Luxembourg esero

A HOW-TO GUIDE

WATER ROCKET Challenge

esa

LUXEMBOURG SPACE AGENCY

LE GOUVERNEMENT DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Éducation nationale, de l'Enfance et de la Jeunesse

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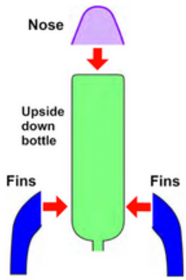
1.Introduction

Welcome to the 1st edition of the Luxembourg Water Rocket Challenge 2023 !

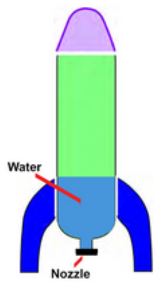
1.1 What is a water rocket?



A water rocket is a type of rocket that uses water and pressurized air as its propellants. The rocket consists of a plastic bottle partially filled with water and pressurized air. At its simplest, a water rocket is an upside-down fizzy drinks bottle, which has a 'nose' cone and some fins added.

The nose cone
The job of the nose cone is to make the snub-nosed end of the fizzy drinks bottle more aerodynamic.

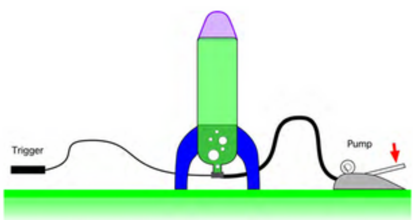
The fins
Technically, fins are important for ensuring that the rocket flies smoothly, but they are also the parts of a rocket that really give a rocket its character.



Once we have added the fins and the nose cone, we have something which looks like a rocket. But how do we make it go like a rocket?
First, we need to add some water, plug the rocket into a launcher that will keep the water in the bottle, until we choose to release it. The water will then leave the bottle through its nozzle. Typically, the bottle will be between about one quarter and one third filled with water.

Launch
To launch the water rocket, we need to pump air into the rocket to provide energy for the launch. As the air enters, it bubbles up through the water and pressurizes the 'empty' space above the water. You can see that the launcher allows air into the rocket, while not allowing the water to escape until we activate a trigger.

When the trigger activates the release mechanism, the pressurized air within the rocket pushes the water rapidly out through the nozzle, sending the rocket rapidly into the air.



Launch pad

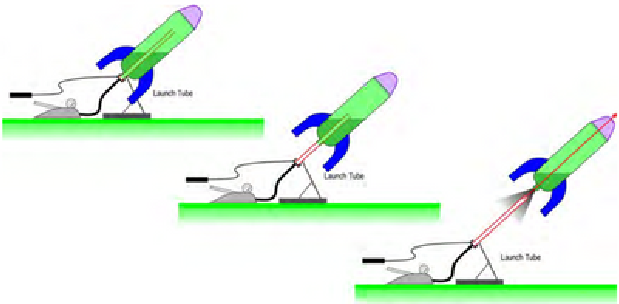
Since your goal is to reach a target at **exactly 70 m** from the launch point, the launch pad will need to be inclined at a certain angle.

On the launch day, **ESERO** (European Space Education Resource Office) will provide a launch pad for each team.

The launch pad contains a tube that runs through the nozzle of the rocket.

When the trigger activates the release mechanism, the rocket slides along the launch tube before fully attaining 'free flight'.

This has two advantages. The first is that the launch tube stops the rocket from 'flopping over' just after launch, acting like a kind of 'internal launch ramp.' The second advantage is that once the trigger has been activated, the high-pressure gas inside the rocket expands, and pushes (as the middle section of the figure below shows) the rocket along the launch tube. As it slides along the launch tube it accelerates, and it can move quite fast when it leaves the launch tube. However, while it is on the launch tube, it is not losing any water. This gives the rocket a kind of 'moving start' and allows it to use its charge of water more effectively.



1.2 Educational and pedagogical values

Building and launching rockets is just enormously enjoyable. It combines the simple pleasure of watching in awe at the power of a compressed gas, with the more subtle pleasure of mastering an engineering problem. In short, it is fun for all ages.

