Activity – Bottle Rockets Challenge

Activity Summary

A rocket made from a two litre fizzy drinks bottle, e.g. a lemonade bottle, is partially filled with water and pumped up using a bicycle pump. It is fired off a launch pad and can travel over 20 metres. The challenge is to see who can get their bottle to travel the furthest.

Consumables

Per rocket
2 litre plastic fizzy drinks bottle
2 sheets of stiff card
Sponge or soft foam
Duct tape

Per launch pad

2 m of wood around 20 mm x 20 mm section

Per valve assembly

1 old bicycle tyre with working valve which fits the pump
Wine cork which fits the bottle

Equipment

Scissors
Glue gun (or wood screws)
Stanley knife
Hacksaw
Vice
Drill with drill bit of same diameter as the valve
Bicycle track pump (also known as a floor or stand pump)
Marker pen
Tape measure

Introduction

The plastic drinks bottle acts as a reservoir in which compressed air is stored. Due to the compressibility of air, this is an effective way of storing energy. The water does not compress, and therefore does not store energy. When the pressure in the bottle is enough to blow the cork out, the water is also forced out by the compressed air, providing the reactive force which propels the bottle forwards.

Engineering principles:

1. Storing energy using compressed air.
2. Transfer of stored energy to kinetic energy of the bottle and the water.
3. Newton's third law – action and reaction are equal and opposite.
4. Stability of flight.
5. Optimising angle of trajectory to give maximum range.

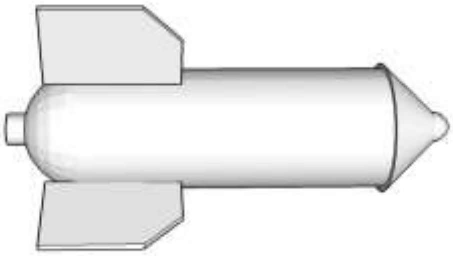
Difficulties and suggestions:

1. Bend the fins out as shown to avoid getting them caught in the launch pad when it fires.
2. Don't push the cork in too far, as it will require too much pressure to get it to fire.
3. Plastic corks are more robust than cork ones, and less likely to leak.
4. The hole in the cork must be a tight fit on the valve.
5. It is good to make a spare valve, as they can leak.
6. If you keep back one bottle without adding fins and a nose cone you can compare the flight.
7. You can make launch pads at different angles (say 45° to 75°) to compare trajectories.
8. If launching at a very shallow angle the water won't cover the valve, so you blow out compressed air instead and it doesn't fire properly.
9. Stand to one side when firing, otherwise you may get wet!
10. Make sure no-one is standing in the launch area when firing.
11. You can experiment with different amounts of water to try and get maximum range.

Main activity

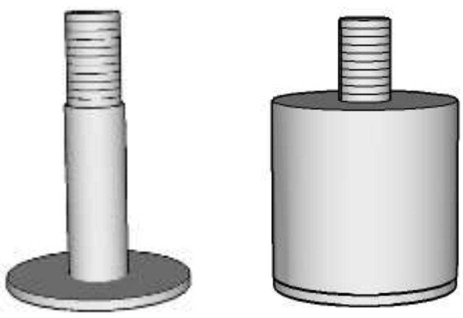
A. Construct the rocket (here is a typical design):

1. Cut a circle of stiff card, slightly larger in diameter than the bottle.
2. Cut out a 90° segment and form a cone shape.
3. Tape or glue down the seam.
4. Tape the cone to the base of the bottle using duct tape.
5. Cut out a piece of sponge or foam and tape to the point of the cone. This is to protect anything the rocket might land on!
6. Cut out three fins and tape to the sides of the bottle as shown, at the opposite end from the cone.



