Basic Rocket Stability

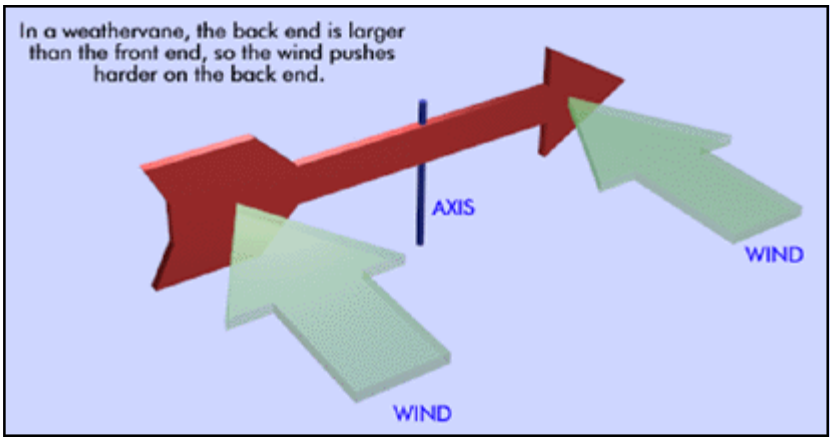
Adapted from Ed Bertchy's web site :

http://www.azstarnet.com/%7Eelb/rockets/

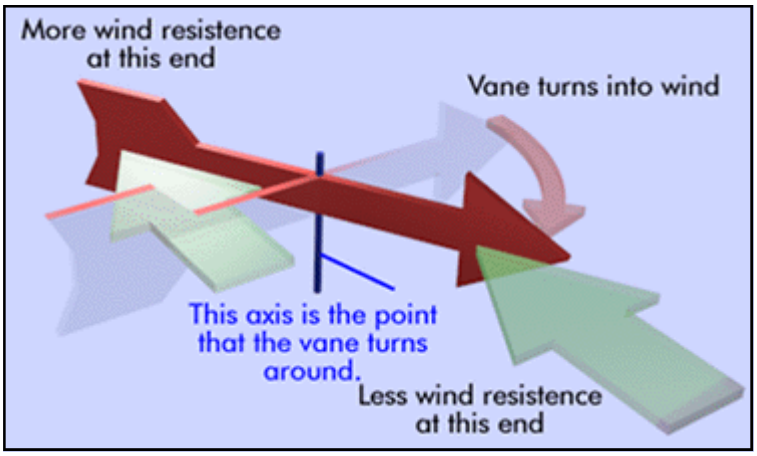
Model Rocket Stability: The Basics

If you want to start scratch building your own rockets, it helps to understand a little about the theory of how rockets fly, what makes them stable, and how to check it for yourself.

The Weathervane Model

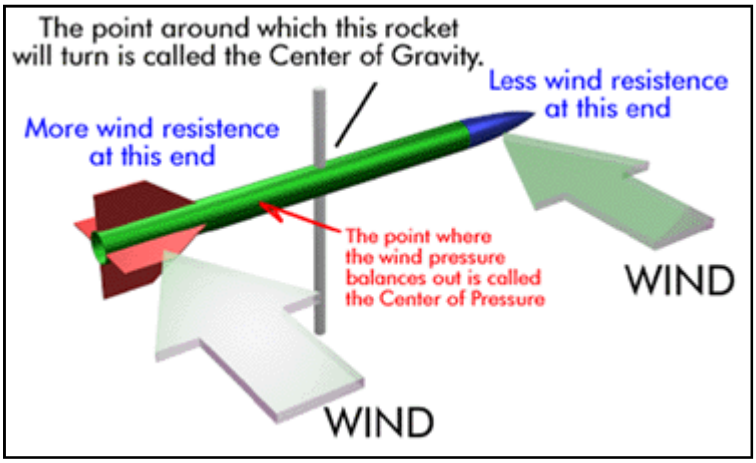


Most discussions of rocket stability start with a weather-vane.

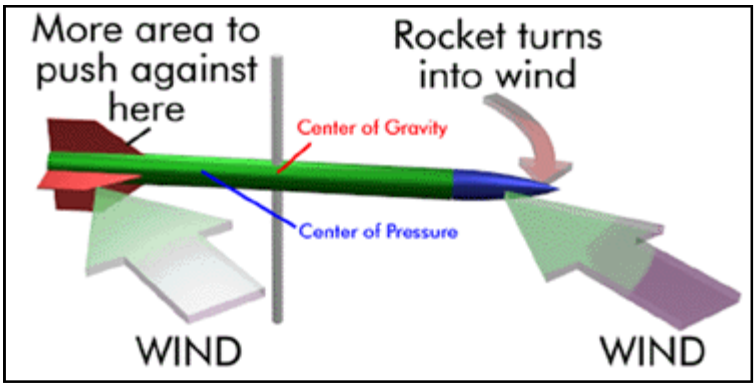


The principle of air pressure blowing against an object and causing it to turn is well demonstrated by a weathervane.

