

# Water Bottle Rocket (WBR) Design Competition – Middle and High School Divisions

## Competition Description:

Get ready to unleash your creativity and engineering skills in the "Soar to Success" Water Bottle Rocket Competition! The Water Bottle Rocket Competition helps familiarize students with the fundamental principles of engineering and design. SECME student teams will design and manufacture a Water Bottle Rocket using a clear two-liter bottle. The rocket must be propelled only by water and air. **NEW!** For this year's challenge, the winning rocket will have the highest apogee (peak height) in meters, as measured by a [clinometer](#).

Each SECME team is required to create an **engineering notebook** and a **presentation** as part of the design process.

## 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 of the 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. The TOTAL cost of the water bottle rocket should not exceed \$10.00
  1. Recycled and donated materials should **NOT** be included in the total budget but **DO** show documentation of how you obtained the material

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

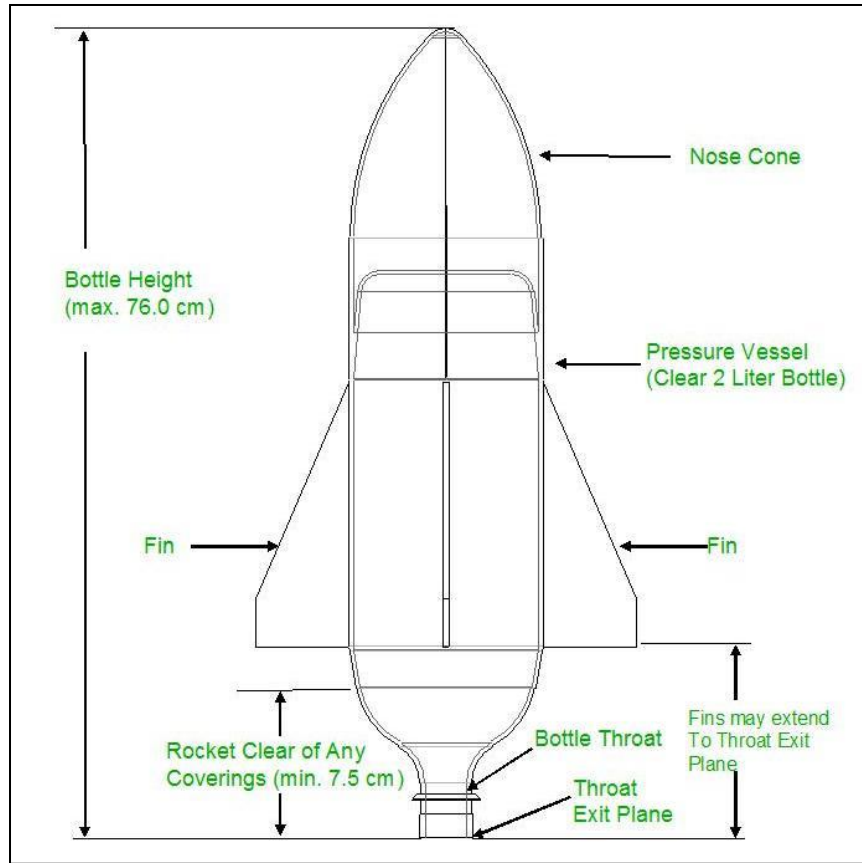


Diagram 2

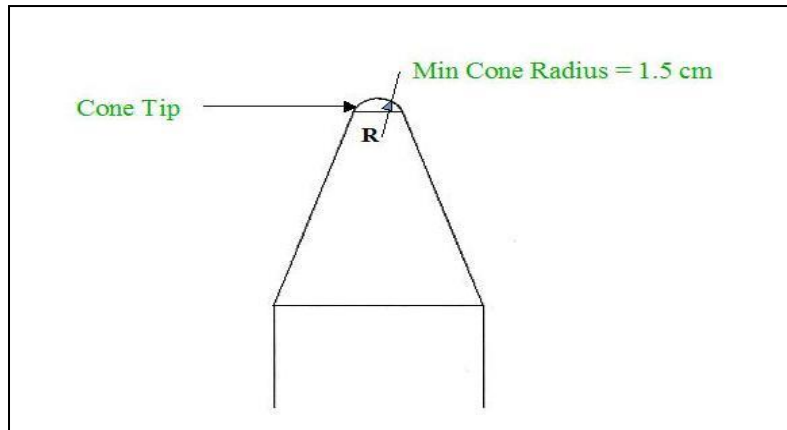
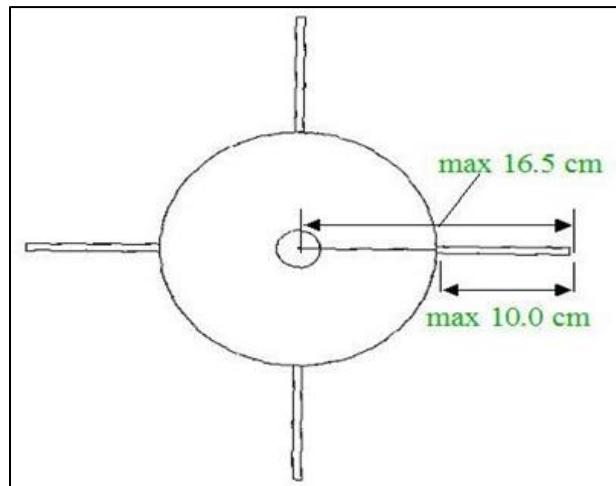
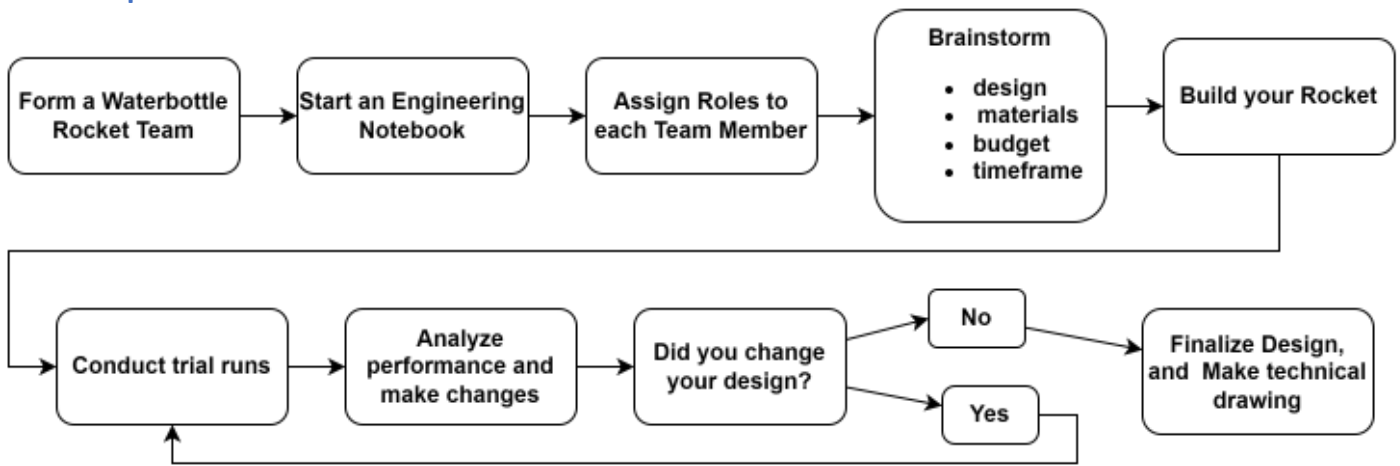