Water rockets are also a popular tool for teaching science concepts:

1. Physics principles: Water rockets provide a hands-on demonstration of fundamental physics principles such as Newton's third law of motion, which states that for every action, there is an equal and opposite reaction.

2. Forces and motion: Students can learn about various forces at play during the launch of a water rocket, including thrust, drag, and gravity. They can explore how these forces affect the rocket's trajectory and velocity. By modifying factors like the amount of water or the rocket's design, students can investigate the impact on these forces.

3. Aerodynamics: participants experiment with different fin designs, nose cone shapes, and body configurations to observe how they affect the stability, flight path, and air resistance of the rocket.

4. Pressure and energy: Water rockets involve the use of pressurized air to expel the water. This offers an opportunity to learn about pressure, energy, and potential energy. Students can investigate how the air pressure affects the rocket's performance, and they can explore the relationship between pressure, volume, and the rocket's trajectory.

5. Experimental and problem-solving skills: Water rocket experiments encourage students to use scientific inquiry, formulate hypotheses, and test them through trial and error. They can analyze and interpret the data obtained from their launches to draw conclusions. It promotes critical thinking, problem-solving, and the scientific method.

6. Teamwork and collaboration: Participants work together to design and construct the rocket, share ideas, and troubleshoot any challenges. It fosters communication, cooperation, and the development of interpersonal skills.

2.The Water Rocket Challenge

Building and launching rockets is just enormously enjoyable. It combines the simple pleasure of watching in awe at the power of a compressed gas, with the rather more subtle pleasure of mastering an engineering problem. In short, it is fun for all ages !

2.1 Rules of participation

The following conditions must be met for a team's registration to be accepted:

- Teams must be made up of **2 to 4 students**, aged between 8 and 19 years old.
- Teams must be made up of students attending a **primary or secondary school in Luxembourg.**
- Each team must be supervised by **an adult in the role of mentor.**

Team members do not necessarily have to attend the same school.
The mentor must accompany the students on the launch day.

The teams are divided into 2 categories:

- **Category 1** (8-12 years old): maximum 20 teams, launch in the morning.
- **Category 2** (13-19 years old): maximum 20 teams, launch in the afternoon.

2.2 Objective

Launch a self-made water rocket and land it as close as possible to a zone **70 meters** away, by changing different variables such as air pressure, amount of water or launch angle. Each team will have **3 attempts** to get as close as possible and accumulate points on each attempt..

2.3 Provided material

ESERO provides a bottle nozzle and a rocket launcher and a bicycle pump to each team during the competition.

2.4 Prizes and awards

There will be awards for the **first**, **second**, and **third** places in each age category. The winning team in each category will receive a rocket launcher.

Category 1 teams will be given awards to:
- The Most Beautiful Rocket
- The Best Team Uniform

Category 2 teams will also be given awards to:
- The Most Beautiful Rocket
- The Best Rocket Launchers

2.5 Notes

- A mentor can register multiple teams.
- A tent with support materials will be available to repair rockets suffering damages after their launch.
- Food & drinks will be offered at lunch time.
- Toilets available.
- We will take photographs and videos at the event for promotional purposes

The complete challenge rules can be found in section 7.

3. Launching a Water Rocket

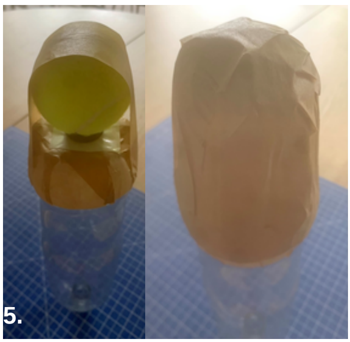
In this section, we will see in detail how to make a basic water rocket that will fly well in a wide range of conditions. It takes about 30-40 minutes to build your own rocket.

3.1 Necessary material

- A 1.5 to 2 liter fizzy drinks bottle that will form the main body of the rocket. Be sure only to use bottles that contain fizzy drinks. We recommend 1.5 Coca, Pepsi or Schweppes bottles.
- A tennis ball weighing about 60g that will form the main part of the nose.
- To make the fins, either some old CDs, some corrugated cardboard, or better still, corrugated plastic.
- Duct tape or equivalent strong, sticky tape.
- Electrical insulation tape
- Double-sided adhesive tape
- Liquid glue
- Scissors or a knife.