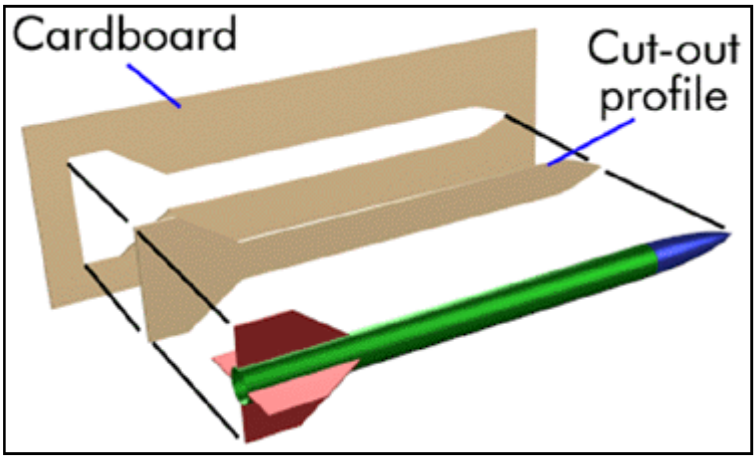
Now, lets put a rocket in place of the weathervane.



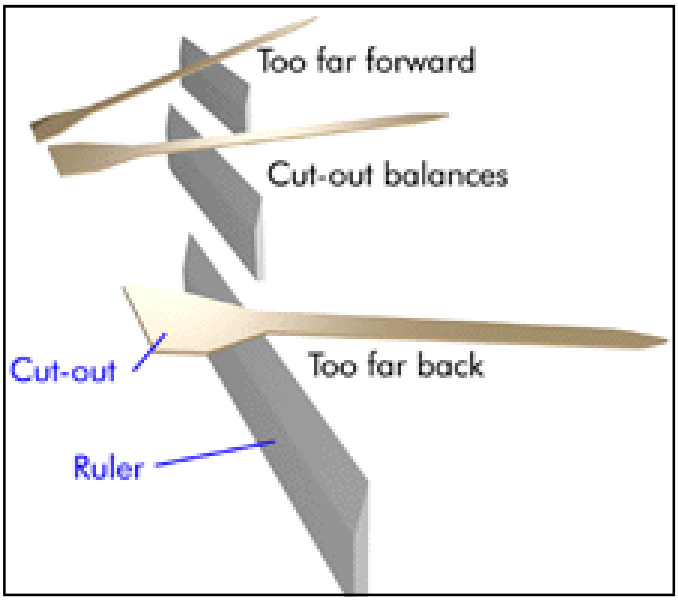
Pretty simple? Don't worry about the Center of Gravity and Pressure just yet. We're getting to that. The idea here is that it is the pressure of air flowing over the rocket which pushes it around like a weather-vane. My example is rather two dimensional. Real rockets are affected like this from all directions.



How to find the Center of Pressure of your Rocket

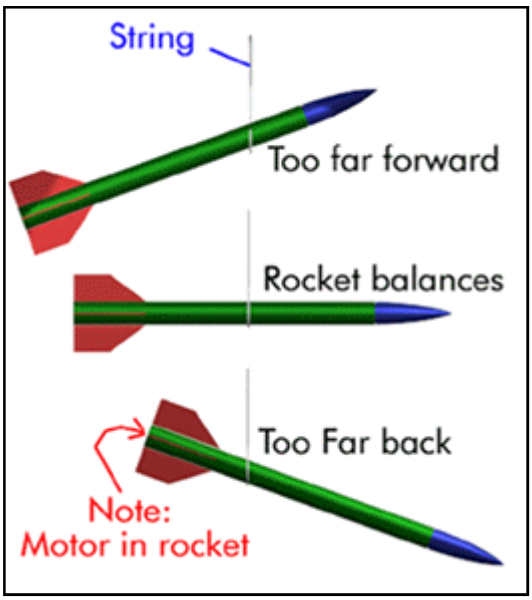


Step 1: Cut out a profile of your rocket in cardboard. It doesn't have to be the same size, but it does need to be accurate in shape and scale.

