# Water Bottle Rocket (WBR) Design Competition – All Divisions

## Competition Description:

The Water Bottle Rocket Competition helps familiarize students with the fundamental principles of engineering and design. MISSION: STEM student teams will design and manufacture a water bottle rocket using a clear two-liter bottle as the pressure vessel. The rocket must be propelled only by water and air and will be measured by the amount of time it stays aloft (measured in seconds).

Each MISSION: STEM team will also create a **paper engineering notebook** as part of the design process and create a **patch design**.

Teams will consist of 3 students. At least one student per team must be present on competition day to compete.

## Competition Requirements:

*Design Requirements:*

1. The pressure vessel must be ONE clear two-liter bottle (**NO tinted bottles allowed**). See Diagram 1.
2. Water and air pressure is the sole source of propellant.
3. Leave **7.5 cm** from the throat exit plane (bottom of the rocket) clear of any coverings (paint, markings, drawings, etc.). See Diagram 1.
4. The maximum total height of the rocket is **76 cm**; see Diagram 1.
5. The nose-cone tip must have a minimum radius of **1.5 cm**; see Diagram 2.
6. Fins may extend to the throat exit plane; see Diagram 2. **(No forward-swept types of fins are allowed to be used on the rocket.)**
7. The bottle's maximum fin width distance is **10 cm** (or **16.5 cm** from the center of the bottle axis). See Diagram 3.
8. Parachutes are **NOT** allowed.
9. 3D-printed parts are **NOT** allowed.
10. Purchased rocket kits are **NOT** allowed.
11. The TOTAL cost of the water bottle rocket should not exceed **$10.00**
    - Recycled and donated materials should **NOT** be included in the total budget but **DO** show documentation of how you obtained the material in the engineering notebook.
12. While adults are encouraged to supervise and mentor the students, all ideas and work should ultimately be completed by the students.

The following materials cannot be used to construct your rocket. They are dangerous and could harm the operator and bystanders at launch.

