Robogals Science Challenge

Minor Challenge Set #1
STEM Field: Astronomy
Level: Intermediate
Challenge Name: Launch Your Own Rocket
Project cost: 20-50 USD
Materials required:

- Empty plastic bottle (2L)
- A wine cork
- A launchpad (you can either buy this, or see details in the Instructions section for building your own)
- Safety goggles (put these prior to starting the challenge)
- Miscellaneous craft material (scissors, tape, foil, cardboard, etc)

You can choose between a chemical launch (option 1) or a pressurized launch (option 2), or both. The materials for both options are listed below:

- Option 1: Chemical launch
  - Baking soda (bicarbonate of soda)
  - White vinegar
  - Paper towel
- Option 2: Pressurized launch
  - Water
  - Bicycle pump - including an air valve
  - Materials to create fins and nose cones (e.g. scissors, tape, construction paper, foam, foil, cardstock, etc)
  - Material to drill the wine cork

Safety:

- Adult supervision is required when drilling the cork and during the rocket launch.
- This activity needs to be conducted outdoors away from people and buildings. Do not stand too close to the rocket. Wear safety goggles.
- For Option 1: Rinse off everything with water after the launch is done. This is important to ensure that all the reactants (vinegar and baking soda) are neutralized and don't cause any damage.
- For Option 2: Do not pressurize the rocket past 40 psi (pounds per square inch) or 275 kPa (kilopascal)

Duration:

- This challenge will take about 3 hours to complete. However, the time guideline is an estimation only, and students and mentors can complete the tasks around their schedules.

Introduction:

Rockets are cool! You can build your own and have fun launching it and seeing how far it can go in this challenge. In this experiment, you have the choice between making a chemical based rocket, a pressurized one, or even both!

<u>Option 1: Chemical launch</u>

The chemical launch is based on a very popular reaction between baking soda (chemical name: sodium bicarbonate) and vinegar (contains acetic acid). The reaction between these two reactants is a simple acid-base chemical reaction that produces carbon dioxid e (amongst other things), which is the gas responsible for the bubbling you will see.

Here is the chemical formula of this reaction:

$$C_2H_4O_2 + NaHCO_3 \rightarrow NaC_2H_3O_2 + H_2O + CO_2$$

Acetic acid + Sodium bicarbonate -> Sodium acetate + Water + Carbon dioxide

<u>Option 2: Pressurized launch</u>

The pressurized launch is based on Newton's third law of motion. By filling the bottle rocket with compressed air, the air pushes the bottle upwards. The more pressure you add, the greater the acceleration, and the higher the rocket will fly!

Instructions:

Safety: Make sure you're wearing your safety glasses before you start.

1. Set up your launchpad! If you bought one online, follow the instructions that came with it. If you decide to make one yourself, there are many fun ways to do this. The idea is to build something that will be the right size to hold the bottle and be stable and strong.

   Suggested materials include LEGO (see Figure 1), craft sticks, tinker toys, cardboard and glue (see Figure 2), etc. Be creative! Make sure you set up your launchpad outside, in a big open area, on flat ground.

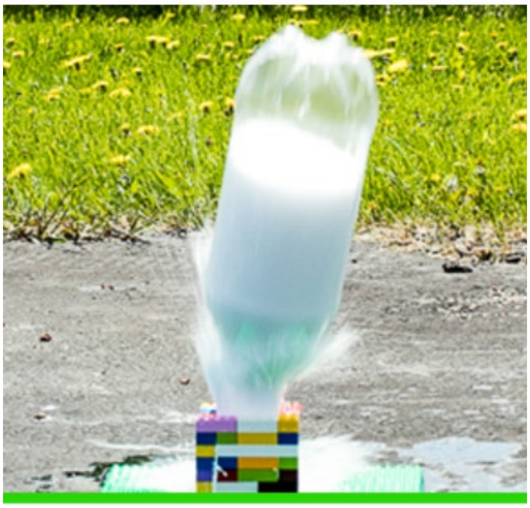

Figure 1. Chemical launch with LEGO launch pad.

Figure 2. Pressurized launch with cardboard launch pad.

2. Prepare the rocket!

   Option 1: Place approximately 1–2 cups of vinegar in the bottle. Take a piece of paper towel and cut it into a 4 inch (10 cm) square. Place a tablespoon of baking soda in the centre of the paper towel. Fold up the paper towel so the baking soda is wrapped up inside and it fits snugly inside the mouth of the bottle. Insert a wine cork into the mouth of the plastic bottle, make sure it is in there tightly.