3.2 Instructions for building a water rocket

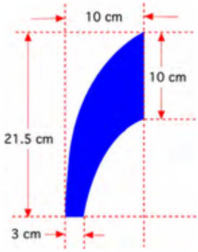
1. Empty out the fizzy drink, get rid of the labels, and rinse it with water. Make sure you **do NOT** damage the bottle with scissors or other sharp tools.
2. Reinforce the top of the bottle with several layers of duct tape
3. Stick a piece of double-sided tape in the centre of the bottle
4. Glue the bottle cap, turned upside down, to the centre of the double-sided tape.
5. Firmly tape the tennis ball to the end of the bottle with duct tape.

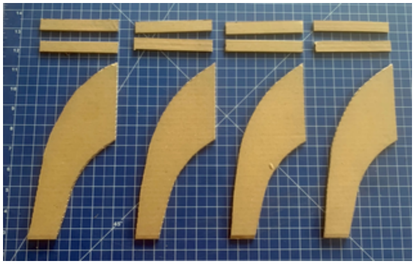


6. Cut the fins

First, you must decide if you want your rocket to have 3 or 4 fins.
Then choose the fins material. One option is to cut up old CDs to use as fins but if you do this, please then make sure you put tape over any sharp edges in case your rocket should hit someone.
Corrugated cardboard will do but does tend to get wet and fragile after a few launches.
Corrugated plastic (known as Corriflute™) is waterproof and has excellent rigidity for its weight. It is the same material used by real estate agent's 'For Sale' boards.
Another option is to use 3mm thick PVC hard foam panels.

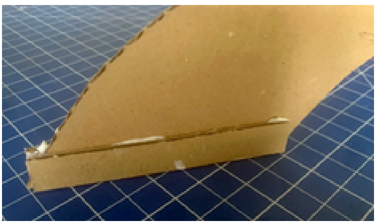
Here is a suggestion for the design of the fins but you can improve it with your own design.
For each fin, cut 2 extra pieces of material, about 10cm long, to reinforce the base of the fins.

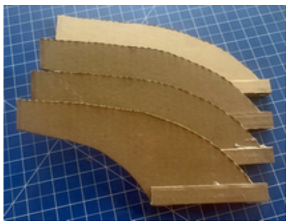




7.Reinforcing the base of the fins

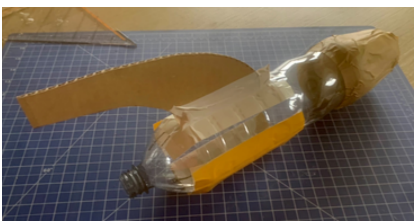
Use the liquid glue to stick the rectangles to each side of the fins





8.Attach the fins on the bottle

Put double-sided adhesive paper on the bottle, at the place where you want to fix the fins. Firmly attach the fins to the double-sided adhesive paper.
Reinforce the junction between the fin and the bottle by placing electrical insulating tape on either side of each fin



The fins will certainly be damaged on landing, but they will not be too difficult to repair.

Whether you use this fin design or your own, the important things about the fins are that:

- All the fins should be the same as each other,
- They should be positioned at the bottom of the rocket.
- They should be arranged symmetrically around the rocket (every 120° if you have three fins or every 90° if you have four)
- They should be thin when viewed ‘head on’ (around 3mm to 5mm thick)

9.Decorate your rocket.
Do not forget to give a name to your rocket and make it beautiful!

3.3 Rocket launcher

Here is the rocket launcher that will be used on the launch day.

It is not necessary to test your rocket flight before launch day. You may want to build your own launcher, but it’s a pretty tedious task. If you really want you can buy this cheaper and efficient launcher.

4.Optimizing your rocket

Aside from firing the rockets, designing the rocket itself is part of fun.
In this section, we will look at some factors you will need to consider if you want to optimize your rocket's design.