- Metal
- Glass
- Hard plastics
- Spikes
- Antennas of any kind
- Rocks

Diagram 1

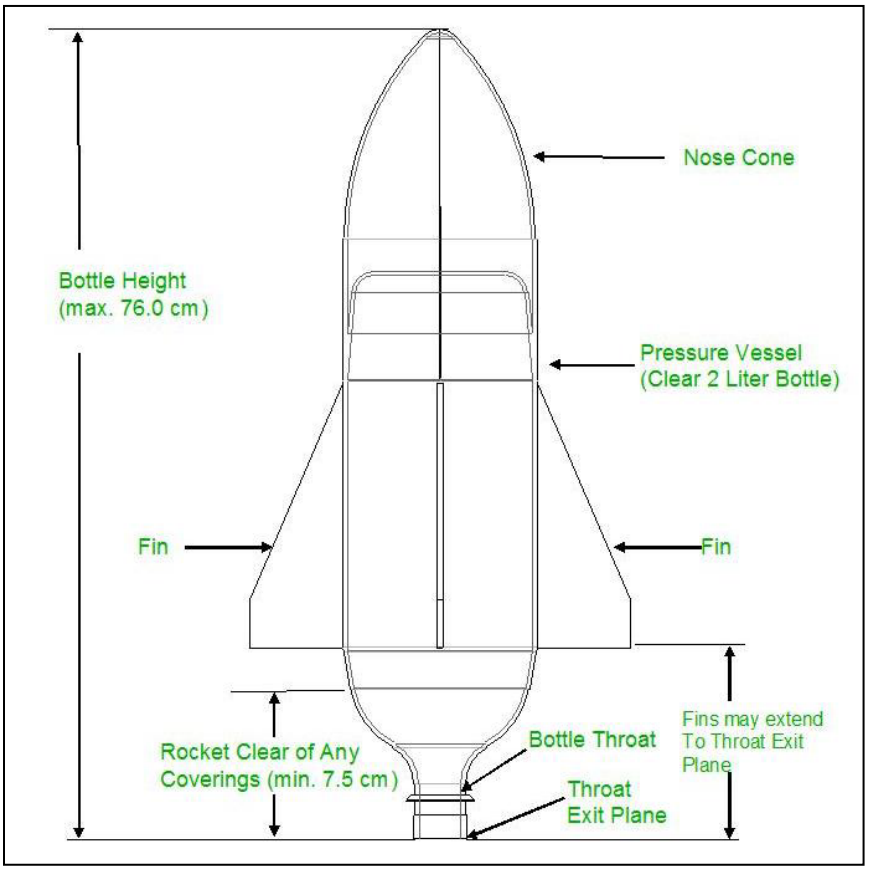


Diagram 2

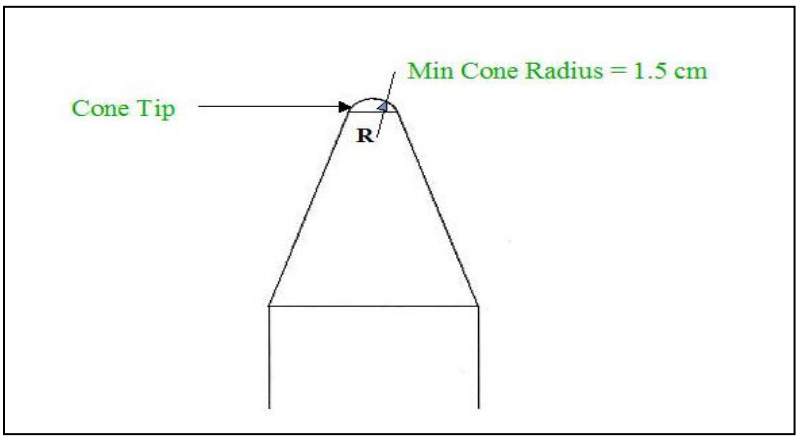
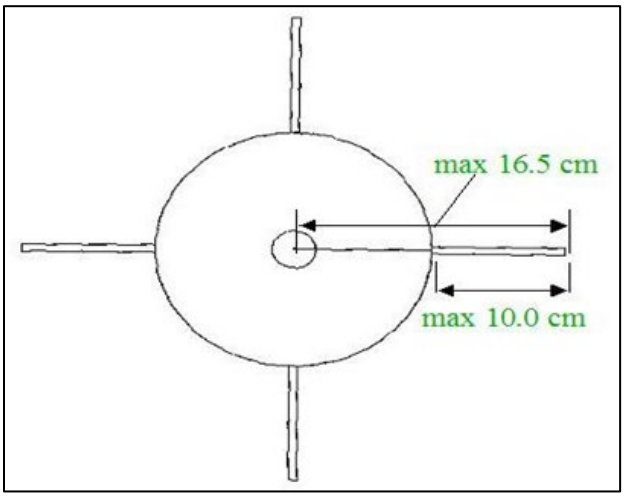
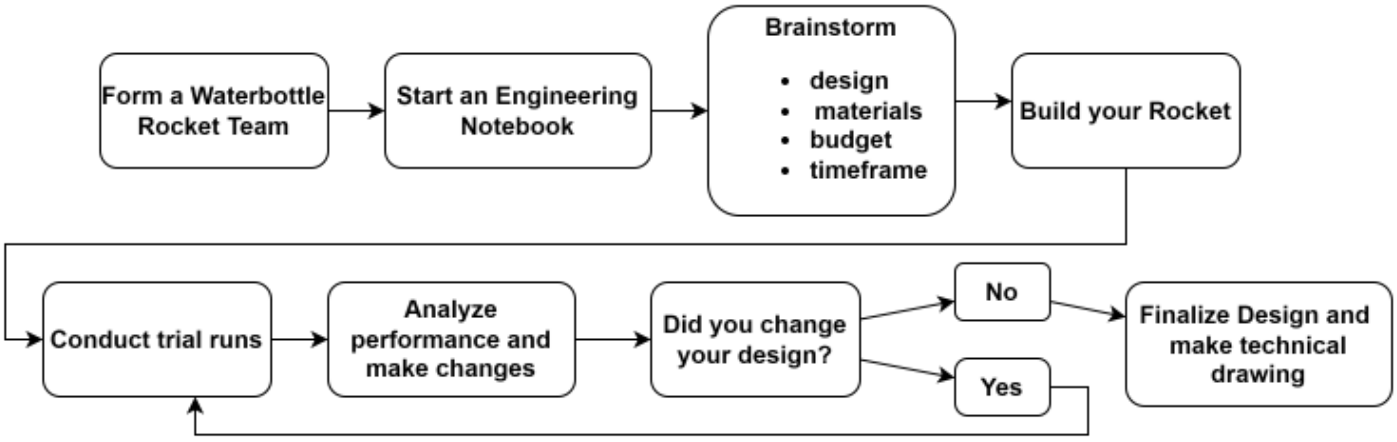



