HIGH POWER PAPER ROCKETS

What design feature of the rocket has the greatest effect on flight performance?

Air rockets fly through the air and therefore have to be designed to create as little air resistance as possible. Crooked fins or a blunt nose cone increases air drag (friction), causing the rocket to slow quickly. The second most important design feature is weight. Weight is a more complicated factor than streamlining. Too much weight, and the rocket will not fly very high. The same effect takes place if the rocket weighs too little. Crumple a piece of paper into a ball and see how far you can throw it. Crumple a second ball of paper around a nickel throw it again. It will go farther. Very lightweight air rockets have a hard time fighting drag as they fly. Very heavy air rockets have a lot of inertia to overcome.

From: https://www.nasa.gov/pdf/295786main_Rockets_Adv_High_Power_Paper.pdf

---

Rocket aerodynamics

Image: Ātea-1 rocket

Rocket aerodynamics is the study of how air flows over a rocket and how this affects drag and stability.

The nose cone and fins of a rocket are designed to minimise drag (air resistance) and to provide stability and control (keep it pointing in the right direction without wobbling).

Nose cone and rocket diameter affect drag

The amount of air resistance that opposes a rocket’s motion depends mainly on the shape of the nose cone, the diameter of the rocket and the speed of the rocket.

The first point that meets the air is the nose cone at the front end of the rocket.

If the speed of a rocket is less than the speed of sound (1200 km/h in air at sea level), the best shape of a nose cone is a rounded curve. At supersonic speeds (faster than the speed of sound), the best shape is a narrower and sharper point.

Rockets with a larger diameter have more drag because there is more air being pushed out of the way. Drag depends on the cross-sectional area of the object pushing through the air. Making a rocket as narrow as possible is the best way to reduce drag.

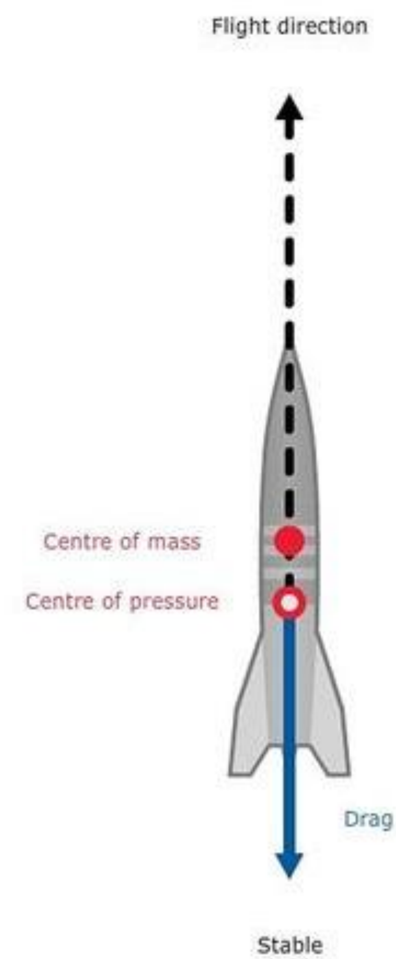
The speed of a rocket through the air similarly increases drag. As speed doubles, drag increases four times as much.

Fins control direction and stability

The stability of a rocket is its ability to keep flying through the air pointing in the right direction without wobbling or tumbling.

Fins are used on smaller rockets to provide this stability and control direction. It works in the same way as placing feathers at the tail of an arrow. The greater drag on the feathers keeps the tail of the arrow at the back so that the point of the arrow travels straight into the wind.

To understand how to place fins and how large to make them, it is important to understand about centre of [mass] and centre of [pressure].



Centre of mass

The centre of mass of an object is the point at which all of the mass of an object can be thought to be concentrated.

To find the centre of mass of a rigid object such as a water bottle rocket, balance the rocket on your finger so that the rocket is horizontal. The centre of mass is a point directly above your finger.

The centre of mass can be moved closer to the nose cone end of a rocket by adding some mass near the nose cone. This will increase stability.

Centre of pressure

The single point at which all of the aerodynamic forces are concentrated is called the centre of pressure.

To find the approximate position of the centre of pressure, draw an outline of the rocket on a piece of paper. The centre of the area of the outline shape is approximately the centre of pressure.

For a rocket to be stable, the centre of pressure needs to be closer to the tail end than the centre of mass. If the centre of pressure is at the same position as the centre of mass, the rocket will tumble. Stability increases as the distance between the centre of mass and the centre of pressure increases.

Placing fins at the tail end of a rocket moves the centre of pressure closer towards the tail end and increases stability. However, this also increases drag, so there is an optimal size for fins so that the rocket has enough stability without having too much drag.

From: http://sciencelearn.org.nz/Contexts/Rockets/Science-Ideas-and-Concepts/Rocket-aerodynamics