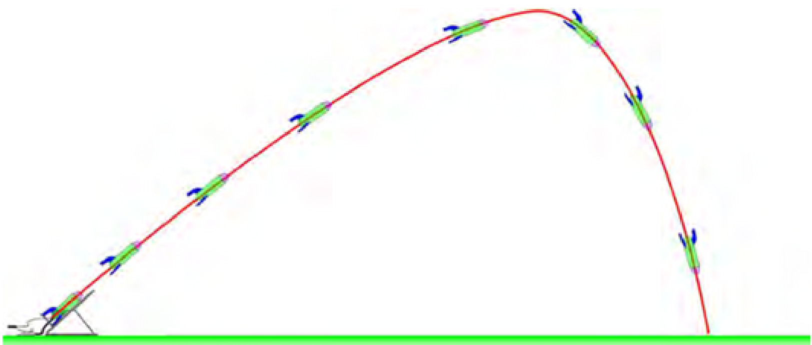
4.1 Bottle volume

The rocket's volume determines the maximum amount of energy stored in the compressed gas. Energy is proportional to both the pressure and the volume. There are limits to the pressure that the rocket can sustain: **6 bars** is a safe working limit. It is common to find **500 ml, 1 liter, 2 liter** in shops.
We suggest using **2-liter bottles** to maximize efficiency.

4.2 Weight

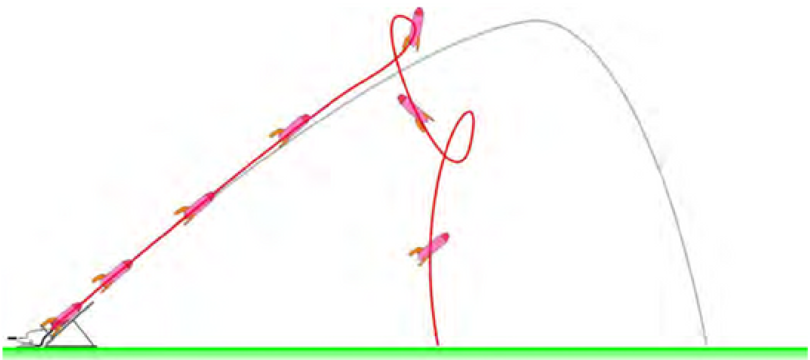
The lower the weight of your water rocket, the better it will fly. Most of the work of designing a lightweight rigid structure has been done for you already by the manufacturers of plastic bottles.
To capitalize on the strength-to-weight ratio of the bottles, you need to avoid adding too much weight as you improve the aerodynamics of the bottle.
It is also important to add the weight in the correct places so that your rocket is aerodynamically stable.
The distribution of weight along the length of the rocket is one of the factors which determines whether it will fly like a rocket, or like a bottle. What is the difference?
An aerodynamically stable rocket flies with its nose first and should have a flight trajectory like a beautiful smooth arc.

Below: An aerodynamically stable rocket trajectory. Notice that air-resistance tends to make the trajectory asymmetric, with the rocket falling rather more steeply than it ascends.



An aerodynamically unstable rocket may start out with its nose first, but its flight will quickly become unstable, and it will flap and tumble in the air, and then simply fall to Earth.

Below : An aerodynamically un-stable 'bottle' trajectory

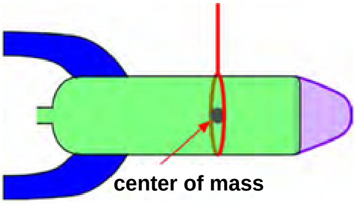


To make your rocket fly 'like a rocket' rather than 'like a bottle,' the weight needs to be in the front half of the rocket. However, depending on the design of your fins, this may or may not be enough to ensure aerodynamically stable flight. One of the most important properties of your rocket is the position of its center of mass, sometimes called its center of gravity.

4.3 Estimating the center of mass

Since your rocket will spend most of its flight without any water in it, this makes it easy to find its center of mass by simply tying a string around the rocket and moving the suspension point along the rocket until you find the balance point. The further forward this balance point, the more likely it is that your rocket will be stable in flight.

Below: Finding the center of mass of a rocket by suspending it from a thread.



