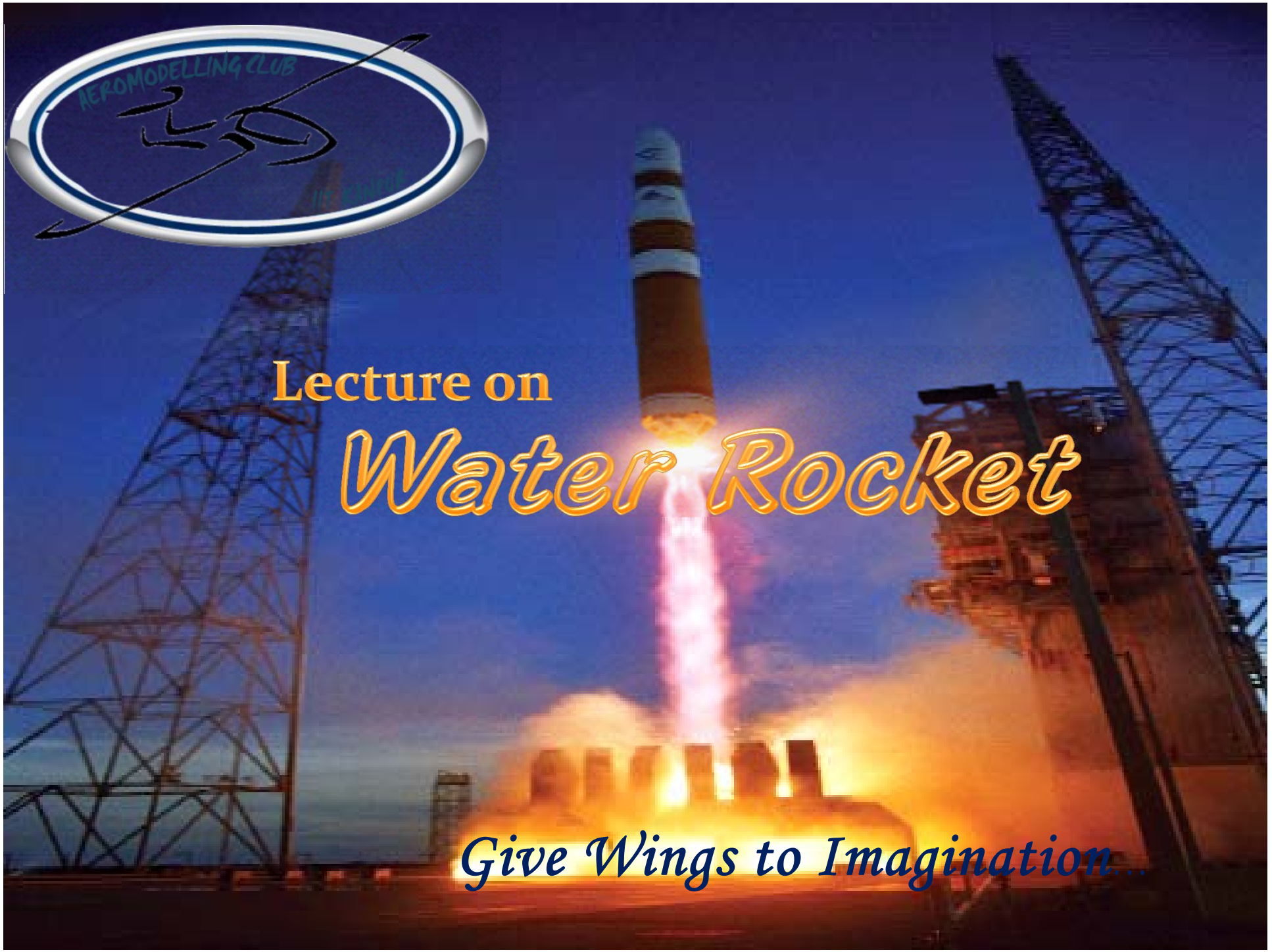
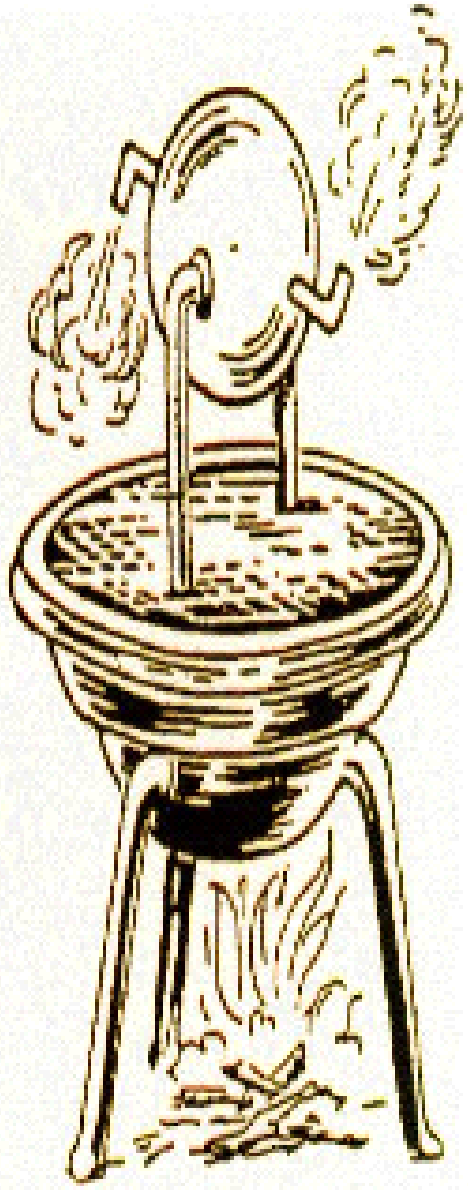

AEROMODELLING CLUB
IIT KANPUR
Lecture on
Water Rocket
Give Wings to Imagination...

WHAT IS A ROCKET?

- A rocket is a missile, spacecraft, aircraft or any other vehicle which obtains thrust from rocket engine.
- Rocket engines work by action and reaction.
- Rocket engines push rocket forward simply by throwing their propellant exhaust backwards.