Diagram 3



## Process Map:



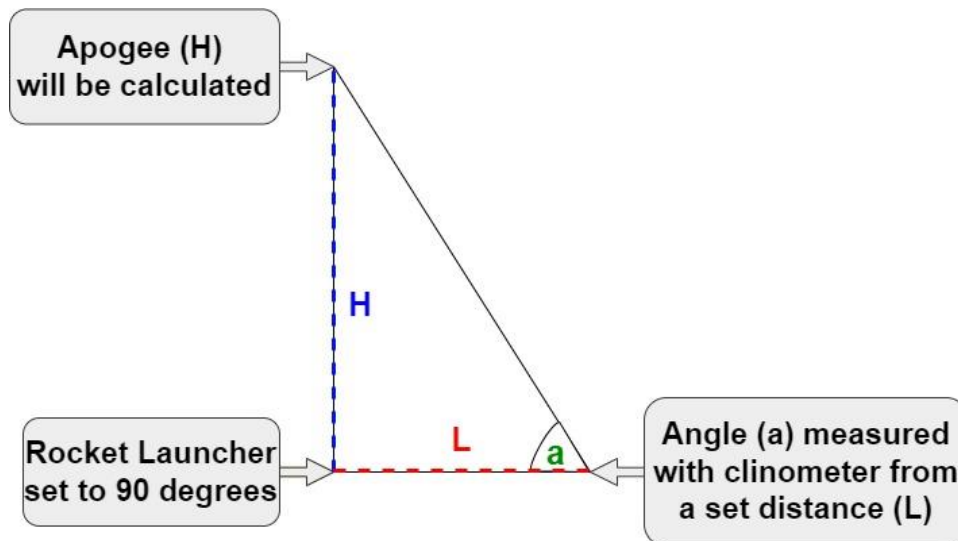
## Rocket Launch and Apogee Calculation

Rockets will launch straight up. Therefore, the launch angle will be set to **90 degrees (90°)** and 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 apogee will be calculated using the following equation:

$$H = L \times \tan a$$

- **H** is the apogee, or peak height measured in meters.
- **L** is the distance between the rocket launcher and where the measurement is being taken with the clinometer measured in meters.
- **a** is the angle measured using the [clinometer](#)



The score will be determined using the following calculation where:

- The **team apogee** is the maximum height reached by the water bottle rocket. (This measurement will be taken using a clinometer.)
- The **max apogee** is the apogee of the best performing team recorded during the SECME Competition.

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

## SECME Engineering Notebook Requirements

The SECME Engineering Notebook will allow your team to show all your hard work. Below, you will see the requirements for your team's Engineering Notebook. The engineering notebook must be completed in a physical notebook, for example, a composition notebook.

### Cover Page

- SECME Team Name
- Team's Competition Type and Division
- Each team member's name and grade
- School Name and District Name
- School City and State
- Name and Email of team's school representative (coordinator or teacher)

### Table of Contents

- Include headings and page numbers

### SECME 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. Roles are based on 4 person teams. If your team has only 2 or 3 members, you can combine roles or double up as needed.
  - 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: This team member is responsible for keeping the Engineering Notebook up to date and taking any meeting notes. This person should have clear and legible handwriting. They also will need to communicate with each team member to collect information and work for the Engineering Notebook.
  - 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.
  - Data Analyst: This team member is responsible for recording all data for the team's original water bottle rocket and its trial runs. This includes apogee (height) 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. The data analyst will use the materials list to collaborate with the team lead on the budget.

### 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

- Please 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 photo 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 (ex-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

## Photos

- Include photos of the front, side, and top views of the design

## 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. (i.e., Trial Run – Design 1 – Test 1)
- Include **ALL** water bottle rocket design trial runs.

## Meeting Notes

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

## Trial Runs

Your team will use the apogee 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. Each water bottle rocket design requires a minimum of 3 trial runs. Each SECME team must complete and record a minimum of 6 trial runs of their water bottle rocket design in their SECME engineering notebook.

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

1. Apogee (peak height) measured in meters using a clinometer.
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 will need to include a statistical analysis of your water bottle rocket's performance. Include the following data from your team's tests:

1. Average time traveled from trial runs.

a. 
$$\bar{h} = \frac{h_1 + h_2 + \dots + h_n}{n}$$

$\bar{h}$  is the average height traveled from trial runs measured in meters.

$h$  is the height traveled from a trial run measured in meters.

$n$  is the number of trials runs performed by the team's water bottle rocket.

## Presentation

The Presentation will allow your team to showcase your work in a presentation format. You may use the platform of your choice (PowerPoint, Google Slides, Canva, etc.) We hope that through this presentation your team will be able to further showcase your design and all the hard work you have done. Please use the information below as a template for your presentation.