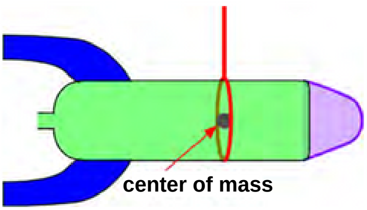
4.4 Fins

The fins on a rocket provide a mechanism by which aerodynamically stable flight can be ensured. To understand the role of the fins, it is necessary to consider the forces on a rocket when it becomes slightly misaligned in flight. If these forces act to increase the degree of misalignment, then the rocket will not fly well. If these forces act to decrease the degree of misalignment, then the rocket will fly… like a rocket! We will see how the fins help to achieve stability in the next section.

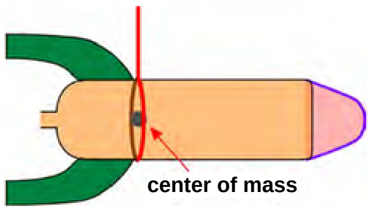
4.5 Aerodynamic stability

To understand aerodynamic stability, we need to consider the forces which act on the rocket both when it is flying correctly, and when it is misaligned. Let us consider two different rockets (let us call them **Rocket A** and **Rocket B** which are the same shape and have the same fins, but which have different weight distributions and so have their center of mass positioned at different places. Let us assume that **Rocket B** has its center of mass much further back than **Rocket A**.

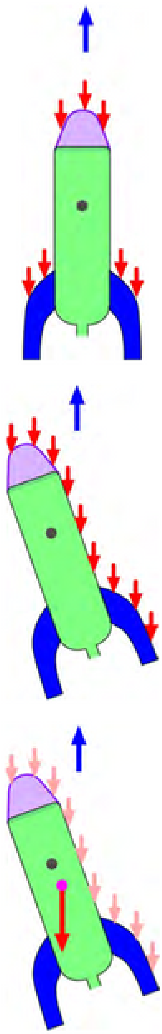
Rocket A



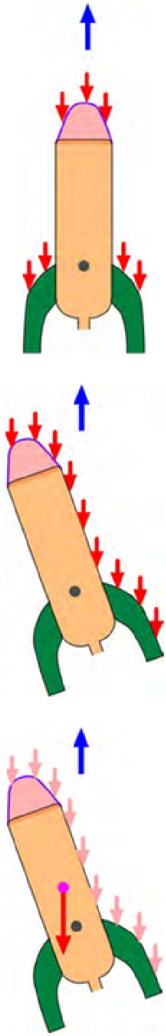
Rocket B



Rocket A



Rocket B



Now let's think about the forces when the rocket is travelling in the direction of the blue arrow.

The main drag forces act on all the surfaces exposed to air moving past the rocket. For a typical rocket oriented 'correctly', these forces act mainly on the nose cone, because the fins are usually very thin and expose very little cross section to the air through which they move.

Now consider what would happen if the rocket became slightly misaligned. In this case much more of the rocket would be exposed, and the drag forces would increase significantly.

The forces would act:

- on the nose of the rocket,
- along the exposed side of the rocket,
- and on the fins.

The forces along each portion of the rocket are difficult to calculate or measure precisely, but there will be some point on the rocket which is their effective point of action. This point is known as the centre of pressure and is marked with a purple dot in the figures right and left.

Because the shapes of the two rockets are the same, the centre of pressure lies in the same place. But because the centre of mass occurs in different places on each rocket, the effect of the same drag forces on each rocket is quite different.

For **Rocket A** the center of mass lies further forwards along the rocket axis than the centre of pressure. The extra drag forces therefore act more on the back end of the rocket and tend to 'push it back into line'. Technically we say the drag forces exert a torque which acts about the centre of mass to restore optimal flight attitude.

For **Rocket B** the center of mass lies further backwards along the rocket axis than the centre of pressure. The extra drag forces therefore act more on the front end of the rocket and tend to 'push it even further out of line'.

So, it is the relative positions of the center of mass and the center of pressure that determines whether a rocket is aerodynamically stable (like Rocket A) or unstable (like Rocket B). We saw in a previous section how to determine the position of the center of mass, but how do we determine the position of the center of pressure?