02

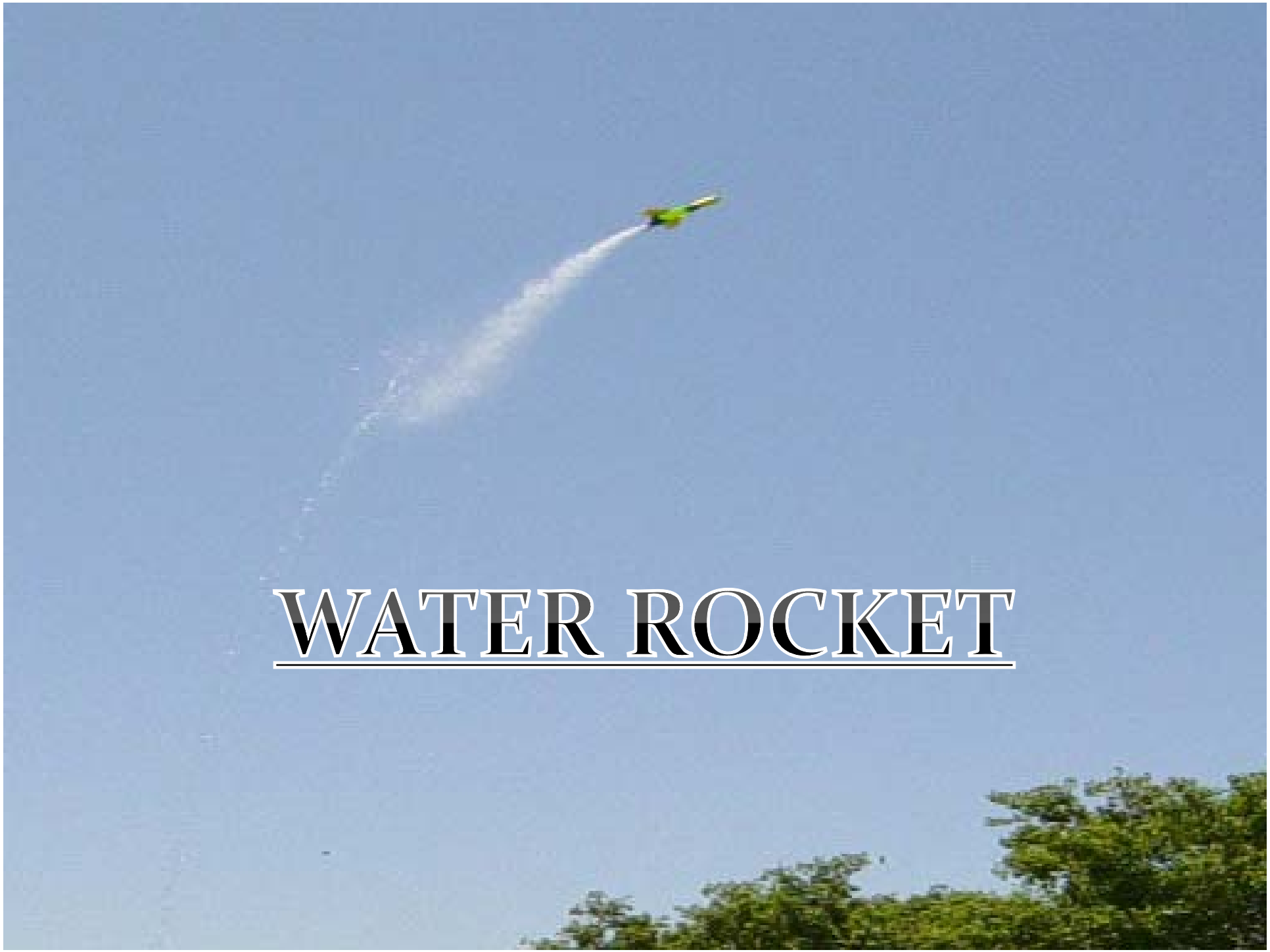
Legendary characters used the power of mythology to fly through the heavens. About 100 BC a Greek inventor known as Hero of Alexandria came up with a new invention that depended more on the mechanical interaction of heat and water. He invented a rocket-like device called an aeolipile. It used steam for propulsion. Hero mounted a sphere on top of a water kettle. A fire below the kettle turned the water into steam, and the gas traveled through the pipes to the sphere. Two L-shaped tubes on opposite sides of the sphere allowed the gas to escape, and in doing so gave a thrust to the sphere that caused it to rotate.

03

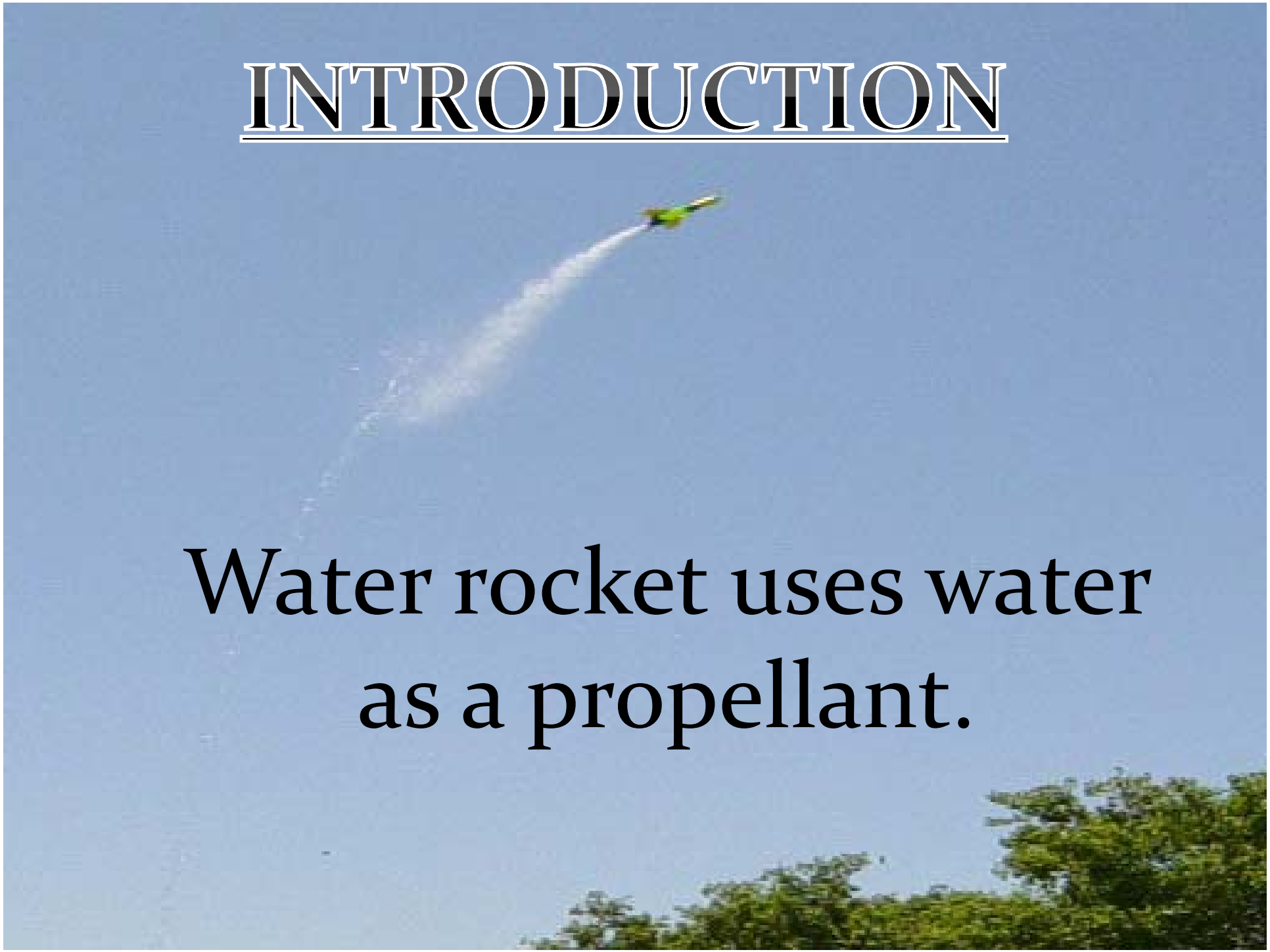
04

In 1232 AD the Chinese used rockets against the Mongols who were besieging the city of Kai-fung-fu. An arrow with a tube of gunpowder produced an arrow of flying fire. [Reproduced from a painting by Charles Hubbell and presented here courtesy of the Western Reserve Historical Society, Cleveland, Ohio]

According to one ancient legend, a Chinese official named Wan-Hoe attempted a flight to the moon using a large wicker chair to which were fastened 47 large rockets. Forty seven assistants, each armed with torches, rushed forward to light the fuses. In a moment there was a tremendous roar accompanied by billowing clouds of smoke. When the smoke cleared, the flying chair and Wan-Hu were gone.(Illustration courtesy of United States Civil Air Patrol)


