the bridle higher (closer to the top of the kite) in a strong wind will reduce the angle of attack and allow the kite to spill more wind to either side.

Lift *Photo by Cathy Palmer*

Students learning to make and fly kites at school may most often be plagued by lack of lift—calm air or very light wind in a small playground, with the flow of the wind disrupted by buildings nearby. Helen Bushell, a kite designer and flier from Australia, advises that, in such conditions, you use a "rhythmic pumping action" to tug on the line and move your kite around the sky. She says, "On a light day there are always little pockets or eddies of wind that a good kite can find. By coaxing your kite around the sky you can 'feel' the pattern of the wind."


Protection

Photo by Cathy Palmer

But lift in strong or gusty wind can also be a mighty force, one that attacks unexpectedly. In the words of kite designer David Pelham, "To a far greater degree than the sea, the air is terribly unforgiving of any carelessness, incapacity and neglect." Protect your hands with gloves when you fly in strong winds or with a hard-pulling kite. Unwary kiters practicing extreme kite sports—kite buggying and skiing, kite surfing, and now kite tubing—have been injured and even killed by the wind's lifting them to dangerous heights. In summer 2006 the US Corps of Engineers banned kite tubing on lakes in certain states because the tubes' design lacked control and stability. The lifting force of the wind deserves respect. Watch where it can take your kite—or even you! Take Pelham's words to heart: "Possibly the most attractive thing about flying kites is that it presents an opportunity of mastering the third element [air] without actually entering it."

Drag

Drag sounds like a force to avoid when you are trying to get and keep a kite in the air. But lift invariably creates drag. Whether an object is moving forward through the air, like an airplane or a car, or is stationary as the wind moves past it, like a kite, it will meet with some resistance. As the wind rubs against the materials of your kite—the sail, the spars, and particularly the tail—the rubbing creates friction, or drag. Turbulence in the air behind the kite also creates drag.

This friction actually contributes to the stability of the kite's flight. Drag along the tail helps to keep your kite pointed into the wind by pulling the bottom of the kite in the direction the wind is blowing. Drag also prevents it from flapping or turning too far to either side. If the kite turns to one side in a gust of wind, the snake-like movement of the tail will counteract the kite's turning. Keep the tail long but light, to avoid too much weight.


Drag

Photo by Kiyomi Okawa

Thrust

As its name implies, thrust is a forward-moving force. But a kite does not move forward relative to the wind, like a bird flapping its wings or an airplane using its engines. It stays in place in the sky. So how does thrust affect a kite?

Thrust

Photo by Cathy Palmer

Think of thrust in a kite this way. The kite requires a force to keep it in place against the wind. If the kite were not held in place by its line, it would move backward, in the direction the wind is blowing. The kite line, or tether, creates thrust from the force of the air moving past the kite at a certain velocity (the air movement created either by the wind or by running with the kite, pulling it past still air). Thrust can be felt in the tension of the line, holding the kite in place. In these photographs the line, taut to an anchor, holds this giant kite (the "Frilled Neck Lizard" by Phil McConnachie) steady against the thrust of the wind. Thrust opposes drag and helps the kite to maintain lift.

Photo by Greg Kono

Four Forces

Here is the shorthand source of the forces that affect your kite's flight:

- Thrust: from the wind
- Lift: from the angle of the kite's face into the wind
- Drag: from resistance or friction
- Gravity: from weight

How these forces interact to determine flight, how your particular kite will fly on a particular day, will be affected by all sorts of factors: the size of your kite, its balance and bridling, the speed of the wind, its steadiness or turbulence, the altitude at which you are flying, the flow of air through the material of your sail, the size of your kite's tail, the flexibility of your frame, the depth or shallowness of your kite's bow. Kite expert Harm van Veen reminds us that "extremely small differences in initial conditions may result in spectacularly diverging effects."

Flight—Kite by Michael Alvares *Photo by Kiyomi Okawa*

With a basic understanding of the forces of flight, and plenty of practice, you will learn to diagnose flying conditions and adjust your kite to accommodate them, just like the mechanic who listens to the "funny noise" in an engine and immediately pinpoints the problem or the musician who retunes his instrument for each song in the set.