4.6 Estimating the position of the Center of Pressure

Estimating the position of the center of pressure turns out to be rather hard to do accurately, but there is a simple technique which you can use to make a rough estimate of its position. This involves making a flat 'silhouette' of your rocket. To understand why this is relevant look at the photographs below which show what the rocket would like if it became misaligned in flight.

A photograph of a rocket from directly above its nose cone: this is what you would see if the rocket were flying directly towards you.

Exposed surfaces of the rocket: The circle shows the area of the rocket exposed to the oncoming air. The fins are rather thin and move easily through the air.

This picture shows a rocket slightly misaligned: this is what you would see if the rocket were flying directly towards you, but its back end had swung around slightly.

In this attitude, additional surfaces (outlined and shaded) are exposed to the oncoming air. Some of these surfaces are on the side of the rocket and some are on the fins.

The silhouette technique considers what would happen if for some reason your rocket were flying sideways. This is obviously a more extreme scenario than the misalignments considered above, but let us follow the logic through. If this were to happen, then the surfaces of the rocket exposed to oncoming air would not form a circle (as when the rocket is correctly oriented) but rather would look like a silhouette of the entire rocket. The position of the center of pressure of the rocket can be estimated by making a silhouette (or cut out) of the rocket, and then estimating the center of mass of the cut-out.

Illustration of the silhouette technique for estimating the centre of pressure.

1. Drawing around the rocket.
2. Cut out the silhouette of the rocket.
3. Assessing the center of mass of the rocket and its silhouette together. We estimate the centre of pressure of the rocket to be in roughly the same relative position as the centre of mass of the silhouette. Notice that the rocket design with its large light, fins projecting back from the body of the rocket help to keep the centre of pressure towards the rear of the rocket. Also, extra weight in the nose

As the photograph above shows, the center of mass of the silhouette is much further back along the rocket body than the center of mass of the rocket itself. To the extent that the center of mass of the silhouette really is a good estimator for the center of pressure of the rocket, we can see immediately that the rocket is aerodynamically stable. If the rocket were flying sideways, then the air pressure would cause an effective force to act at the center of pressure. Since the center of pressure lies further back along the rocket than the center of mass, the air pressure causes the rear of the rocket to be pushed backwards, and the nose of the rocket to swing forward, restoring the correct flight attitude.

4.7 Drag

As the water leaves the rocket's nozzle, it pushes the rocket forward. But this acceleration is decreased because the rocket needs to push air out of the way. The force required to push air out of the way is known as aerodynamic drag.

Travelling at just a few meters per second we are hardly aware of drag, but at higher speeds, drag dominates the motion of projectiles. For the rocket-shaped projectiles we are interested in, drag forces become significant above approximately 10 meters per second. Just after launch, a water rocket can reach a maximum speed of 20 meters per second, and a high-pressure rocket might reach 40 meters per second. At speeds such as this it is essential to create a design with low drag. Assuming your design is basically rocket shaped (pointy-nose, long body, fins) then you can minimize the drag by considering the following points.

Nose: This nose needs to be:

- Cone shaped, but there is no need to make it excessively pointy. In fact, from a safety point of view this is quite undesirable.
- Weight may need to be placed in the nose. I am fond of using tape around a tennis ball, but other designs use plasticine stuffed into a cardboard or plastic nose cone.

Body: The body needs to be:

- As smooth as possible.
- For a given rocket volume, long thin rockets tend to have lower drag than short fat rockets.

Fins: The fins need to be:

- Thin and light
- Arranged symmetrically around the body of the rocket: usually there are three or four of them.
- Positioned as far back along the rocket as possible.

5.Testing your rocket

The way you test your rocket distinguishes those who want to have fun (which is great) and those who want to understand and improve their design (which is the first step on the road to being a successful engineer). At the heart of this test process is measurement. You need to:

- measure the properties of rocket before launch, and then
- measure the performance of a rocket.

You then need to use your understanding of the launch process and flight dynamics to try to work out which launch properties most significantly affect the performance of the rocket.

