Eggstronaut Parachute Challenge Over Easy

Grade Level: **5th-12th**

Suggested Time: **90 minutes**
10 minutes – Introduction & Egg Drop
20 minutes – Parachute Design & Build
15 minutes – Testing & Data Collection
30 minutes – Data Analysis
15 minutes – Class Discussion

Challenge: Teams of 3-4 students will design and build parachutes to slow the descent of an egg and minimize the force of impact when landing.

Objectives:

Following this activity, students will be able to:
- Investigate the effect of parachute shape and size to slow the descent of an egg.
- Apply mathematics to solve real-life problems involving graphing and area.
- Apply mathematics and physics concepts to explore forces and motion, analyze energy of a falling object, and minimize force of impact when landing.

Materials:

For testing parachute:
- ☐ plastic eggs (approx. 4 g) weighted to the mass of a real egg (large egg 57 g)
- ☐ coins, washers, cotton balls, sand, or dirt (to add mass to the plastic egg)
- ☐ parachute material: plastic bags or tablecloth, wrapping or tissue paper
- ☐ tape measure, meter stick, or other device for measuring height and distance
- ☐ string
- ☐ scissors
- ☐ digital scale or balance
- ☐ stopwatch
- ☐ tape and/or glue
- ☐ Student Data Sheet (1 per student)

For safety:
- ☐ safety cones and caution tape or stanchions to cordon off the drop zone
- ☐ safety glasses
- ☐ hard hats

(Optional):
- ☐ smartphone and/or computer for digital video analysis of descent and landing (See Extension Activities: Tracker, Logger Pro, Video Physics)
- ☐ grid paper for estimating surface area of parachutes
- ☐ size 61 latex-free rubber bands (easy on/off harness to attach suspension lines)

Next Generation Science Standards (NGSS):

MS-PS2-2. Motion and Stability: Forces and Interactions: *Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.*

MS-PS3-5. Energy: *Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.*

HS-PS2-3. Motion and Stability: Forces and Interactions: *Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS3-5. Energy: *Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

Common Core Standards for Mathematics (CCSS):

5.G.A.2. Geometry: *Graph points on the coordinate plane to solve real-world and mathematical problems.*

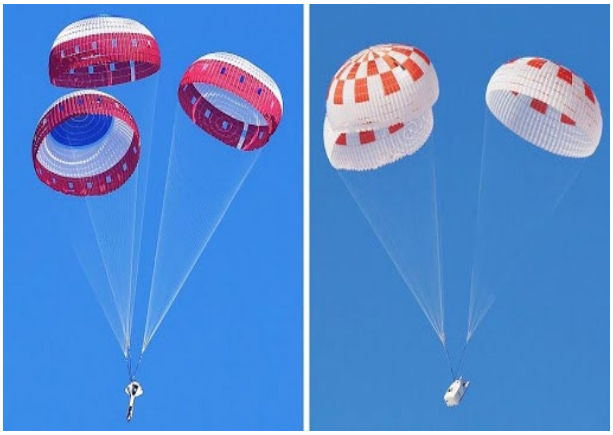
6.G.A.1. Geometry: *Solve real-world and mathematical problems involving area, surface area, and volume.*

7.G.B.6. Geometry: *Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.*

8.F.B.5. Functions: *Use functions to model relationships between quantities.*

HSM. Modeling: *Use mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions.*

MP4. Standards for Mathematical Practice: *Apply mathematics to solve problems arising in everyday life, society, and the workplace.*



NASA Connection:

NASA's Commercial Crew Program (CCP) was formed to facilitate the development of U.S. commercial crew space transportation capable of achieving safe, reliable and cost-effective access to and from the International Space Station. Crew safety is paramount in the return of human spaceflight launches from NASA's Kennedy Space Center, and parachute testing provides valuable data to help commercial partners meet NASA's requirements for certification and safety.

Explore more about NASA CCP Careers (https://www.nasa.gov/content/I-will-launch-america)

Class/Team Procedures:

- As a class, explore what will happen when an egg is dropped from the second story or higher of a building (at least 5m). Demonstrate lab safety. Discuss STEM concepts including energy, drag, etc. Measure the drop time of the egg.
- Introduce challenge and design constraints. Ask students to make a hypothesis.
    - The egg must fall with major or longer axis perpendicular to the ground, the egg must impact the ground first, and nothing can be attached to the egg except the harness. The mass of all Eggstronauts must be constant.
    - Teams will design and test at least three parachutes with the same shape and proportional dimensions to determine the effect of surface area on drag. The number and length of suspension lines should remain constant.
- Teams should create scale drawings of their designs including all measurements, calculate surface area for each parachute design, and measure the drop time for Eggstronaut with each parachute.
- Collect and graph class area vs drop time data for all parachute shapes to look for patterns. Discuss results with class.