Diagram 3




**NOTE: Each entry must pass a visual inspection and height requirement in order to be eligible to compete. Entries that fail inspection will be given ONE opportunity to make modifications to pass inspection before the beginning of the water bottle rocket launching competition.**

## Design Process Map:




## Rocket Launch and Hangtime Calculation:

The launch angle, which can be adjusted from approximately 90 degrees (90°), will be kept the SAME for all rockets launched during a particular competition. Each rocket will be launched using **12 oz** water at **70 psi** of air pressure.

The hangtime score will be determined using the following calculation where:

- The **hangtime** is the time from when the rocket leaves the launch pad until it (or any part of it) reaches the ground or strikes an object. (This measurement will be taken using a stopwatch. 2-3 judges will record the time and the average of the judges' times will be used as the team's hangtime.)
- The max hangtime is the hangtime of the best performing team recorded during the MISSION: STEM Regional Competition.

$$\text{Hangtime Score} = \left(\frac{\text{team hangtime}}{\text{max hangtime}}\right) \times 100\%$$

## Engineering Notebook Requirements:

The MISSION: STEM Engineering Notebook will allow your team to document your work over the course of the year. The engineering notebook must be completed in a physical notebook (for example, a composition notebook). The requirements are listed below.

**Cover Page**

- Team Name
- Competition and Team's Division (E, M, H)
- Each team member's name and grade
- School Name and School District
- Name of team's MISSION: STEM Coordinator/Teacher

**Table of Contents**

- Include headings for:
    - Date
    - Page numbers
    - Description
    - Team members who contributed

**MISSION: STEM Team Norms and Team Roles**

- Each team needs to create a set of Team Norms and Team Roles that should be placed directly after the table of contents
    - Team norms are a set of rules or operating principles that shape team member's interactions
    - Create 5-10 team norms
    - Example: Treat each team member with respect
- Team Roles should be assigned based on each team member's strengths.
    - Team Lead: This team member is responsible for overseeing management of the project and its success. The team lead will make sure the team is on track to complete the project on time and under budget. They communicate with their coordinator/instructor for all questions and concerns.
    - Scribe/Data Anaylst: This team member is responsible for keeping the Engineering Notebook up to date and taking any meeting notes as well as recording all data for the team's original water bottle rocket and its trial runs. This includes hangtime of the original design and/or any updated design. This team member is also responsible for recording the dimensions of the water bottle rocket and documenting the materials list. This person should have clear and legible handwriting.
    - Engineering Lead: This team member is responsible for maintaining the team's original water bottle rocket design and creating any relevant technical drawings for the Engineering Notebook.