5.1 Rocket properties

Weight of Empty Rocket: This is the weight of the rocket without the water in it. Using electronic kitchen scales, it is not too difficult to measure to the nearest gram, which is more than accurate enough for our purposes.

Water Volume: This is something you can easily customize, and which makes a significant difference to the performance. A good starting point is to fill with about one quarter water. The optimum filling depends on several factors but is in the range from 20% to 30%. One thing you can do is to mark the side of the rocket with tape to show where (say) the 20% or 25% mark is: remember you will be filling the rocket when it is upside down so this mark will be in a non-obvious position.

Launch Angle: If the rocket were an un-powered projectile with no aerodynamic drag, then the angle to give the greatest range would be 45°. However, this is not the case for a water rocket, although the optimum angle is unlikely to be very far from 45°. My feeling is that launching slightly more vertically than this gives the best range, but you should check this for your rocket.

Launch Pressure: Increasing the pressure increases the stored energy at launch, which increases the maximum speed attained by the rocket, and this increases the launch range, flight time, and maximum height. However, you will find that increasing the launch pressure by a given amount (a) becomes harder to do and (b) makes less and less difference. The reason is aerodynamic drag which increases very rapidly with increasing launch speed, and 'steals' all the kinetic energy imparted to the rocket. If you have a launch pressure of 6 bars and are still looking for improvements, then it's better to try reducing drag rather than increasing the pressure further.

5.2 Rocket performances

- **Ground Range**: This is the distance between the launch point and the point where the rocket hits the ground.
- **Time in the air**: The length of time spent in the air is a good measure of rocket performance. With a little practice you should be able to measure this to the nearest tenth of a second or so.

You can also record with a smartphone the rocket takes off to observe how the water leaves the rocket and estimate its speed.

5.3 Testing tips

- Bring enough water: at least 2 to 3 liters will be necessary. Plastic hose, funnels, and measuring cylinders are all likely to come in handy.
- Try to get into the habit of recording what you do as you do it. It is amazing how the process of simply writing down 'what I tried: what happened' can help to clarify what may seem confusing results.
- Enter results on a laptop or use the provided testing sheet.
- Do not worry too much about precise measurements. Estimating most quantities to within 5% to 10% is sufficient to gain a good understanding.

Before you begin testing, please read the Section on Safety. Water rockets are overall safe, but the potential exists for an accident. So, for your own sake, and others, **follow the safety guidelines.**

5.4 Testing methodology

- Try to launch with the same parameters **three times**. This will allow you to assess the reproducibility of your rocket's performance. If you can't get your rocket to do roughly the same thing when you launch it in the same circumstances, then you are not going to be able really optimize its performance in any meaningful way.
- **Try launching with no water**: This is a nice demonstration of the principle of rocket propulsion. The rocket will still fly, but if you then add even a small amount of water (perhaps just 5% filling of the rocket), you should see a dramatic effect on the rocket's performance.
- **Launch in teams of at least two**. It is good to talk about what is happening as you launch and to explain your ideas, and one person can act as Safety Marshal or timer as the other launches.
- Try changing the **launch angle** and recording the range. You should find a range of angles (probably close to 45°) where the range is insensitive to the precise launch angle.
- Try changing the **launch pressure** and recording the range. You should find that increasing the launch pressure always increases the range, but by smaller and smaller amounts.

6.Challenge rules

6.1 Rocket design requirements

The rockets must be finished before the launch day. Due to the risk of breakage of the rockets, especially at the fin level, several fins should be prepared in advance.

Furthermore the following requirements **must be met**:

1. The rocket bottle must be a PET bottle designed for fizzy drinks or carbonated water.
2. The total rocket length cannot be greater than 1m
3. The rocket bottle volume must not be greater than 2 litres
4. All energy given to the rocket must only come from the water/air pressure combination. No other source of energy is allowed. You can only compress air manually with the provided bicycle pump.
5. No external metal parts are allowed on the rocket
6. The team name must be clearly visible on the bottle
7. Fins must be built by each team and cannot be bought commercially

6.2 Launch procedure

The following launch requirements **must be met**:

- Teams can only use the provided rocket launcher and bicycle pump
- The launch pressure must not be higher than 6 bars
- The launch angle must be between 30 and 60 degrees

Each team will have **3 tries** to gain as many points as possible during **3 rounds** by getting as close as possible to the 65m zone. Each round takes about **30 minutes**. Between each round, the teams will have about **20 minutes** to repair and optimise their rocket, adjusting the angle, the quantity of water and the pressure.
If you cannot launch within the time allocated for the round, your score for that round will be zero. Wind cones will indicate wind direction and strength.

