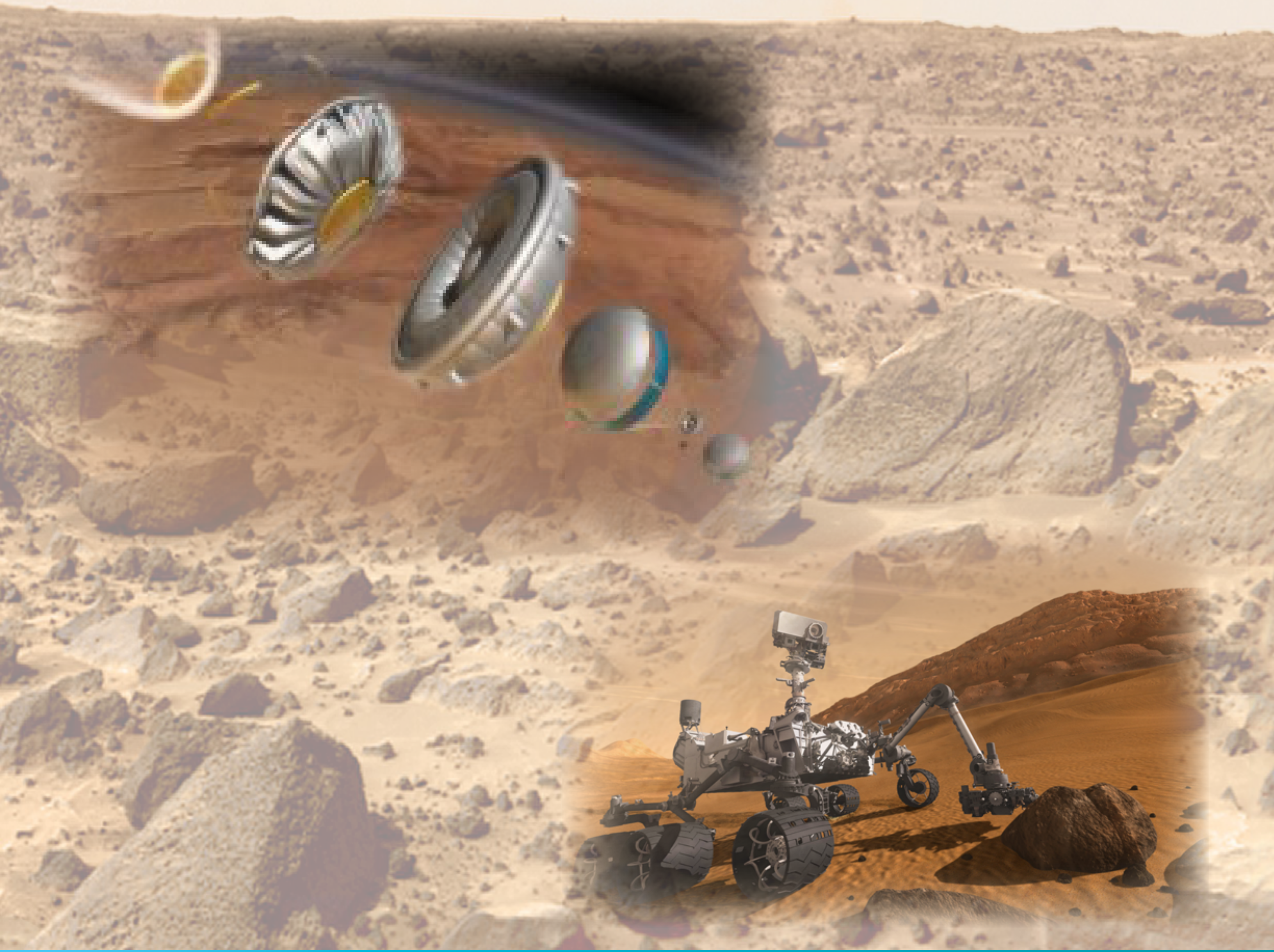
National Aeronautics and Space Administration

GRADES 6-8

Amazing Supersonic Decelerator: Parachuting on to Mars



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Amazing Supersonic Decelerator: Parachuting on to Mars

GRADES 6-8

CHALLENGE

Design and test a drag device to slow a spacecraft and protect its cargo as well as calculate the surface area and measure the mass of spacecraft.