WATER ROCKET

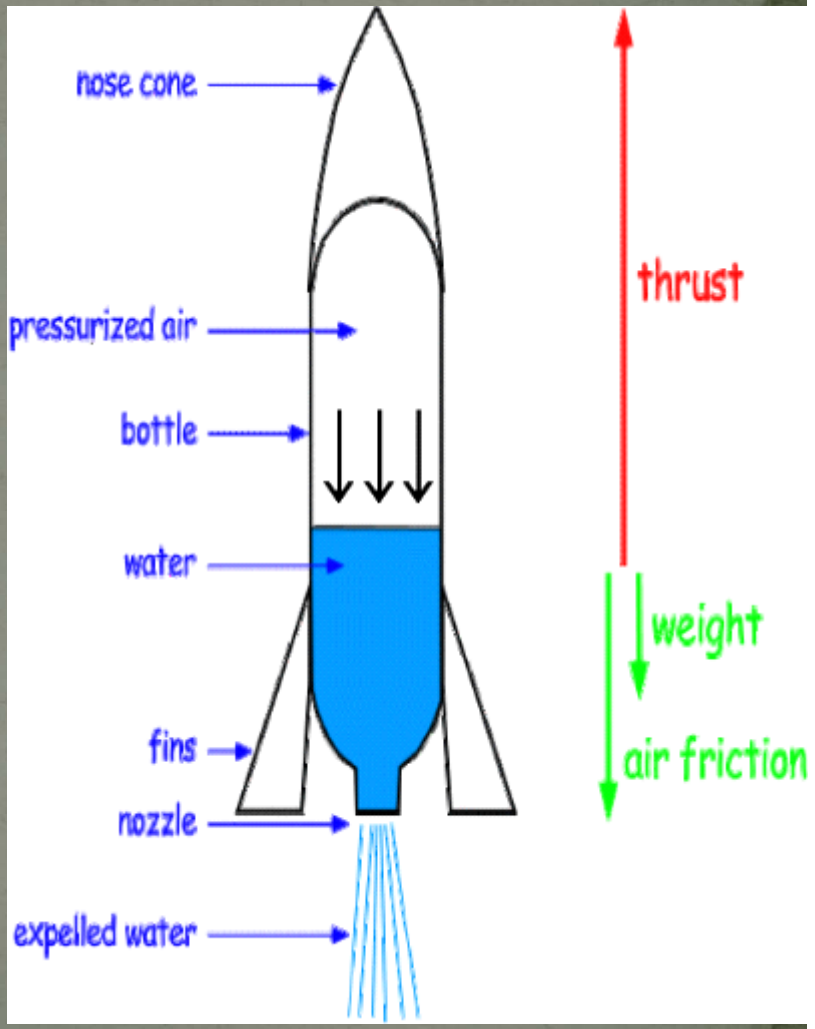
INTRODUCTION

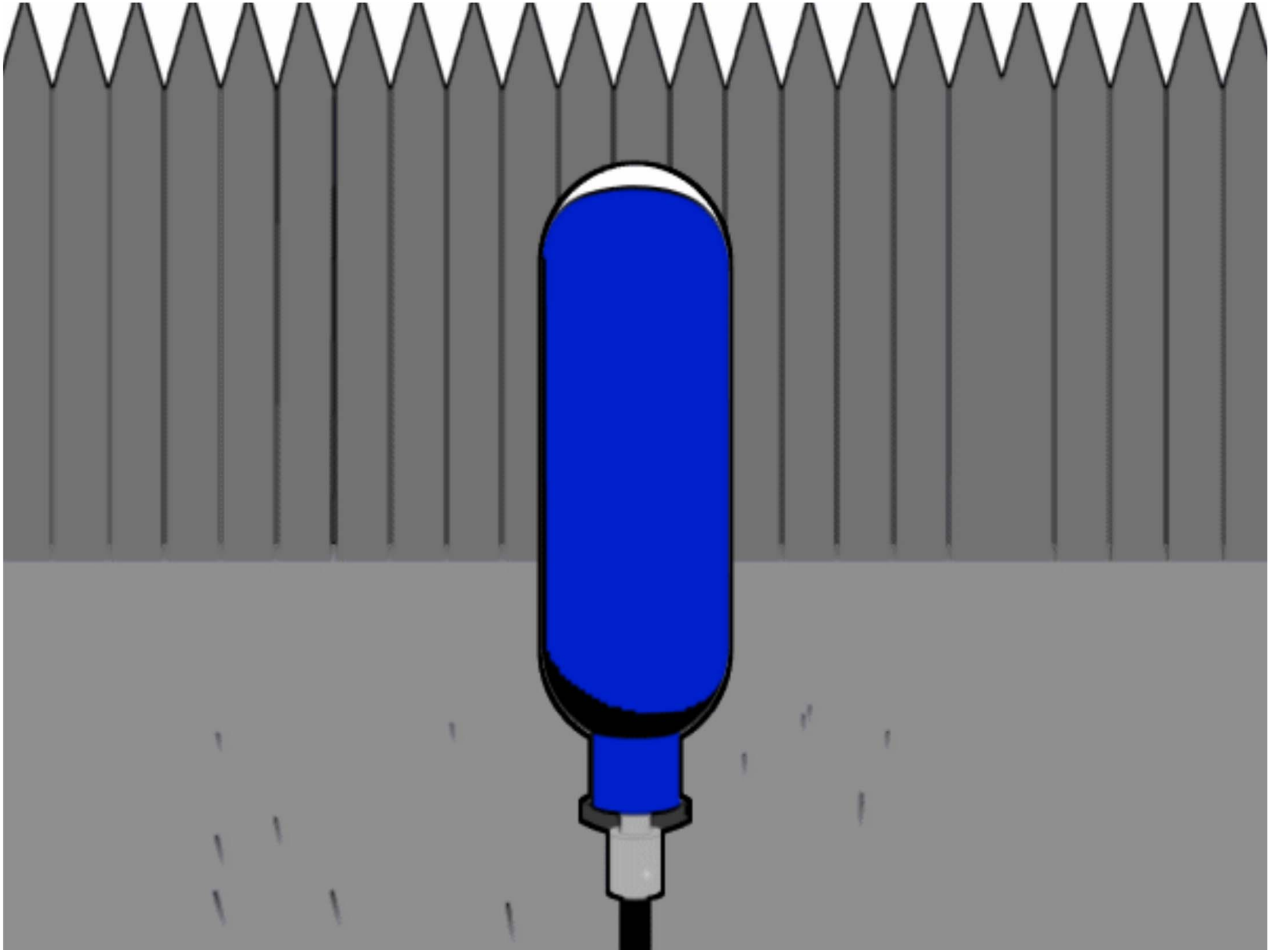


Water rocket uses water as a propellant.

PRINCIPLE

It is based on the
NEWTON'S THIRD LAW OF MOTION.
For a simple model, water rocket consists of a bottle having water above which there is pressurized air. On launching, air pushes the water outside providing the rocket an upward thrust.





PARTS

A water rocket has two main parts.

- Body or Main stage

This has further sub-parts:

1. Nose cone
2. Fins
3. Nozzle
4. Parachute

- Launcher consists of:

1. Cable ties
2. PVC tube

BODY

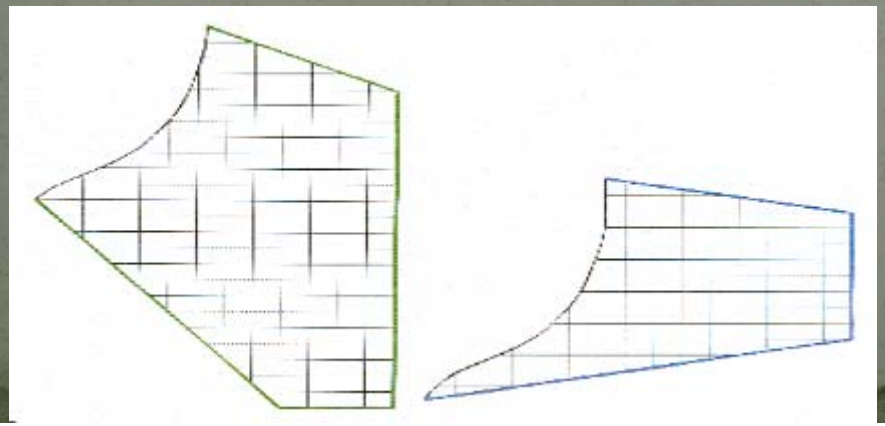
1. Body of a water rocket can be as simple as a single 2l soft drink bottle and also as complex as a body of a multistage rocket.

