MODEL ROCKET READING

There are three important forces governing the movement of a model rocket. The first and most important is gravity, which is why we need a rocket to go up in the first place. It appears to be applied to a point called the center of gravity. Drag, which is the air resistance on a rocket, appears to be applied at a point called the center of pressure. The third force is thrust, which comes from the engine, and is what propels the rocket up.

Understanding these forces is key to creating stable, high-performance model rockets!

Thrust: Thrust is the upwards (hopefully!) force on a rocket, which is produced by the engine. It acts against both of the other forces in order to move the rocket up.

Gravity Gravity is the force which pulls on a rocket and causes its weight. The center of gravity is simply the point around which an object freely rotates. It's where all gravitational force appears to be acting, so the center of gravity in effect is where the object will balance. In a perfectly symmetrical object, the center of gravity is the midpoint of the object. A rocket, however, is not symmetrical, so the center of gravity will be closer to the heavier part of the rocket -- usually the engine.

As previously stated, the center of gravity is usually towards the back, because of the weight of the engine, unless there is a nose ballast added. The center of gravity doesn't stay still, but rather will move forwards in a rocket as fuel is expended. It's important to remember that when working with a model rocket, because while a rocket might be stable with a little engine, a larger engine will move the center of gravity back, so it could become very unstable as you progress to larger engines. This is why the first flight of a model rocket is usually conducted with a smaller engine that normal.

Finding the Center of Gravity There are several ways to find the Center of Gravity. The simplest is to try and balance it on a ruler, or similar thin, long object. It will balance at the center of gravity.

You may also calculate the center of gravity by multiplying the weight of each piece of the rocket by it's own center of gravity, as measured from the base, summing them up, and then dividing by the total weight.

Air Resistance Air resistance is caused by air rushing along the sides of a rocket. Drag is the air resistance opposite the direction of the rocket's velocity with respect to the air. The amount of drag is dependent on the projected surface area. The majority of the drag is from the fins on a rocket. The center of pressure, sometimes also referred to as the center of effort is similar to the center of gravity except it refers to drag, not balance. All drag on a rocket appears to be acting at this point, despite the fact that the air is pressing along the whole rocket. The center of pressure is usually towards the back of a rocket, behind the center of gravity. Because the fins account for the majority of the drag on a rocket, they more than balance out the forward parts of the rocket. In order for a rocket to be stable, the center of pressure must be behind the center of gravity.

Drag is also proportional to the Velocity squared, and the Coefficient of Drag. This results in the formula: **Drag = 1/2 * V^2 * (Air Density) * CD * (Projected Area)**

The CD, or Coefficient of Drag, is a dimensionless number dependent on the shape of an object. A typical model rocket has a CD of about 0.75, while a high performance, highly streamlined rocket may be as low as 0.4. Smaller fins will reduce the CD, but also cause the stability to go down.

Finding the Center of Pressure The easiest way to find the center of pressure is to make a cardboard cutout of the model rocket, out of a thin, flat, stiff piece of cardboard. Using a ruler, or similar object, balance the cutout. The point at which the cutout balance will approximate the center of pressure of the rocket if it were at a 90 degree angle of attack. There is a way to calculate the center of pressure of a model rocket, called the Barrowman method, but it requires as many as a dozen detailed measurements. If you are interested, it is described in appendix 2 (p.. 314) of the book Handbook Of Model Rocketry.