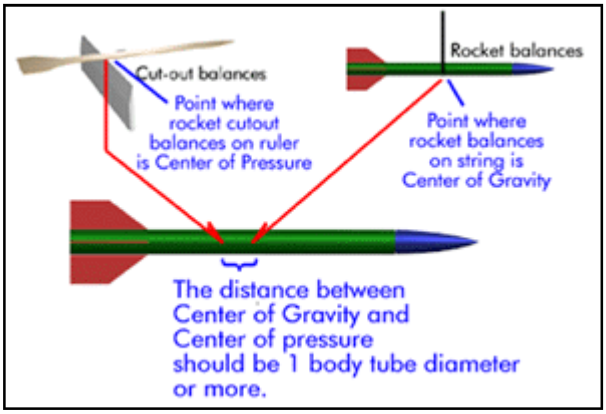


Step 2: Balance the cut-out on the edge of a ruler. Mark where it balances. This spot marks the Center of Pressure of your rocket.

How to find the Center of Gravity for your rocket.

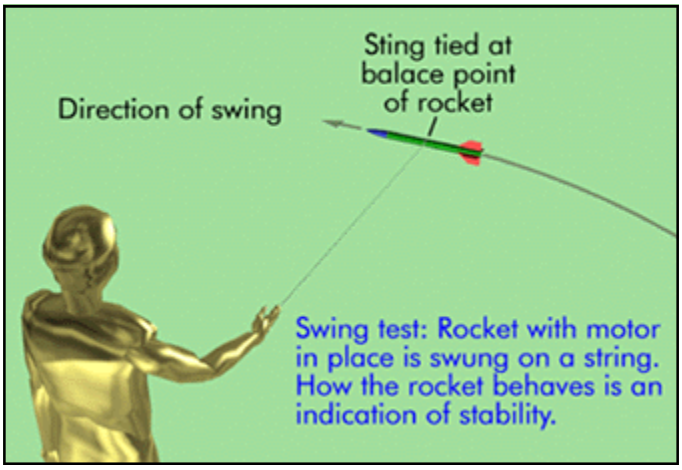


Put a motor in your rocket and tie a string around the middle. Move the string until your rocket balances. The point at which it balances is your Center of Gravity.



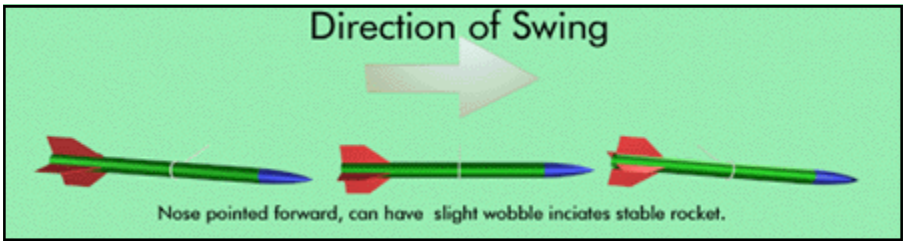
Now you have the two most important things you need to determine your rockets stability. The CG is the point around which your rocket turns, like the axis on a weathervane. The CP is where the cumulative pressure of wind appears to be pushing against. If your CG is in front of your CP, your rocket is stable. Here's how to check further for rocket stability.

The Swing Test

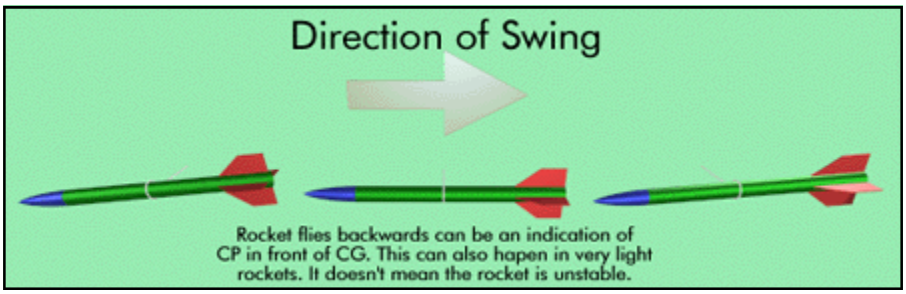


The swing test is a basic test to give you a rough idea how your rocket will fly.