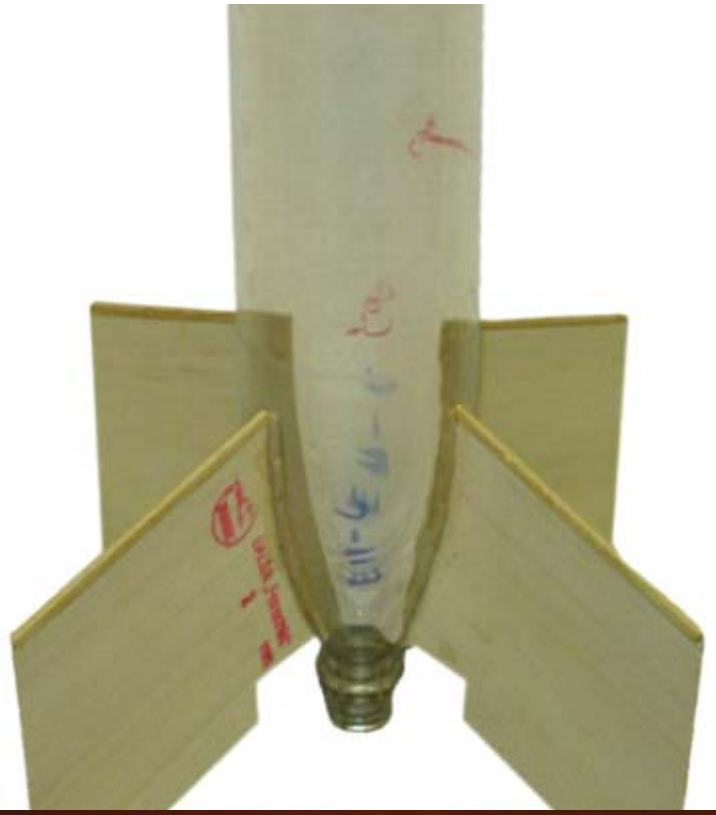
2. To achieve greater volume and aerodynamic stability, two or more bottles can be spliced i.e. joined together as shown in the figure below.

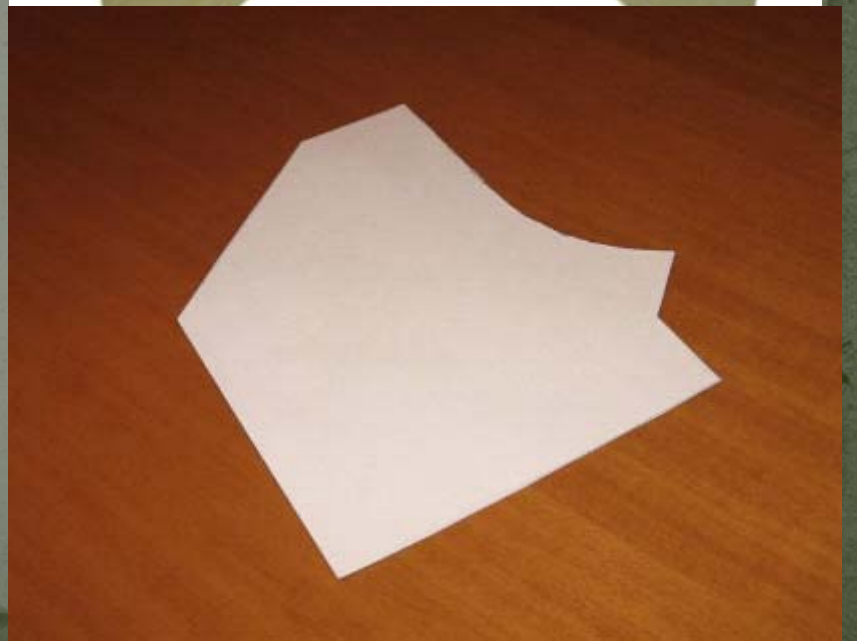
FINS

Why do rockets have fins?

1. The purpose of putting fins on a rocket is to provide stability during flight, that is, to allow the rocket to maintain its orientation and intended flight path.
2. Fins are symmetrically placed around the body (three or four), with enough area so that when the rocket tips off of its path a little bit, the fins provide aerodynamic force to put it straight again.
3. More than four fins add drag and weight.





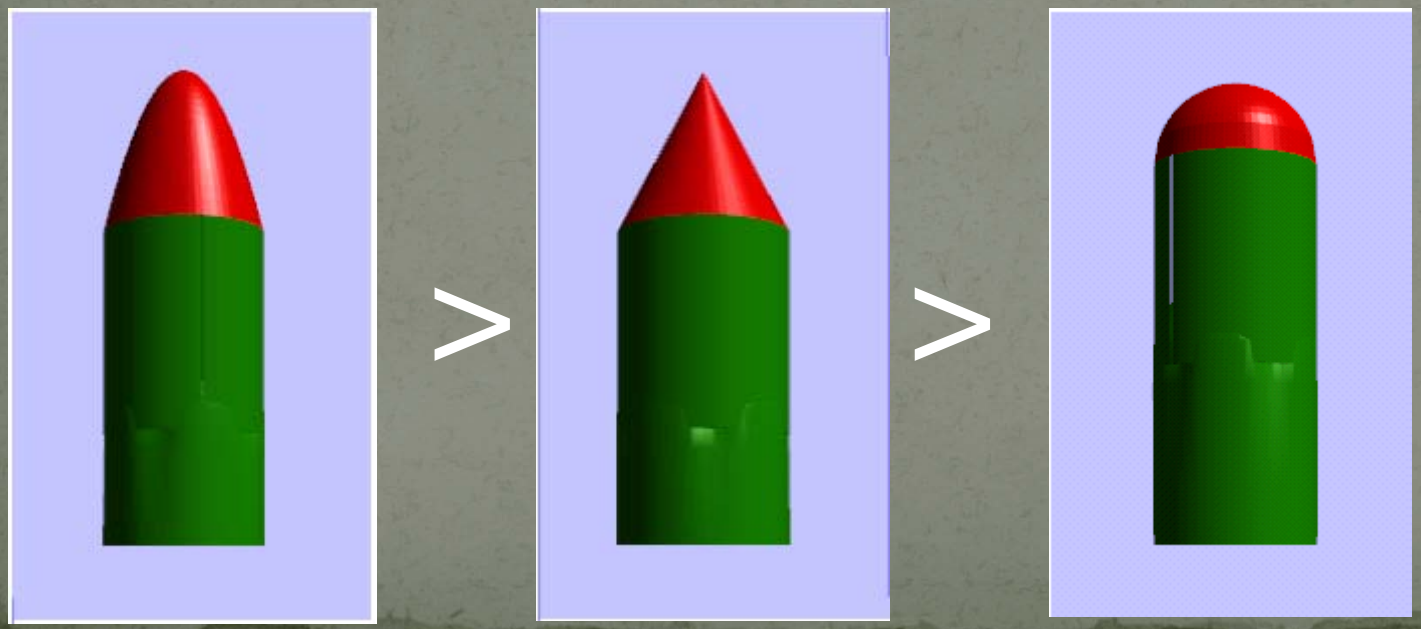


NOSE CONE

1. The cone is shaped to offer minimum aerodynamic resistance.

2. It consists of simply top portion of a cold drink bottle.

Drag



NOZZLE

1. Nozzle serves the purpose of controlling the thrust provided by water.

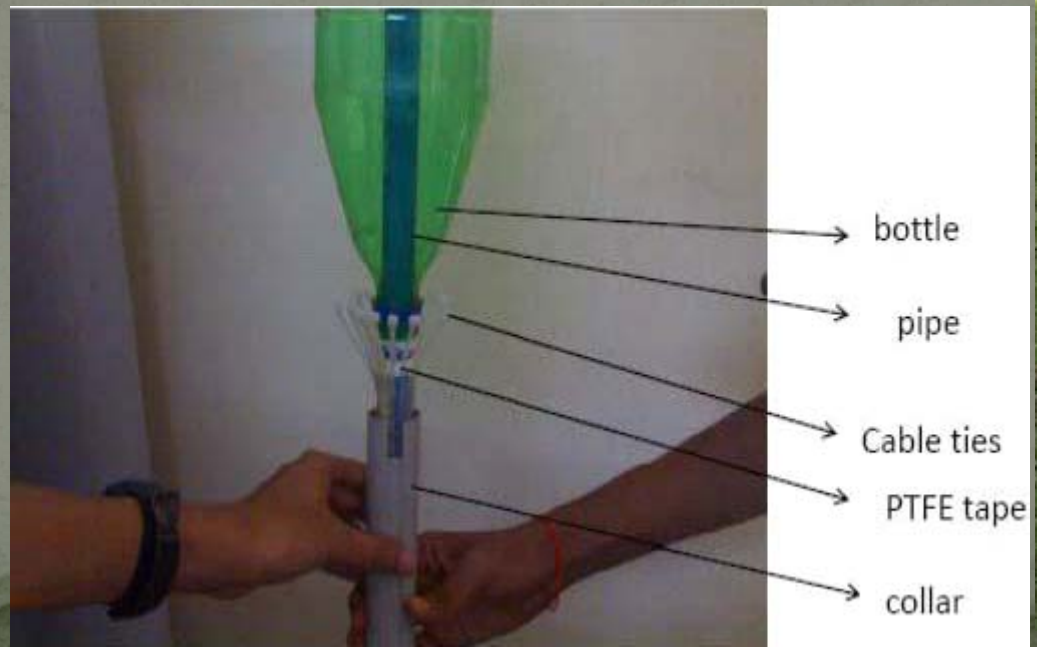
Larger the Nozzle Greater is the Thrust

2.Smaller diameter nozzles can be used to prolong the time of flight by reduced exhaust rate.