MATERIALS

- ☐ Thin string such as embroidery thread or fishing line
- ☐ Small sealable plastic storage bag or plastic egg. One for each team to hold washers/ marbles inside capsule.
- ☐ Washers or marbles to serve as mass in the plastic eggs/ container
- ☐ Hole reinforcements or stickers with a hole punch
- ☐ Scissors
- ☐ Clear Tape
- ☐ Rulers
- ☐ Scale or Balance
- ☐ Cardstock or old file folders for capsule template
- ☐ Template for capsule (see *Appendix*) – one for each team
- ☐ Stopwatch
- ☐ Tall ladder or overhang above a stairway or common area

This activity uses the design of the surface area as the variable, not the material of the drag device. Below are listed some possible materials to use to make the drag devices. Choose and provide only a few for students to select from:

- Plastic trash/ grocery bags
- Large lightweight fabric scraps
- Wrapping paper/ tissue paper

PRE-ACTIVITY SET-UP

More information about the Engineering Design Process (EDP) and instructional videos can be found at: http://www.nasa.gov/audience/foreducators/best/edp.html

Sealable plastic bags/ plastic eggs will hold the weights (washers, marbles, etc.) inside the capsule. The capsule template is found in the appendix. Students will cut out and fold and tape into a pyramid shape. Students might need access to weights to adjust mass, so be sure they do not use too much tape.Pre-determine where the students will drop test drag devices. To get accurate data, drops should be at least 2 meters high, measured from the bottom of the craft to the ground.

The challenge includes the requirement that students must have at least five angled edges. This requirement is to create a more dynamic calculation of surface area and to encourage designs beyond a simple round shape. A simple round or pentagon shape will work, but five angled edges should encourage multiple parachutes, adding streamers, etc. Students could research ahead of time various geometries of parachute designs and provide them some ideas for different shapes.

This activity doesn't include keeping a budget, but could easily be added.

Teacher Page

Motivate

- Review the Engineering Design Process with students. To learn more and find videos see: http://www.nasa.gov/audience/foreducators/best/edp.html.
- For this activity, the spacecraft will be represented by the paper template and the equipment is represented by weights in the capsule.
- Ask students in what ways they think they could slow down or decelerate the spacecraft carrying fragile equipment. Possible answers might include engines, parachutes, drag devices, and streamers. NASA has created various designs over the years to slow down spacecraft two examples are the Apollo and Orion capsule drag devices. Have students research other shapes used in hang gliding, military parachutes, etc. to gather some geometric shape ideas.
- Discuss the Low Density Supersonic Decelerator Program (see Student Section) and how engineers are working to develop various size drag devices for future spacecraft.
- Videos and more information about Low Density Supersonic Decelerator available at: http://www.nasa.gov/mission_pages/tdm/ldsd/index.html. Video about landing on Mars is available at: http://www.jpl.nasa.gov/video/index.php?id=1090.

Ask

- Help students answer any questions they have about the challenge. Use the internet or school library to research answers.
- Explain calculations necessary for determining surface area, and surface area of unusual shapes. The internet can provide formulas for unusual shapes.

Imagine

- Challenge the students to design a drag device system that will keep the cargo safe (no broken or torn materials) during a drop from at least 2 meters high. The cargo (weights and spacecraft template) and the drag device cannot exceed a total mass of 50 grams.

Plan

- Younger students should measure the amount of time it takes for the drag device to fall. Older students or advanced younger students can also calculate the speed of the drop.
- All drawings should be approved before building begins.

Teacher Page

Create

- A template is provided in the *Appendix* to help create a cargo bay to fit the weighted cargo.

Experiment

- Students will follow the directions and answer questions on the *Experiment and Record* and the *Quality Assurance* worksheets.

