Bottle Rockets

Y10 Physics – Teacher Guide

Bottle Rocket Launcher
Type used is an Aquapod Bottle Launcher. This was selected as no special nozzle for the bottle is required. However there are many versions available over a huge price range.

Timeframe
As an assessment task this works particularly well as a three lesson sequence:
- Design and built
- Testing and data collection
- Write-up

Set-Up
The Aquapod Lauchers can be found on eBay for around $30. Other equipment is standard materials easily found in any high-school Science prep room. The items listed are also given with reasons for their choice. This list can be amended, noting that **any** plastic bottle with a **standard size** neck will successfully launch.

- **1.25 lt fizzy drink bottles** (encourage students to bring their own). Note it should be a plastic fizzy-drink bottle specifically, as these are pressure tested and will withstand any pressure delivered via the air pump that is below the safely release on the launcher.

- **Plasticine for nose ballast.** Adding around a golf ball sized lump of Plasticine, or similar, to the nose of the rocket will help it to maintain a straight flight path.

- **Cardboard or plastic for nose cone.** If adding ballast as detailed above, to help streamline the rocket and also keep the mass in place, a nose cone can be added as a design feature. Disposable cups may also be used, but these tend to break after the first landing. If nose cones are added, students need to be extra vigilant about not wandering out into the launch zone, as some cones can be quite pointed.

- **Cardboard or plastic for wings.** Again these are an optional design feature that adds some flight stability. If students add these, care needs to be taken to ensure they do not protrude below the bottle opening, as this will interfere with the fitting to the launcher.

- **Tape, scissors, hot glue** for securing design features. In most cases students will get to launch their rockets serval times, and the crash landing can lead to significant damage if features are not well attached. Care if using at hot glue, as it can melt the bottle walls. Any holes will prevent the pressure building up and thus a failed launch will result.

- **Water buckets and jugs** with pouring spout. To fill rockets for launch.

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Safety and Risk Management

The design aspect of the task is low risk, with the only hazards been those associated with any craft activities (scissors, hot glue guns). Before students partake in the launch activity however, strict guidelines must be set-out. This is not a hazardous activity as long as vigilance is maintained at all times.

- The area used for launching needs to be outdoors and away from buildings (an oval is ideal).
- The launcher comes with a safety strap so that students are several meters away when launching.
- Rockets can gain significant height, and if not triggering/timing the launch in question, other students should stand well away and keep an eye on the rocket in flight.
- Goggles and a hard hat are advised when entering the launch area.
- Under no circumstances lean over a pressurized rocket.
- The launcher is equipped with a safety release valve should the pressure exceed recommended values, please always refer to the manufactures recommendations for your specific launcher.

Any other risk aspect as discussed with your science domain leader/lab manager.

Assessment

The laboratory write-up for this task can be done in a number of ways depending on the outcomes you wish to meet, and the assessment methods of your school.

- Individual prac report (standard assessment)
- Group poster task (excellent preparation for VCE)
- Data collection and analysis:
  - Number of air pumps vs. height achieved
  - Optimizing the air water ratio
  - Effects of design features
- Physics theory questions (examples attached, these can be modified wherever appropriate to your class)

This activity is also an excellent task in meeting the needs of the diverse learner. An unmodified bottle will launch, regardless of its features, and so all students will have the opportunity to be fully involved in the activities. It is also an easy task to extend for more advanced students to move beyond the basic requirements of the assigned lab exercise, and explore the topic at a deeper level, such as the relationships between equations, the energy transformations involved, down to advanced design features such as soft landings.

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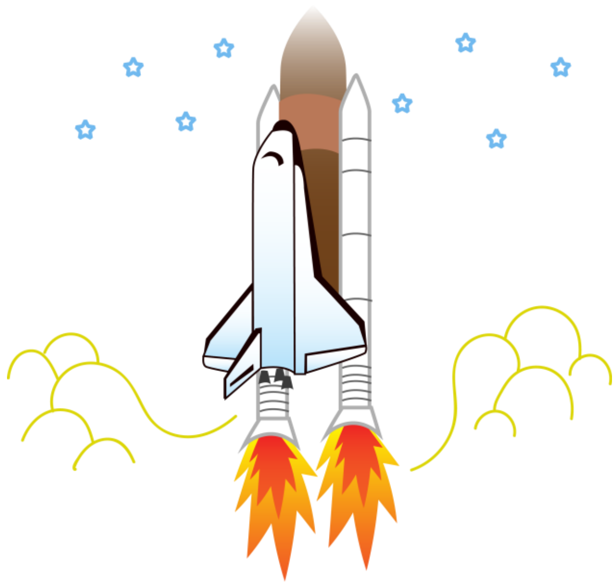
Y10 Physics – Student Worksheet

Aim
To design, construct and test a bottle rocket of your own design, and to complete a detailed physics analysis of its flight.