3. In our case, we will have a fixed size.
The mouth of the bottle will act as a nozzle.

LAUNCHER

It acts as a means to pressurize the rocket with air and as a base to provide support to the rocket before launch.



MAKING OF A LAUNCHER

Closed end

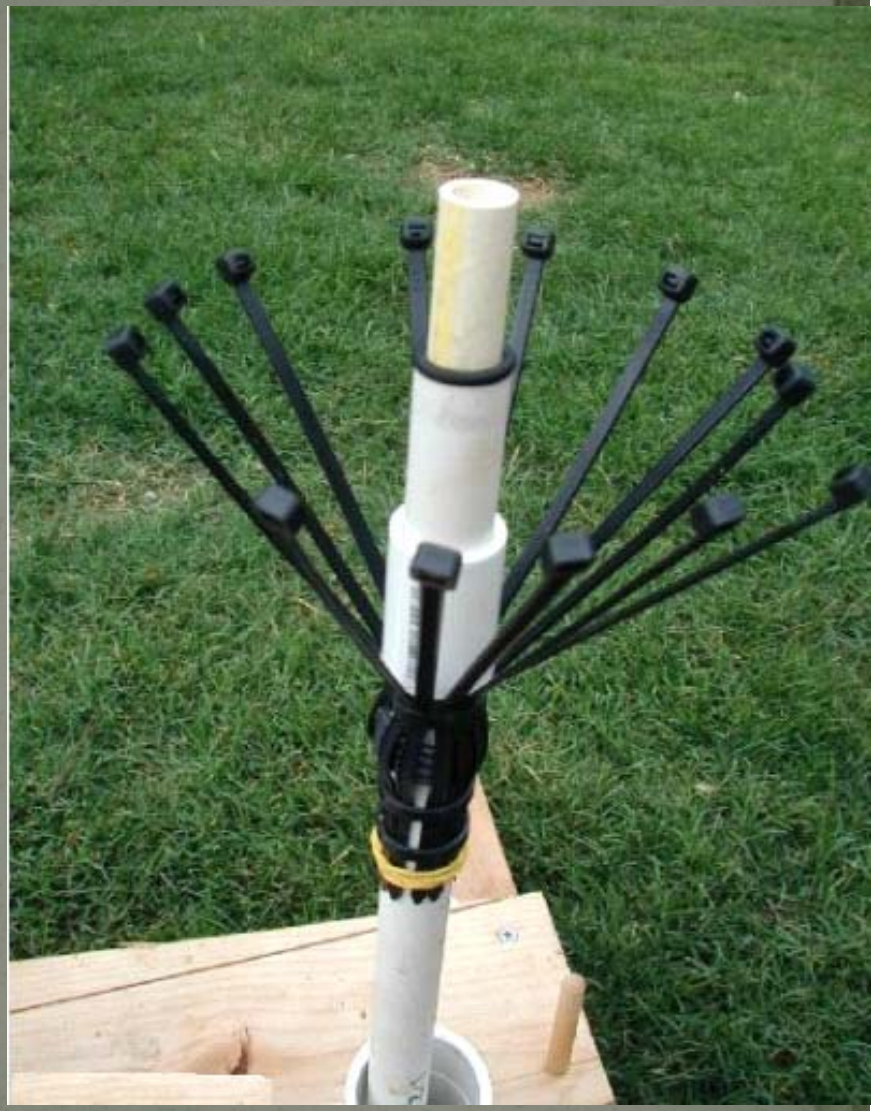
Close this with a cork. Make a hole in the cork and insert a cycle valve in it. This valve can be used to fill in air and increase the pressure inside.

NOTE: All holes and fittings should be leak-proof.

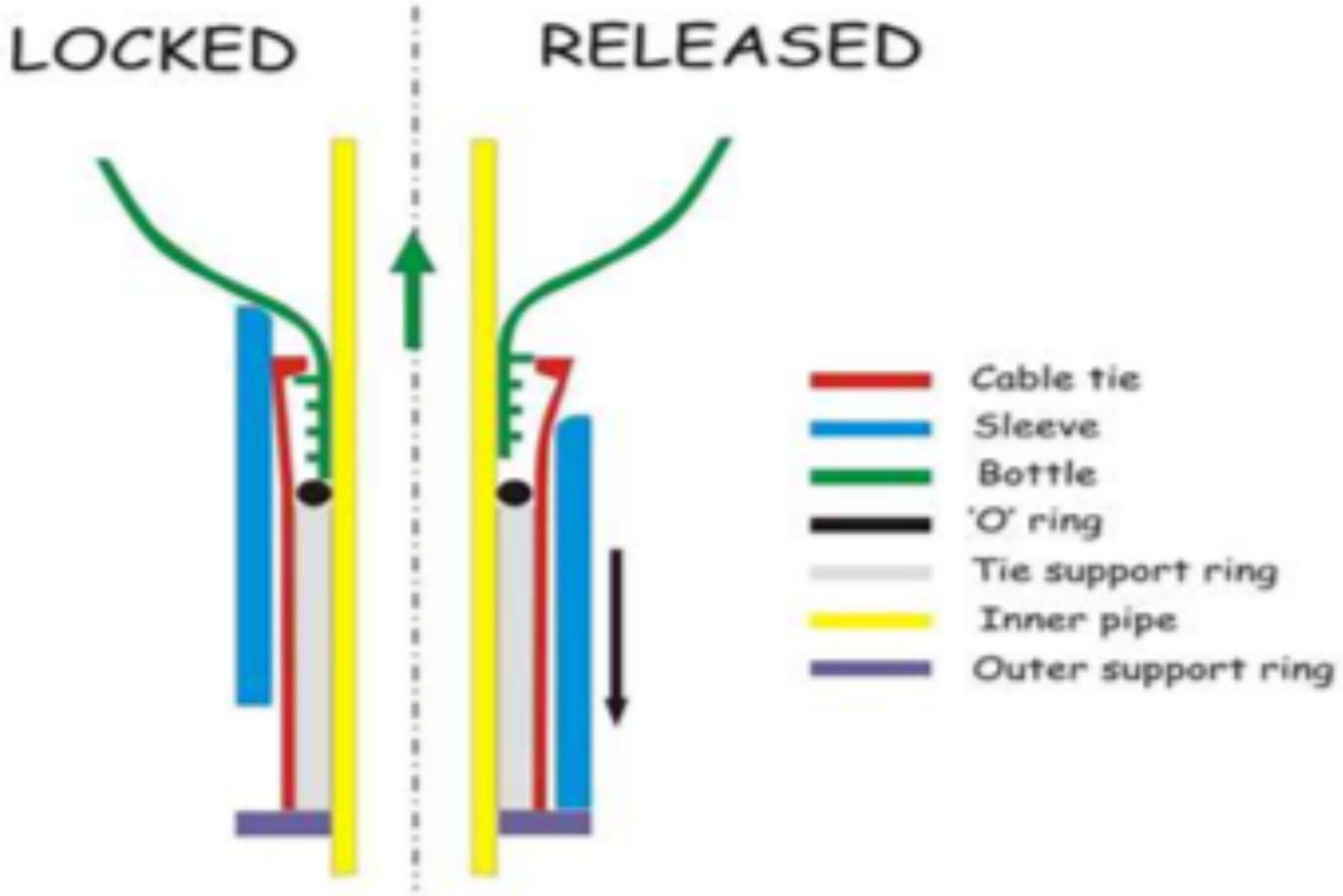
CABLE TIES

1. They help to hold down the rocket while filling the air .

2. The collar is a pipe that can slide over the inner pipe. When pushed up, it will close the cable ties. (They are in open position in the above pic). When closed, they will hold the bottle and will not allow it to move while pressurizing. The collar is pulled down to release the bottle when desired pressure is reached.