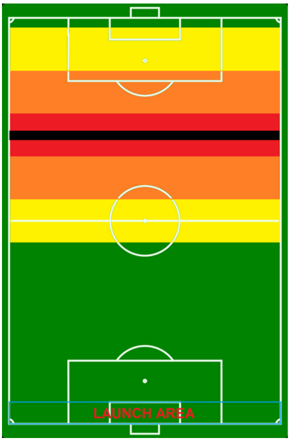
Before each launch, each team must

- Wear the provided **eye protection glasses**
- Adjust the angle of the launcher between minimum **30 degrees and maximum 60 degrees**
- Fill the rocket with the amount of water required
- Pressurize the rocket with the bicycle pump without exceeding **6 bars**
- **Wait for the green flag** shown by ESERO team before launching its rocket.

6.3 Team rankings

The football pitch will be divided into "zones" as shown below

Zone	Distance	Color	Points
A	40 to 50 m	Yellow	50
B	50 to 60 m	Orange	100
C	60 to 64 m	Red	160
D	64 to 66 m	Black	200
E	66 to 70 m	Red	160
F	70 to 80m	Orange	100
G	80 to 90m	Yellow	50



Teams will be given bonus points for each second their rocket fly.
Before each launch, category 2 teams must estimate at what distance their rocket will land using a simulator like this one and receive 10 extra points if their prediction is correct with a 2 meters error margin.

7.Safety

Building and launching water rockets is generally safe but there are some hazards associated with both the launching of water rockets and their construction and you should be aware of them.

7.1 Sharp knives and blades

Any sharp knife or blade presents a potential accident waiting to happen, especially with children present. So, when using craft knives or blades:

- Always cut away from your fingers
- When not using the blade, always cover the sharp surface with either the manufactures cover, or failing that a cork, or piece of soft wood.

7.2 Rocket design

Do not use any sharp points on either the nose cone or the fins and never use metal fixtures or fittings external to the rocket body.

7.3 Pressurized objects and pipes

During launching and testing, pipework and connections will be pressurized, and large forces can be exerted on various parts of your system. Outright failure of component is rare (see below for pressure limits) but it is common for connections to ‘creep’ while under pressure and then to pop out suddenly.
When your launch system is pressurized, it should be treated like an unexploded firework. You should keep children away.

7.4 Pressure limits

Use only PET bottles designed for fizzy drinks or carbonated water. Do not use PET bottles used (for example) for fruit cordial or milk drinks. These are not safe.
Aside from leaking connections, the most likely component to fail under pressure is the water rocket itself. The precise pressure at which bottles will explode depends on the bottle design, its history, as well as any of the strange things you may have done to it. If you are using new undamaged bottles, then keeping the pressure below 6 bar will avoid the risk of explosion.

7.5 Launch procedure

When launching the rocket, you should avoid any possibility that the rocket will hit any living thing since the rocket could land up to 100 meters away.

- Please pick your spot carefully: most public parks are not suitable for any but the shortest flights.
- Launch in a team, with one person's job being to ensure safety. They should look out for people wandering into the firing range.
- Begin by firing at low pressures until you become familiar with your launch system. Remember that an accidental launch of the rocket is a real possibility, whenever the rocket is pressurized.

Credits :
This document has been inspired by UK NPL. Michael de Podesta's booklet for the UK Water Rocket Competition.

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ANNEX
Water Rocket Test Sheet

Date	Time	Rocket Name	Rocket Weight

Launch parameter

Launch number							
Water quantity (cl)							
Launch angle (degrees)							
Launch pressure (bars)							

Launch results

Range (meters)							
Flight duration (sec)							

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