Improve

- After completing the first round of testing, students will make modifications to their designs to try to increase the amount of time it takes for their cargo to drop (increasing drag). Document the second round of designs and test results, calculating the surface area and be sure the mass remains under 50 grams.

Challenge Closure

Engage the students in a discussion by reviewing all of the data and posing the following questions:

- Which drag device 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 (or speed)?
- What information could engineers working on this project learn from your team's results?
- What other tests and calculations could you do before making your recommendations to the engineering team? (Test different materials or shapes, create and test for possible anomalies, determine maximum load the drag device can slow etc.).
- What do you think would be the best way to present your results?

Standards

Next Generation Science Standards

Practices

1. Asking questions, defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using math and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Cross-Cutting Concepts

1. Patterns
2. Cause and effect
3. Scale
4. Systems and system models
5. Energy and matter
6. Structure and function

Core and Component Ideas

Physical Science

PS2: Motion and Stability

PS2.A: Forces and motion

PS2.B: Types of interactions

Earth and Space Science

ESS1.B Earth and the Solar System

Engineering, Technology, and Applications of Science

ETS1.A: Defining and delimiting an engineering problem

ETS1.B: Developing possible solutions

ETS1.C: Optimizing the design solution

ETS2.A: Interdependence of Science, Engineering, and Technology

Common Core State Standards-Mathematics

Standards for Mathematical Practice

MP1: Make sense of problems and persevere in solving them

MP2: Reason abstractly and quantitatively

MP3: Construct viable arguments and critique the reasoning of others

MP4: Model with mathematics

MP5: Use appropriate tools strategically

MP6: Attend to precision

Grades 6-8

Expression and Equations – Reason about and solve one- variable equations. Represent and analyze quantitative relationships between dependent and independent variables.

Geometry – Solve real-world and mathematical problems involving area, and surface area Statistics and Probability- Develop understanding of statistical variability. Summarize and describe distributions.

For the Student

Amazing Supersonic Decelerator: Parachuting on to Mars

STUDENT PAGE

Challenge!

Low Density Supersonic Decelerator

As NASA plans new robotic missions and human expeditions to Mars, it becomes important for the spacecraft to carry heavier and larger payloads to accommodate extended stays on the Martian surface. NASA has been using its current parachute-based deceleration system since the Viking Program, which put two landers on Mars in 1977. The current technology will not sufficiently slow the larger, heavier landers from the supersonic speeds of atmospheric entry to land safely on the surface.

NASA is currently designing three new decelerators as part of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Missions. The first two designs are supersonic inflatable aerodynamic decelerators -- large, durable, balloon-like pressure vessels that inflate around the entry vehicle and will slow down the capsule. One is 6-meter-diameter and the other is an 8-meter-diameter size. The third is a 30-meter-diameter parachute that will further slow the entry vehicle. All three devices will be the largest of their kind ever flown.

To learn more about the Low Density Supersonic Decelerator see:
http://www.nasa.gov/multimedia/videogallery/index.html?media_id=160723121 and
http://www.nasa.gov/mission_pages/tdm/ldsd/index.html

THE CHALLENGE

Design a drag device to protect the weighted cargo bay when it is dropped from a specified height (at least 2 meters). Data gathered in this challenge includes surface area, mass, and descent time. Redesign to improve your drag device drop performance.

The design constraints are:

- Use only materials provided to you to create the drag device.
- The overall mass of your drag device cannot exceed 50 grams.
- Drag devices must have at least five separate angled edges (rounded edges are allowed, but one big circle is not allowed).
- Test drops must be from at least 2 meters.
- Must use the template provided for you to build a cargo bay.

REMINDER!

- Be sure to document all design and test results.
- Make any necessary design changes to improve your results and retest. Document the modifications and results.
- Complete all conclusion questions.

Student Page

Ask

Today you will design a drag device that will slow down the descent of a space capsule. What questions do you have about today's challenge?