RELEASE MECHANISM



PARACHUTE

The rocket uses a parachute to increase drag to slow its descent.

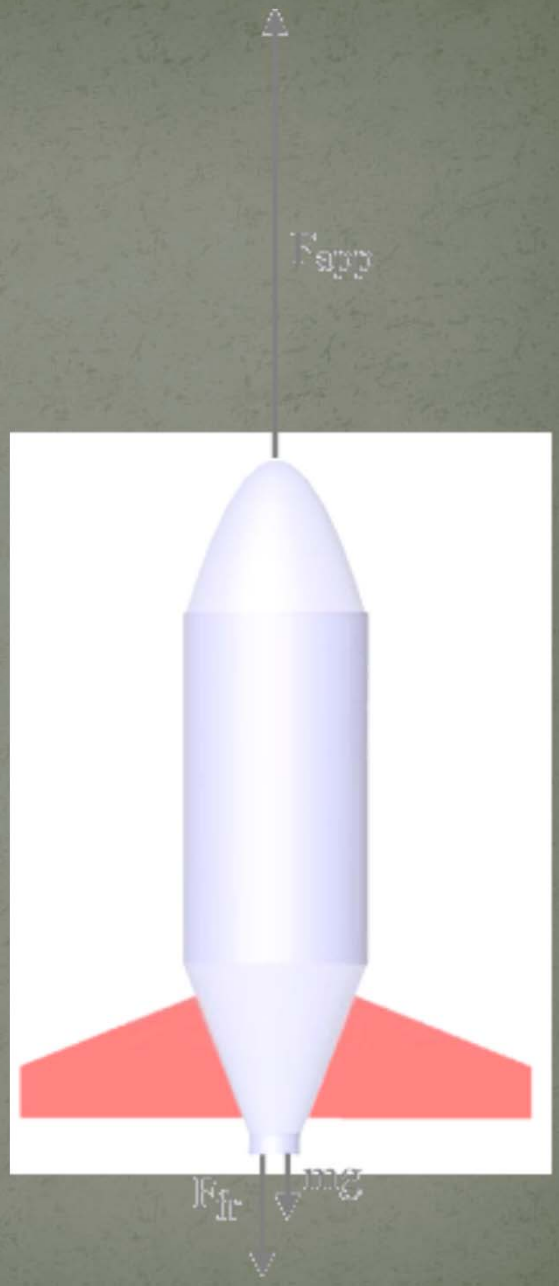
It helps in the smooth landing of the rocket after the fuel is over.

The parachute is generally kept inside the nose cone before launch.

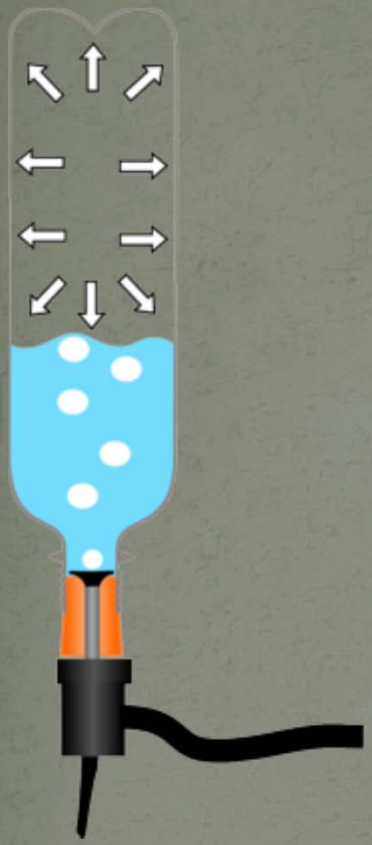
After attaining the apogee the nose cone separates from the rocket releasing the parachute .

Working

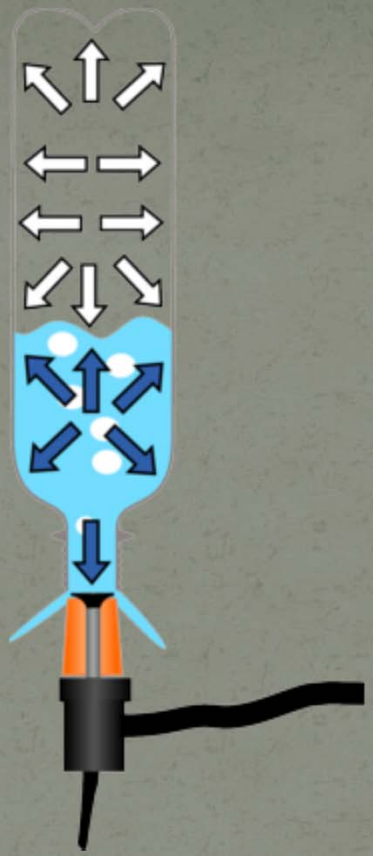
A water rocket works using the same principles as other rockets. There are three main forces in action: thrust (Fapp), drag (Ffr) and weight (w=mg). The water, which is forced out by the difference between internal and atmospheric pressure, is a reaction mass that provides the thrust.



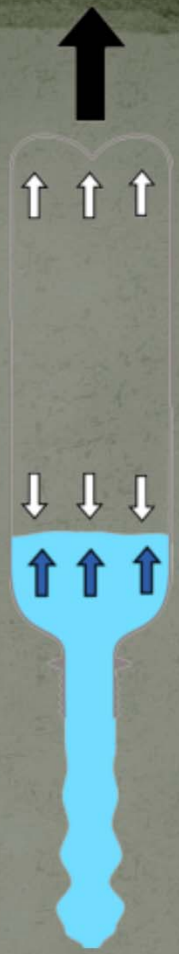
When a water rocket is launched, the difference between internal and atmospheric pressures forces the rocket off the pressure seal, followed by the expulsion of water and air out of the nozzle until the internal and atmospheric pressures are equalized. This action creates a downward force, by applying Newton's Third Law of Motion.



Pumping air into the bottle increases its pressure



Eventually the nozzle is pushed out allowing the water to escape



The air pushes the water down which means the water pushes it back. This force is then transferred to the rocket.

STABILITY

A rocket's stability is critical for achieving high altitude flights - an unstable rocket will go up about 50 feet (max.) and then flutter back down to the ground.

The rule is known as the alphabetical stability rule and states that G comes before P (in the alphabet). From the top of the rocket, the CG comes before the CP.