**Brainstorm**

- Include ALL ideas your team considered in the brainstorming process

**Concept Art/Sketches**

- Any preliminary sketches that were used in the developmental stages of your design process

**Materials List and Budget**

- Provide a list of materials used in your design
- Include cost of **ALL** materials **EXCEPT** recycled materials
- For recycled materials include documentation of where you obtained it
- Include a copy of receipts for **ALL** purchased materials
- Include final cost of all materials

**Technical Drawings**

- The team's Technical Drawings are required to show the front, side, and top views of the design
- Label all parts of design
- Label all relevant dimensions of the design (For example, Length, Width, or Height)

- Label all units in centimeters
- The technical drawings can be hand drawn or created digitally using a CAD program.
- Ink pens, pencils, or markers may be used

**Trial runs**

- Please include documentation of each trial run and notes/observations from each of the trial runs of the water bottle rocket design.
- Indicate which version of your water bottle rocket design you used for each trial run. (For example, Trial Run – Design 1 – Test 1)
- Include **ALL** water bottle rocket design trial runs. See below section for additional details.

**Meeting Notes**

- Include **ALL** meeting notes for water bottle rocket design.
- **ALWAYS** include the **DATE** and **TIME** of each meeting for water bottle rocket design.

## Trial Runs:

Your team will use hangtime to understand the performance of your water bottle rocket design. Your team will be able to use these data points to evaluate the effects of changes made to your water bottle rocket design. New trials must be documented each time a new design change is made to the rocket.

When documenting your water bottle rocket trial runs, record your rocket's:

1. Hangtime (see Hangtime Calculation section on page 4)
2. Include notes about the water bottle rocket's performance
3. Include a hypothesis (or prediction) of what your team thinks will happen given the new changes made by the team

Additionally, your team should include a statistical analysis of your water bottle rocket's performance. Include the following data from your team's tests:

- Average time traveled from trial runs.
  - $\bar{t} = \frac{t_1 + t_2 \ldots + t_n}{n}$
  - $\bar{t}$ is the average time traveled from trial runs measured in seconds
  - $t$ is the time traveled from a trial run measured in seconds
  - $n$ is the number of trials runs performed by the team's water bottle rocket

## Patch Design:

A patch is a creative display that reflects the dedication and mission of the MISSION: STEM student team. This symbolic picture must comply with the following patch design challenge:

1. Each student team will submit photos of their completed patch design and explanation of their patch design prior to the competition date (see deadlines on website and FAQ's).
2. Each student team will bring the physical patch and explanation with them to the competition.
3. Each entry is to be prepared and submitted by the student team members that will be participating in the Water Bottle Rocket Competition.
4. Patch designs must be submitted on a 13" x 13" poster board.
5. All patch entries must incorporate the MISSION: STEM competition theme: **Destination SpaceU**
6. A short (less than one-page) explanation of the patch's symbols must be included on the back of the patch design.

The following information should also be included on the back:

a. Team name
b. Division (ex. Elementary School Division)
c. School Name and School District
d. Student Team Members' Names and Grade Levels
e. MISSION: STEM Coordinator's/Teacher's Name

7. All student teams participating in the Water Bottle Rocket Competition must display their patch before the launch of their rocket and may be asked additional questions by the judges regarding the design.
8. **Patch Design must be the original work of the student team.** It must be hand-made (**NOT** computer-generated) and age-appropriate.
9. Only ink pens, pencils, colored pencils, crayons, markers, or paint may be used.

**NOTE: Any patch design deemed inappropriate will be removed from the competition, and the team will receive zero patch design points.**

**THE PATCH DESIGN WILL BE JUDGED ON THE FOLLOWING CRITERIA:**

1. Paper Size Requirement (13" x 13" poster board)
2. Incorporation of the theme: Destination SpaceU
3. Appearance
4. Creativity
5. Explanation of Patch – Less than one page explanation of your patch

## Submission Requirements and Scoring

An overall winner will be judged upon the following criteria (based on 100 points):

1. Final Hangtime of Rocket – 50%
2. Engineering Notebook – 30%
    - The notebooks will be evaluated by judges at the regional competition. You must bring your physical notebook to receive a score.
3. Patch Design – 20%
    - Photos of the patch to be submitted prior to the regional competition. Teams must also bring the patch design to the regional competition for final scoring.

**Final Score = Hangtime Score (0.50) + Engineering Notebook (0.30) + Patch Design (0.20)**