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Balloon Rockets

Introduction

Experiment with Newton's third law of motion and launch a balloon rocket across the classroom.

Concepts

- Newton's third law of motion
- Bernoulli's principle
- Rocket engine thrust
- Friction

Background

Newton's third law of motion states that for every action force there is an equal and opposite reaction force. Rockets clearly show Newton's third law in action. When a rocket burns fuel, hot gases are forced out the bottom of the rocket at high speed. The fast-moving gas particles are pushed by the rocket chamber in one direction and the gas particles, in turn, push on the rocket in the opposite direction. A common misconception about rocket thrust is that when the fast-moving gas particles exit a rocket engine, the gas particles push against the air outside the rocket and this causes the rocket to shoot upward. However, if this were the case, then rockets would never work in outer space because there are no air molecules in space for the fast-moving gases to push against. Instead, the fast-moving particles are forced out the rocket engine by the body of the engine.

When the fuel burns, a great amount of heat is created and the pressure inside the rocket combustion chamber increases. At the same time, the walls of the combustion chamber push back on the fast-moving gas particles. Rockets are composed of strong, solid materials with a small opening at the bottom. This opening is the only region on the engine where the pressure can be released. Since gas particles move from high to low pressure, the gas shoots out the bottom of the rocket. This creates a net force that thrusts the rocket in the opposite direction of the ejected gases (see Figure 1).

{13256_Background_Figure_1}
An enormous amount of fast-moving gas particles need to be generated in order to lift a rocket into orbit. A small thrust channel increases the speed of the hot gases as they exit from the larger combustion chamber. Gases always accelerate toward lower pressure, so the high-pressure gas moves faster and faster as it rushes out of the nozzle. The constricted flow path increases the speed of the gas particles. This increase in particle speed in a chamber as the diameter decreases is an example of Bernoulli's principle (see Figure 2). The small-diameter chamber increases the speed of the exiting particles and therefore increases the net force that blasts off the rocket.
{13256_Background_Figure_2}

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{13256_Overview_Figure_3}

Experiment Overview

The purpose of this experiment is to investigate the variables involved in launching a "balloon rocket" across a classroom. Balloon thrust, friction and rocket "guidance" play crucial roles in the successful launch of a balloon rocket across the classroom.

Materials

Balloons, thin and long, 2–3

Clothespin (to temporarily seal the balloon)

Fishing line, classroom-length (for rocket guidance)

Scissors

Straw

Support stands, 2 (optional)

Tape, masking

Prelab Questions

1. Define Newton's third law of motion in terms of how a rocket "works."
2. What are some variables or conditions that may affect the distance a balloon rocket travels? Suggest some possible modifications in the rocket or launch design that may improve the rocket performance. (**Hint:** The fishing line must be as taut as possible, without breaking, for the best performance.)
3. Read the *Experiment Overview* and *Materials* sections. On a separate sheet of paper, write a step-by-step procedure for launching a rocket balloon on a string across the classroom. Include a data table to record information about each rocket launch. What distance did the rocket travel? What problems arose? How can the problems be addressed?

Safety Precautions

Use caution when launching the balloons. Be sure no one is in the path of the balloon rocket on the string before launching the balloon. The fishing line may be difficult to see. Be aware of your surroundings as you walk through the classroom. Do not overinflate the balloons and cause them to pop. Wear safety glasses. Follow all normal laboratory safety guidelines.

Procedure

1. Verify the procedure (see *Prelab Question* 3) with your instructor and review all *Safety Precautions*.
2. Carry out the procedure and record all data in a suitable data table.

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3. Answer the *Post-Lab Questions*.

Post-Lab Questions

1. Why does the balloon move when it is blown up and the pressure inside the balloon is released?
2. Why is the air pushed out of the balloon?
3. Write a paragraph describing how the balloon rocket performed. Did the balloon travel the entire length of the classroom? How many attempts were needed to achieve the desired goal? What were some major problems that needed to be solved before the balloon rocket traveled across the classroom? How were the problems solved? What aspects of the rocket or launch design were most helpful in achieving the goal of the rocket traveling the length of the classroom?
4. List some suggestions that might improve the performance of the balloon rocket.