### Title Slide

- SECME Team Name
- Team's Competition Type and Division
- School Name and District Name
- School City and State
- Name and Email of team's school representative (coordinator or teacher)

### About Your Team Side

- Team Photo
- Team members names, grade levels, and team roles.
- Years involved with SECME

### Brainstorm and Sketches

- Include the final ideas your team considered in the brainstorming process
- Explain why you **DID NOT** use them in your final design
- Include any sketches you used in your brainstorming process

### Drawings of the Final Design

- Include a sketch of the final design (this is **NOT** your technical drawing)
- Explain what you used from your brainstorming process and why you included it

### Materials list and Budget

- Please provide a list of **ALL** materials used in your design along with pictures of the materials
- Include cost of **ALL** materials **EXCEPT** recycled materials
- For recycled materials include documentation of where you obtained it
- Include recipes for **ALL** purchased materials
- Include final cost of all materials and how much money you had left

### 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 and explain their functionality
- Label all relevant dimensions of the design in centimeters (ex-Length, Width, or Height)
- Include a color photo of your water bottle rocket next to the technical drawing

### Trial Runs

- Include data from your most recent trial run on your final design

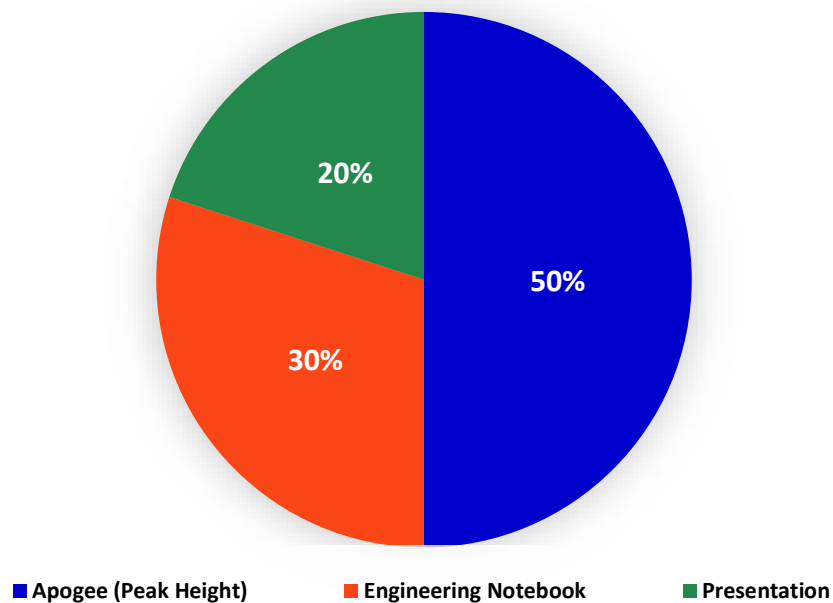
### Conclusions and Future Recommendations

- Provide your team's conclusion on your design process and any recommendations you have to better your design in the future (For example, if cost were not a constraint)

## Submission Requirements and Scoring

1. **Final Hangtime of Rocket – 50%**
  - The notebooks will be evaluated by judges at the competition. You must bring your physical notebook to receive a score.
2. **Engineering Notebook – 30%**
  - The notebooks will be evaluated by judges at the competition. You must bring your physical notebook to receive a score.
3. **Presentation – 20%**
  - The presentation must be submitted as a PDF with the file name SECME\_WBR\_Presentation\_Your Division\_Your School Name.  
\*Your division is either “Middle” or “High”.

Water Bottle Rocket Competition Scoring





**\*\* NOTE – Only Teams Proceeding to the National Competition!!!!**

Teams who place 1st at their Regional Competitions and proceed to the National Competitions must submit a video recording of themselves presenting their design.

Please use the information below as a guide for your video recording.

- Introduction
  - State your School Name, School City, School State, Team Name, and Competition Type/Division
  - Introduce your team with your names and grade levels
- Engineering Notebook
  - Please present and show all aspects of your engineering notebook
  - Explain all aspects of your design and your design process
  - Avoid reading directly from your Engineering Notebook
- Conclusions and Future Recommendations
  - Provide any conclusions you have on your design process and any recommendations you have to better your design in the future (For example, if cost were not a constraint)
- Expectations and Requirements
  - ALL team members should be in their Video Presentation and have a speaking role
  - The video should be between 5 and 7 minutes, in mp4 format, and with the file name “SECME\_WBR\_Video\_Your Division\_Your School Name.”  
**\*\*Your Division” is either “High” or “Middle“**