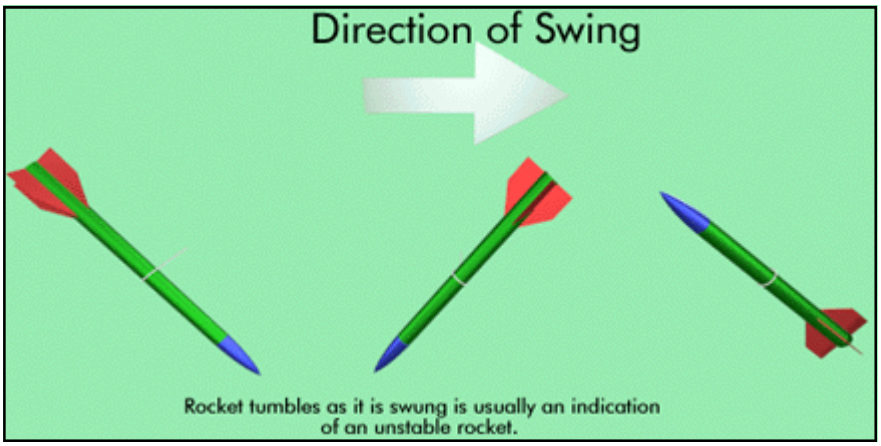
There are basically three things that can happen when you do this test:



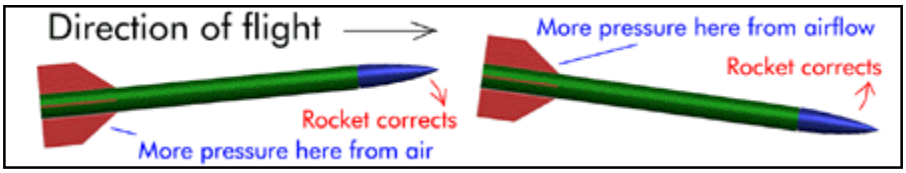
If you swing your rocket and it points in the direction you swing it, it is a good indication that your rocket will be a stable flyer.



Sometimes your rocket flies backwards. I have had this happen when a rocket is very small or light. The motor is so heavy in comparison, that the Center of Gravity is very near the Center of the motor. On a standard type tube-with-fins rocket, if it balances on a string with a motor in it, and it balances in front of the fins and motor, you don't need to worry about it.



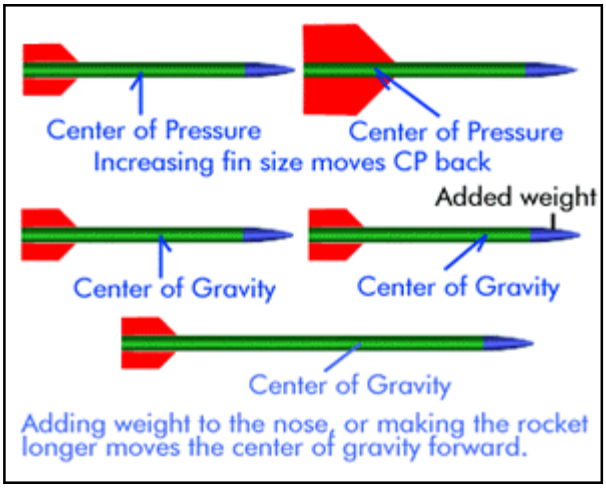
Sometimes a rocket will just cartwheel as you swing it. It is usually a sign that the CP and CG are too close together. Try adding a little weight to the nose, and see if your rocket straightens out.



The idea is to make a rocket which will use air pressure to correct its own flight. As the rocket flies upwards, it will try to turn or tumble. As it deviates from straight up, the pressure of the wind will push the tail fins back behind the center of Gravity. *The Center of Pressure always tries to follow the Center of Gravity.* So, you can see that if your Center of Gravity is closer to your fins than your Center of Pressure, your rocket will try to fly backwards! If your rocket is very light, and your motor heavy, this sometimes puts your center of gravity so far back that your rocket becomes unstable. This is one of the things you need to check for when you design your own rockets.

What you can do about it.

There is almost nothing you can do about your Center of Pressure other than to make your fins larger. The bigger your fins, the farther back the CP. You can more easily move your Center of Gravity by adding weight to the nose of your rocket, or making your rocket longer. This moves the CG towards the front. Ideally, you want your Center of Gravity to be one or two body tube diameters in front of your Center of Pressure. This is called one-calibre stability, and most rockets are close to this.



Well, those are the basic ideas when trying to check the stability of a model rocket. I suggest checking the CP and CG on rockets that you know are good flyers, and then trying to match that on your own scratch built versions. After awhile, you will be able to almost see where the CP on a rocket will be, and you will only need to do a swing test on unusual shaped rockets.