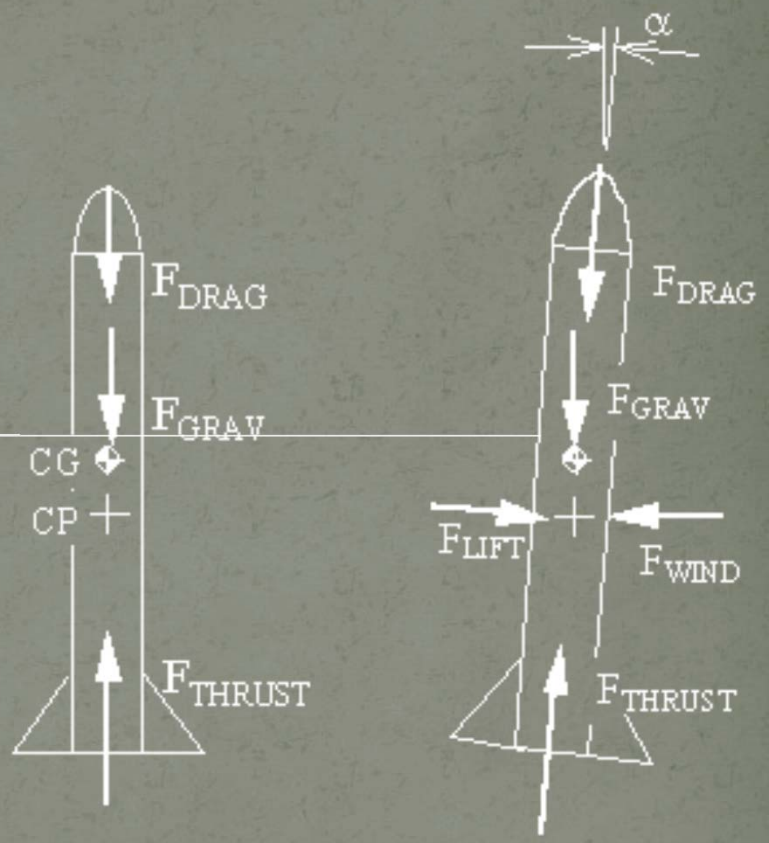


FIG. 1A FIG. 1B

STABLE ROCKET -- CP AFT OF CG

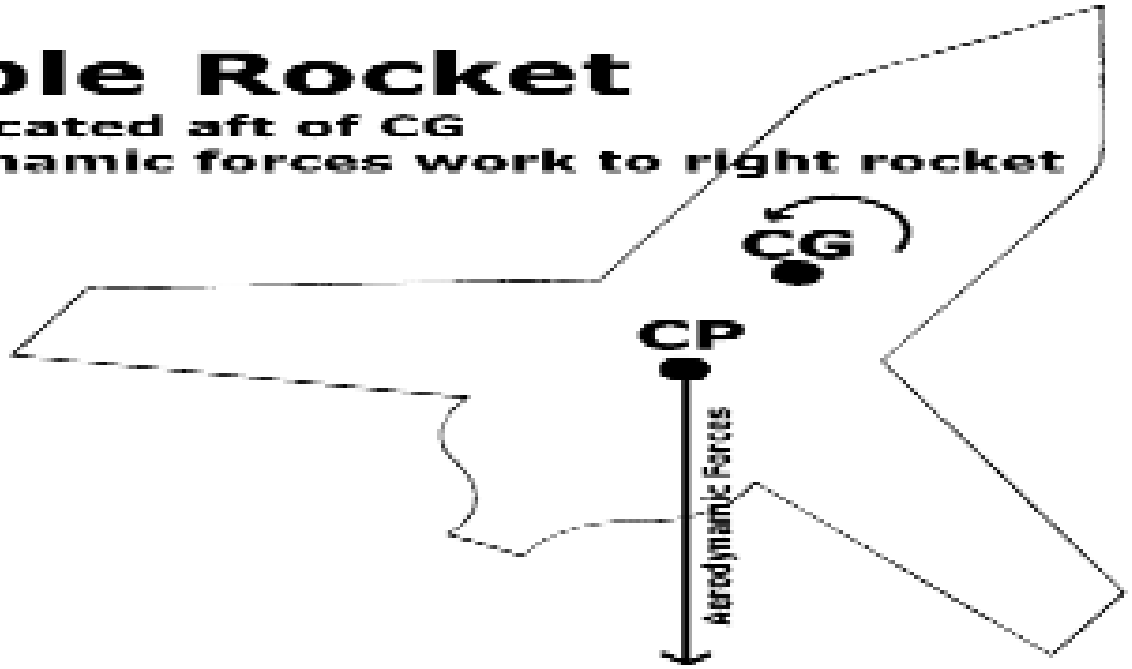
Centre Of Pressure

We call the average location of the pressure variation the **center of pressure** in the same way that we call the average location of the weight of an object the center of gravity. The aerodynamic forces- lift and drag- act through the center of pressure in flight.

This is because the aerodynamic forces centered at the center of pressure are in the direction of the relative wind (the opposite direction of the rocket). If the rocket is moving up, the aerodynamic forces are pushing down on it. If the center of pressure is located aft of the center of gravity, the aerodynamic forces will work to pull the bottom of the rocket back in line with the relative wind, pointing the rocket back in the direction of the relative wind. This makes a stable rocket. If the center of pressure were forward of the center of gravity, the opposite would happen. The aerodynamic forces would pull the nose in the opposite direction that it should move, causing the rocket to spin out of control—an unstable rocket.

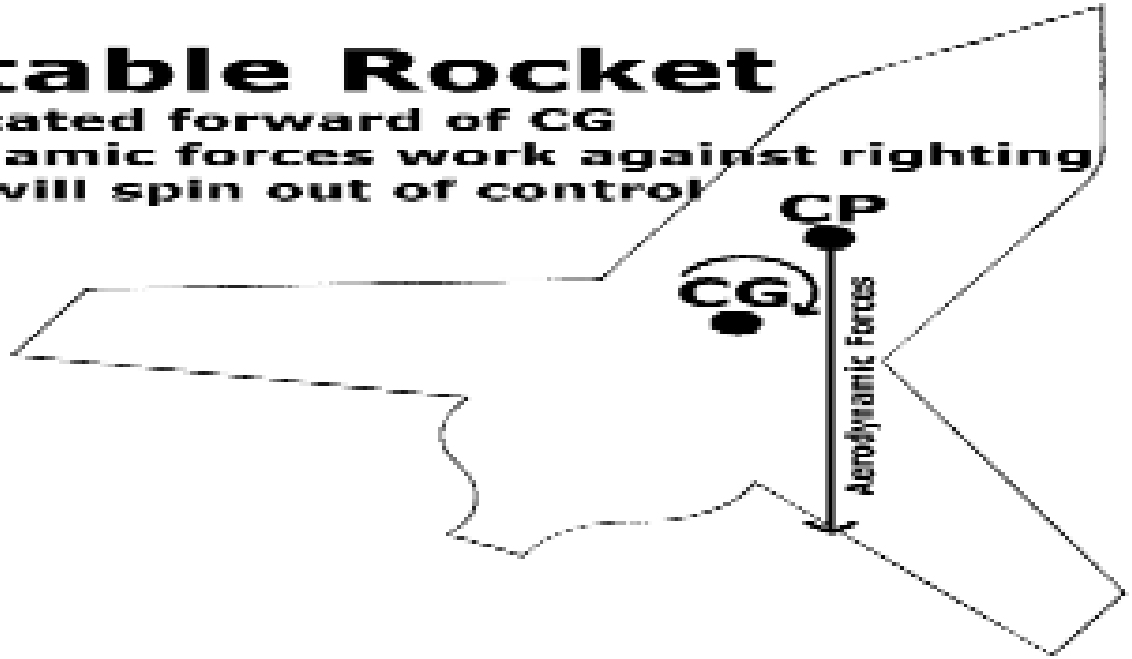
Stable Rocket

CP is located aft of CG
Aerodynamic forces work to right rocket



Unstable Rocket

CP is located forward of CG
Aerodynamic forces work against righting
Rocket will spin out of control



FLYING HIGHER

Use higher pressures but in safe limits (100 psi)

Keep weight to a minimum.

Increase rocket volume.

Streamline the body of the rocket to reduce drag.

Use the right amount of water (30 to 40%)

Streamline the leading and trailing edges of your fins.

Water Rocket With Boosters

1.One of the possible modifications in the simple water rocket is making water rocket with boosters.

2. In our case, in addition to main stage, we have three drop away boosters attached with it to increase the launch velocity in order to achieve a greater altitude.

3. When the water in the boosters runs out, they automatically get detached from the main body, allowing it to go much higher easily.

4. We are going to attach the boosters at an angle of 120 degrees to one another to make the rocket stable during the flight.