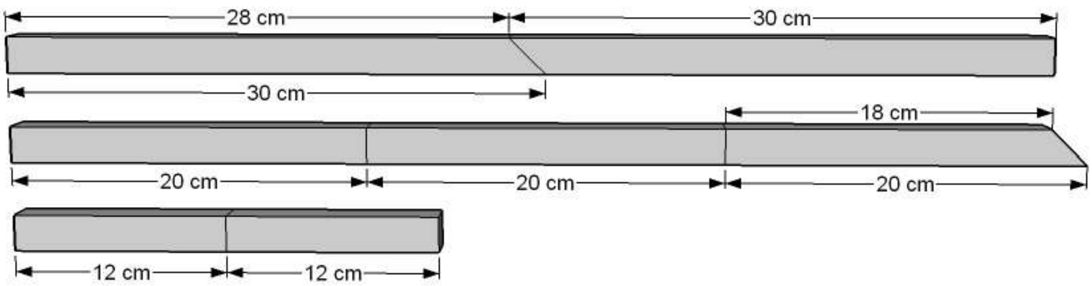
B. Construct the valve assembly as follows:

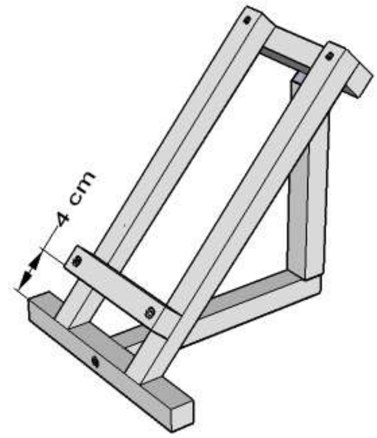
1. With the valve in the middle, cut a disc in the bicycle tyre the same diameter as the cork.
2. Cut the cork to approximately 20mm long using the Stanley knife. The valve must protrude enough to engage with the pump properly.
3. Drill a hole down the centre of the cork. It must be a tight fit on the valve.
4. Press the valve firmly into the cork.



C. Construct the launch pad:

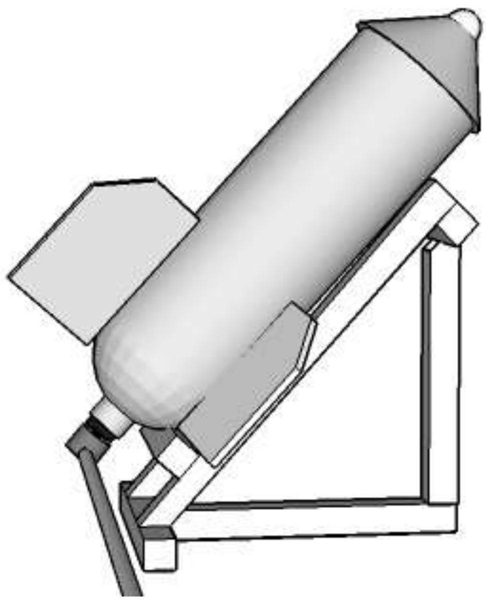
Here is a typical design giving roughly 45° trajectory. You can launch all the bottle rockets from one launch pad or make different launch pads for different angles of trajectory.





1. Cut the wood to the following lengths using the hacksaw: 3 x 200mm, 2 x 300mm, 2 x 120mm.
2. Cut one end of the two 300mm pieces at 45°. Also cut one end of a 200mm piece at 45°.
3. Glue or screw together as shown to make the launch pad.

D. Trial the rocket:



1. Push (or screw, depending on pump type) the valve assembly into the pump adapter.
2. Fill the bottle with water until it is about a third full. You could mark the level on the bottle so that you can compare trajectories for different amounts of water.
3. Push the cork into the bottle – if you push the cork in more the bottle will generally go further. However if you push it in too far it won't come out at all.
4. Bend the lower fins out to the sides and rest the bottle on the launch pad with the cork downwards.
5. Ensure there is no-one in the firing zone.
6. Stand to one side of the rocket and pump it until it fires.
7. Measure and compare the distance travelled and try to work out what variables you need to vary to optimise the trajectory.

Wrapping up

Which rocket went the furthest?

Was there an optimum amount of water?

What was the best angle of trajectory?

How did the rockets with fins and nose cone fly, compared to those without? (Without the fins and nose cone they can tumble head over heels as they fly. The ones with nose cone and fins are more likely to fly straight.)

What was the most difficult part and what was the solution?

Curriculum links

1. Energy storage
2. Kinetic energy
3. Energy transfer
4. Angle of trajectory

Activity variations

Pop rockets – these use fizzy tablets to produce the air pressure required to fire the rocket.

Squeeze rockets and stomp rockets – apply force to the outside of the bottle to produce the pressure to fire the rocket.

See *Technology for Fun 1* and *Physics for Fun* for details of how to make these variations.