Your analysis must include the following points for inquiry.

- Calculating the maximum height
- Optimising the water to air ratio
- Discussion of errors



Instructions
Working in pairs, you will have three lessons to complete this task:

1. Design and construction. During this first section you may use the internet/books for research, make sure you include all references.
2. Testing and collecting data
3. Write-up. Under test conditions, you are allowed to bring a calculator and your raw data/notes from the previous two lessons.

The report must include the following sections. Everything up to the results section should be completed at home, either in your lab books or typed and printed. Make sure you bring this with you to the final lesson where the remaining write up will be completed under test conditions.

- **Introduction** – A paragraph or two of the theory that relates to the experiment, including a general introduction to forces and motion and how these ideas interact with our everyday lives.

- **Aim** – Describe in a single sentence how and what you are going to test and what you are looking for in the results. What is the purpose of doing this experiment? What are you trying to find/calculate/compare?

- **Hypothesis** – In this section you write down what you think the results will be, using scientific reasoning to explain your hypothesis. For example; if *x* occurs then *y* will happen. Make sure you justify your hypothesis, thus includes making numerical (calculated) predictions wherever possible.

- **Materials** – List all the equipment you are going to use to carry out the experiment including the quantities e.g. 20ml of water.

- **Method** – In this section write down the numbered steps for carrying out the experiment. You also need to provide a detailed and accurately labelled diagram where relevant. Note that more than one diagram may be required, and should be drawn clearly and of a good size.

- **Safety** – List all relevant safety considerations associated with the experiment.

- **Results** – Present your results in a table where possible. This should include appropriate headings, and graphs (if appropriate) should be included in this section. All calculations should be completed in this section making sure you show the equations, define the symbols and show all working out. All observations should be described in detail.

- **Discussion and Conclusions** – Re-read your aims and your hypothesis. What do you think your results show about the experiment? What things could affect the accuracy of your results? What were the variables in your experiment, and how did you control them? Did you encounter any problems while completing the experiment? How did you overcome these problems?

- **Limitations and Improvements** – Are there any changes that could be made to your method section to improve the experiment? What other tests could be done, for example to help you explain the results of this experiment and to extend your investigations

The report should be written in the third person (don't use I/we).
DO NOT cut or pierce your plastic bottle… the rocket will not work!

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Y10 Physics – Accompanying Questions

1. In 1.2 seconds a bottle rocket falls a distance of 20 metres (**2 marks**):
   a) What is the average velocity of its fall in ms^{-1}?
   b) Convert your answer to km/hr.

2. Draw a diagram to show the forces acting on the rocket at each of the following stages of its flight (**3 marks**):
   a) On the launch pad.
   b) Falling back to Earth.
   c) At the top of its flight where direction changes.

3. Discuss the energy transformations involved through the entire bottle rocket launch and flight. Start with the potential energy stored by the compressed air (**3 marks**).

4. Explain what is meant by terminal velocity for a falling object. Why can it not be exceeded (**3 marks**)?

5. If a 3 kg rocket is falling with a terminal velocity of 100 km/hr, what is its kinetic energy (**2 marks**)?

6. A rocket has 1500 units of momentum. Using the equation for momentum to support your answer, what would be the rockets new momentum if (**2 marks**):
   a) Its mass was doubled?
   b) Its velocity was doubled?
   c) Its velocity was tripled?
   d) Both its velocity mass were doubled?

7. Discuss Newton’s third law in terms of a rocket launch. Your answer should include a diagram with the forces clearly labelled (**5 marks**).

8. If your bottle rocket had a mass of 250 grams, and the entire flight (from launch to landing) took 3.8 seconds, calculate the following values.
   a) Maximum height (**3 marks**).
   b) Gravitational potential energy at this height (**1 mark**).
   c) Kinetic energy when it hits the ground (**1 mark**)?
   d) From this determine its velocity on impact (**3 marks**).

9. Your rocket made it into space! An astronaut leaves the rocket for extravehicular activities. Her mass (including her space suit) is 105 kg and she is travelling with a velocity of 7000 ms^{-1}.
   a) What is the astronaut’s momentum (**1 mark**)?
   b) The astronaut encounters a cloud of stationary space dust and the dust sticks to her suit. As a result her speed changes from 7000 ms^{-1} to 6800 ms^{-1}. Calculate the mass of the dust that has accumulated on her suit during the collision (**3 marks**).
   c) If the collision with the dust cloud took 30 seconds, calculate the average force on the astronaut during this time (**3 marks**).

Time 60 mins
Total marks available: 35