Water Rocket With Boosters

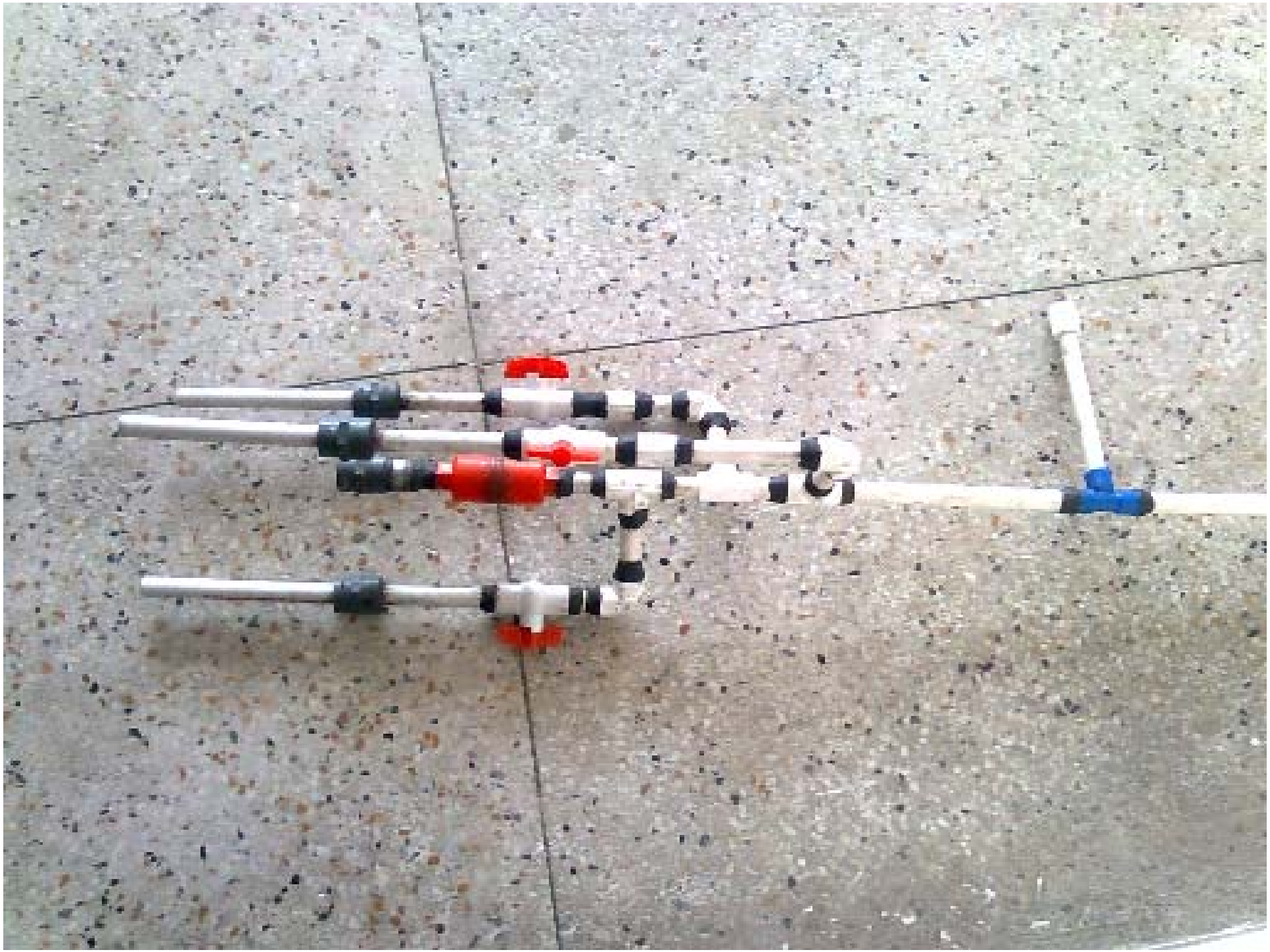
- The main idea behind its implementation is that the boosters must produce more thrust than the main stage, which can achieved by using bigger nozzle than the main body.
- Also, main body plus the boosters must be released simultaneously.
- All the boosters must provide the same thrust. It can be done using the boosters having same air pressure, same volume and same water content.

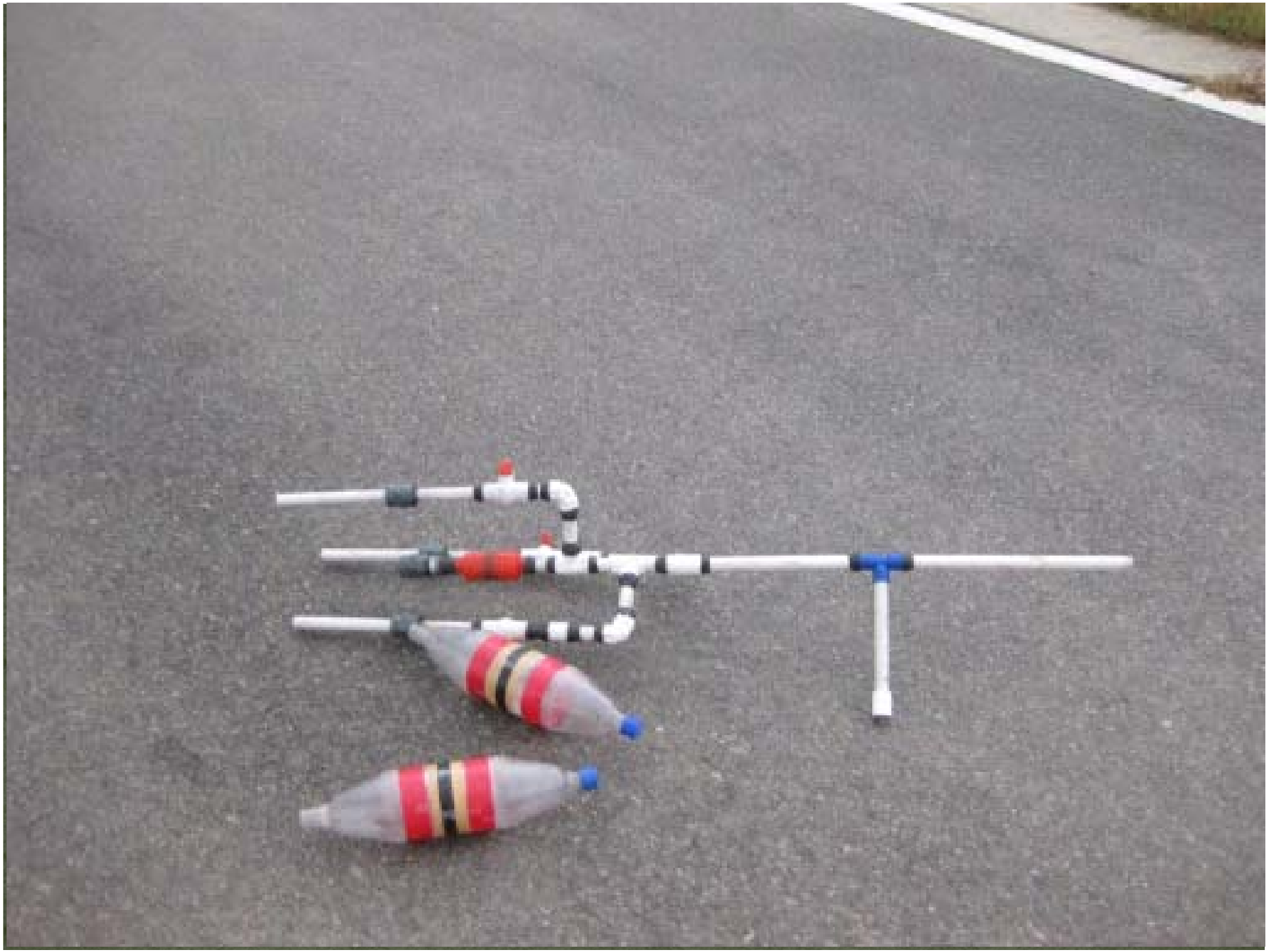
Some FACTS about Water Rockets-

The 2004 world record altitude for a water bottle rocket is more than 300 meters.

The maximum air speed for a water rocket has been clocked at up to 200 km/h

SOME PICS OF OUR BOOSTER WATER ROCKET





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Thank You