   Option 2: With adult supervision/ask your parent/guardian to drill a hole into the wine cork to allow the air valve from the pump to be inserted. Fill the bottle with about 300-400 mL of water (about ¼ full). Fit the cork into the bottle. Turn the rocket (your bottle) upside down on the launching pad. See Figure 2.

3. *[Optional]* Decorate the rocket! Feel free to use markers or other materials to make the bottle look like a rocket. Feel free to add a passenger (hard boiled egg, tennis ball, etc.). You can also add fins and a nose cone to help it fly along a straight path. To balance the rocket, you can also add a small amount of ballast weight inside the nose cone.

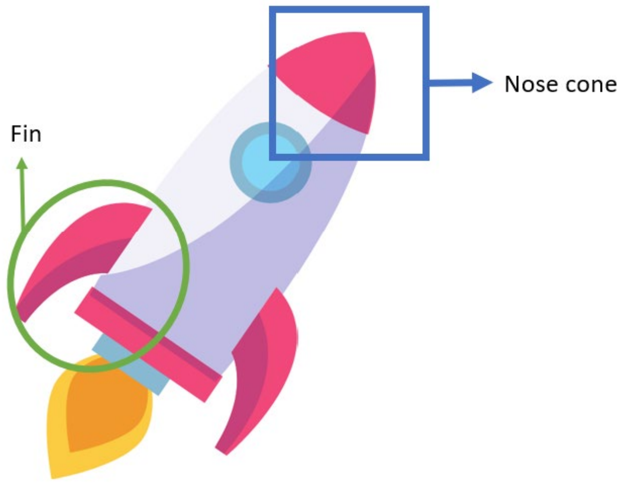

Figure 3. A visual example of nose cone (highlighted in blue box) and fin (highlighted in green circle)

4. Launch!

   3… 2…1… Launch!

   Option 1: Flip the bottle over and place it in the launch pad. Move back quickly and enjoy!

   Option 2: Stand back and carefully pump air into the bottle. The pressure will start to build and after a few seconds, your rocket will blast off into the air!

5. Experiment with different bottles' sizes for the rockets or vary the amount of water inside the bottle. What do you notice?

6. *[Optional]* So, how do things get launched into space?

   Navigate to this website on your computer or tablet: https://spaceplace.nasa.gov/launching -into-space/en/

   This article from NASA includes information and an excellent video on how satellites and spacecraft are put on rockets with enough fuel to boost them above most of Earth's atmosphere.

Extension:

Task 1: Try to find ways to make your rocket go higher! Experiment with different pressure levels and different amounts of water inside the rocket.

Task 2: Build a Bubble-Powered Rocket

If you would like to try and build another rocket using paper and fizzing tablets, here is an activity with building instructions from NASA.

https://spaceplace.nasa.gov/pop -rocket/en/

In addition, check out the explanation at the bottom of the webpage describing how the pop -rocket works!

Reflection Questions:

- Are there any improvements you would make to this challenge?
- What real world application/s can you apply this challenge to?
- What are the key science and engineering concepts that relate to this challenge?

- If you vary the bottles' sizes: Would a smaller or larger bottle go higher?
- If you vary the amount of water inside the bottle: Does the rocket fly higher if it is filled with only air? Why, or why not?
- How can you modify the bottle rocket to get longer or higher flights?
- Can you estimate how high the rocket goes or measure the speed of the rocket as it leaves the launchpad?

Submission Guidelines:

- Submit a photo of your rocket setup. Include a short summary that addresses the reflection questions.

> Note: Remember, if you want to upload pictures of your Minor Challenge that also include you, please check if it is OK with your mentor first.

- The submission form is on the Minor Challenges page: https://sciencechallenge.org.au/index.php/minor -challenges/ Fill out the details and make sure you upload your submission.

Learn More! Resources:

- Newton's third law of motion: https://www1.grc.nasa.gov/beginners -guide-to-aeronautics/newtons -laws-of-motion/
- The chemical reaction between baking soda and vinegar: https://sciencenotes.org/chemical -equation-for-baking-soda-and-vinegar-reaction/

Bibliography:

- STEAM Powered Family. 2021. Bottle Rockets - Simple and Fun Summer STEM. [online] Available at: <https://www.steampoweredfamily.com/activities/bottle-rockets/> [Accessed 31 December 2021].
- Science World. 2021. Pop Bottle Rocket, Part I: Action and Reaction - Science World. [online] Available at: <https://www.scienceworld.ca/resource/pop-bottle-rocket-part-i-action-and-reaction/> [Accessed 31 December 2021].
- Stem.org.uk. 2022. [online] Available at: <https://www.stem.org.uk/sites/default/files/preview/elibrary-resources/legacy_files_migrated/22820-14_water%20rockets.pdf.jpg> [Accessed 1 January 2022].