Class Discussion Questions:

- *Which parachute design characteristics provided the most reliable results?*
- *Which design had the slowest descent (longest drop time)?*
- *What was discovered about the relationship between surface area and drop time? What other information could engineers learn from your results?*
- *What other tests and calculations could you do to learn more?*

Assessment: Collect student data sheets and assess responses to class discussion questions.

Extensions:

- Advanced students can also use video analysis of the fall to analyze position, velocity, and acceleration data during the drop. Check out the Eggstronaut Parachute Engineering Design Challenge Guide for more information.
- Add constraints or incentives for a parachute with less mass or a design that is more cost-effective (assign cost to supplies, time, labor, etc.).
- Experiment with multiple parachutes instead of one. Boeing uses 3 main parachutes and SpaceX uses 4 main parachutes.

Safety and Warnings

- Clear the landing area of people. Supervise students when they are dropping their parachute. Plan for additional adult supervision if teams will be working in the classroom while other teams test at the Drop Zone.
- Do not allow anyone to attempt to catch a falling parachute.
- It is recommended that eggs are dropped on grass, sand, or dirt surfaces. Dropping plastic eggs on concrete or hard surfaces may result in plastic shattering. Keep students back from landing area to avoid shrapnel. If using coins or washers inside the egg, tape them together with the cotton balls to avoid pieces flying during impact.


Student Data Sheet:

Eggstronaut Parachute Challenge Over Easy

NASA's Commercial Crew Program (CCP) was formed to facilitate the development of U.S. commercial crew space transportation capable of achieving safe, reliable and cost-effective access to and from the International Space Station. Crew safety is paramount in the return of human spaceflight launches from NASA's Kennedy Space Center, and parachute testing provides valuable data to help commercial partners meet NASA's requirements for certification and safety. Explore more about NASA CCP Careers.

Challenge: Work as a team to design and build parachutes to slow the descent of an egg and minimize the force of impact when landing. Each team member will build a parachute with the same shape but different size to determine the effect of surface area on drop time. Your team must ensure that each parachute has proportional dimensions.

Drop time for Eggstronaut without a parachute: _____ Height of drop: _____

Plan: Make a scale drawing of your canopy design. Be sure to include measurements.

Surface area of canopy (show calculations):

Create: After assembling your canopy, harness, and suspension lines, find the weight.

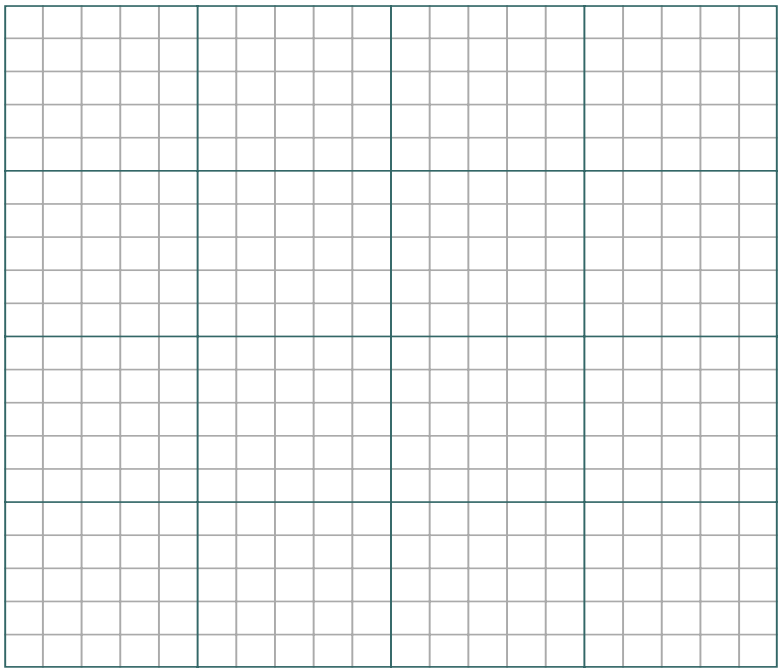
Weight of Eggstronaut: _____ Weight of Parachute: _____

Test: Drop your Eggstronaut with the parachute from a consistent, known height. Use the provided tools to collect data.

Drop time: _____

Data Analysis: Summarize the results of data collected below. Document any observations about the performance of your parachute and carefully note any signs of trauma to the Eggstronaut.

Graphing Analysis: Complete the graphing activity after all class data has been collected. Plot surface area (independent variable on x-axis) vs drop time (dependent variable on y-axis) with a different color for each shape. Label the graph appropriately.



What was discovered about the relationship between surface area and drop time?