Drexel-SDP GK-12 ACTIVITY

Ah Chute!

Subject Area(s) Data Analysis and Probability, Measurement, Number & Operations, Physical Science, Problem Solving, Science and Technology

Associated Lesson Chute-ing Among the Stars

Activity Title Ah Chute!

Grade Level 7 (6-12)

Time Required 1 hr (split over 2 class periods)

Group Size 2

Expendable Cost per Group $1-5

Plastic shopping bags, paper coffee filters, mylar (from balloons), string, scotch tape, duct tape, washers

Summary

Students create parachutes to slow a mass falling from a specified height. The expected free-fall time for the washer can be calculated or measured experimentally with a stopwatch and compared to the free-fall time when connected to the parachute.

Engineering Connection

Parachutes demonstrate the effect of fluid flow on an object, and in the context of the Mars Rover space mission, play an integral role in slowing the rover bots prior to landing. There is a portion of the video dedicated to the design and testing challenge for a suitable parachute: the original design failed, and engineers had to iteratively design and test parachutes that the team would depend upon to land the rover. Besides recreational use, parachutes are used to deliver supplies to military forces and countries in need of aid (Red Cross). It is important to scale the parachute so that the magnitude of the drag force is greater than the gravitational force and parachute decelerates the object for a safe landing.

Keywords

parachute, design, materials, free-fall, drag

Educational Standards

- PA Science:
  - 3.1.7 – Unifying themes
  - 3.2.7.B – Apply process knowledge to make and interpret observations
  - 3.2.7.D – Know and use the technological design process to solve problems
- PA Math:
  - 2.1.8.D – Apply ratio and proportion to mathematical problem situations involving distance, rate, time, and similar triangles
  - 2.3.5.D – Convert linear measurements within the same system
  - 2.4.5.B – Use models, number facts, properties, and relationships to check and verify predictions and explain reasoning
  - 2.5.8.B – Verify and interpret results using precise mathematical language, notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs, and diagrams
  - 2.5.8.C – Justify strategies and defend approaches used and conclusions reached
  - 2.7.8.D – Compare and contrast results from observations and mathematical models
  - 2.8.8.B – Discover, describe, and generalize patterns, including linear, exponential, and simple quadratic relationships

Pre-Requisite Knowledge

Background of Newton's laws and concept of gravitational acceleration may aid engagement, but is not considered necessary.

Learning Objectives

After this lesson, students should be able to:

- Compare the time of it takes an object in **free fall** to drop an equivalent distance when attached to a parachute
- Identify how the effective surface area of the parachute is proportional to the attached mass
- Discuss how materials perform as a result of drag forces

Materials List

To share with the entire class:

- Scissors
- String
- Clear tape
- Duct tape
- Mylar sections (cut from circular balloon)
- Coffee filters
- Plastic bags
- Washers (or other masses, such as penny bags)
- Stopwatch (optional)

Introduction / Motivation

Show the "Mars Rover" clips to establish perspective – landing a multimillion-dollar piece of equipment is a great task and requires an effective parachute design. Stop after the animation of the first rover landing on Mars.

In order to make this landing possible, the speed of the spacecraft had to decrease from 12,000 mi/hr to about 120 mi/hr before the last jets decelerated the rover "package." There are no brakes, so a parachute became the solution.

Hold up a washer. Imagine this washer is your Mars rover and it needs to survive a landing from [an elevated space]. You are given the included set of materials and your goal is to slow the speed of the washer in free-fall from that given height. The best design will be determined by comparing air times, with greater air times being more desirable and indicative of an effective parachute.

If the time will be calculated from a known height, complete the calculation in class on the board. For higher-level students, there are additional kinematic relations that can be used under **Activity Scaling** section below.

Set the students to work…

Procedure

Background

A simple parachute using the supplied materials can support a washer suspended from a string. The top of the parachute should have a hole or slits to allow air to pass through. The string can be taped or tied to the side.

After students have completed their models, have students test their parachutes by timing the free fall after students release them from rest (*i.e.* no tossing upwards). Time the free fall of a single washer for comparison (all masses on earth fall at the same rate – 9.81 m/s^2, so the size of the washer is irrelevant). Alternatively, calculate the time of drop using the formula

$$t = \sqrt{\frac{2d}{g}},$$

where d is distance (in feet or meters) and g is 32.2 ft/s^2 or 9.81 m/s^2, depending on units chosen for distance. The most effective design for a given mass will take the most time to fall.

Before the Activity

- Show a completed parachute model with string and a washer attached.
- Remind students that a larger parachute surface area results in increased drag force (which will slow a larger mass)

With the Students

1. Spread out materials on table
2. Assist with questions (and monitor/limit tape consumption!)

Safety Issues

- Students with scissors

Troubleshooting Tips

Mylar tends to roll up when cut from the balloon shape. A thin strip of duct tape around the perimeter will help limit this occurrence and reinforce the material.

Investigating Questions

1. Which parachute designs worked best?
2. How do the best designs compare to less-effective designs?
    a. Is material a factor?
    b. Does parachute size matter?
3. Did the more effective designs have a larger surface area than less-effective chutes carrying the same mass?
4. In *Roving Mars*, the original parachute design had to be modified, re-designed and tested. Could that extra, rushed work be due to the additional weight attributed to the Mars Rover's increasing size and complexity during the design and testing phases?

Assessment

Activity Embedded Assessment

Have groups (or individuals) keep track of time

Activity Scaling

- For upper grades
    - Use the additional kinematic relation

      $$d = \frac{1}{2} g t^2 + v_{avg} t$$

      to find the time-averaged velocity v_{avg} of the parachute during free fall.

    - Calculate the average drag force F_d acting on the parachute, using the density of air at room temperature, ρ_{air}=1.204 kg/m^3 and the area A of the projected surface.

      For a hemispherical parachute, the cross-sectional area will be a circle. Assume C_d, the drag coefficient, is 1.0:

      $$F_d = \frac{1}{2} \rho_{air} v_{avg}^2 C_d A = \frac{1}{2} \rho_{air} C_d v_{avg}^2 \left(\pi r^2 \right).$$

Additional Multimedia Support

Activity_AhChute_Media.zip contains the "Roving Mars" video clips:

Roving Mars 1_5.mp4, originally downloaded from http://www.youtube.com/watch?v=1t-f8j2Tt2g.
Roving Mars 2_5.mp4, originally downloaded from http://www.youtube.com/watch?v=rjaCkI63NpY.
Roving Mars 3_5.mp4, originally downloaded from http://www.youtube.com/watch?v=XopXGNh9FMM.
Roving Mars 4_5.mp4, originally downloaded from http://www.youtube.com/watch?v=8I25CgP08mw.
Roving Mars 5_5.mp4, originally downloaded from http://www.youtube.com/watch?v=vW17MhZslxE.

Owner

Drexel University GK-12 Program

Contributors

John C. Fitzpatrick, Mechanical Engineering and Mechanics, Drexel University

Copyright