Imagine

What will the general shape of your drag device be? What special features will you include?

Student Page

Plan

Draw and label your drag device. Be sure to include measurements!

Approved by: ______________________________

Write a hypothesis that describes how the surface area of the drag device will affect the time it takes for the payload to drop.

For the Student

Student Page

Team Name:

Experiment & Record

1. Record the mass and calculate the surface area in the table below. Use the space below to show calculations.

2. Record the drop height: ____

3. Drop drag device attached to capsule while timing descent. After each drop, note any damage to the drag device or capsule. Each device should be dropped three times and results averaged together. For advanced students, calculate the speed. Record results in table below.

	Mass (g)	Surface Area (cm^2)		Time (sec)	Speed (cm/sec)	Note any damage after each drop
Design 1			Drop #1			
			Drop #2			
			Drop #3			
			Average			
Design 2			Drop #1			
			Drop #2			
			Drop #3			
			Average			

Team Name:

Experiment & Record

4. Plot results on a scatter graph. The surface area (the independent variable) is plotted on the X axis, and the time it takes for the drag device to drop (the dependent variable) is plotted on the Y axis. For students calculating speed, plot the speed of descent on the Y axis. Label graph appropriately.

5. Improve the design of your drag device and repeat the testing. Record your results for Design Two and plot results on graph above in a different color.

6. For evaluation, exchange your drag device with another teams and complete the *Quality Assurance* document.

Quality Assurance Form

Each team is to review another team's design and model, then answer the following questions.

NAME OF TEAM REVIEWED: ______________________________

	Yes	No	Comments
Was the drag device securely attached to the cargo capsule?			
Was the mass of the entire drag device below 50 grams?			
Did the team correctly collect, calculate and record data?			
Did the team have a successful drag device? (No broken materials.)			

LIST THE SPECIFIC STRENGTHS OF THE DESIGN:

LIST SPECIFIC WEAKNESSES OF THE DESIGN:

HOW WOULD YOU IMPROVE THE DESIGN?

Inspected by: ______________________

Signatures ______________________

____

____

Student Page

Conclusion

As a class, review all the data and answer the following questions.

1. Which drag device design characteristics provided the most reliable results and why?

2. Which design had the slowest descent (longest drop time)?

3. What was discovered about the relationship between surface area and drop time (or speed)?

4. What information could engineers working on this project learn from your team's results?

5. What other tests and calculations could you do before making your recommendations to the engineering team?

6. Present your results.

MORE FUN WITH ENGINEERING

Activity One:

On a playground or large outdoor area, measure out the diameters of the three decelerators that NASA is currently designing as part of LDSD, 6 meters, 8 meters, and 30 meters.

Activity Two:

Atmospheric Conditions

In your classroom experiments today, you probably didn't have to worry too much about wind conditions, temperature, atmosphere, etc like NASA engineers do when they are preparing for missions to Mars. NASA engineers have only landed massive spacecrafts on Mars a few times, so in preparing for these future missions, they must make predictions on what the atmospheric conditions will be like for these future Mars landings. With these predictions of conditions, they then attempt to simulate entry conditions on Earth to be sure the spacecraft can handle a variety of situations.

The Mars Science Laboratory Entry Descent and Landing Instrument (MEDLI) sensors captured detailed data about the atmospheric conditions when Mars Science Laboratory landed in August 2012. This information will help engineers to mimic the conditions of Mars during their simulated Low Density Supersonic Decelerator (LDSD) entries to Earth. Very soon engineers will be testing the LDSD designs at supersonic speeds in Earth's stratosphere. Based on the new data, they will make even more precise predictions of what they can expect on an entry to Mars. This information will help ensure mission success!

Research what is known about the atmospheric conditions on Earth and Mars.
http://quest.nasa.gov/aero/planetary/mars.html
http://www.nasa.gov/offices/marsplanning/faqs/index.html

- What environmental or weather conditions do you think they should try to simulate on Earth ahead of time?
- Which conditions do you think would have the largest effect on the design?
- Based on the designs you did today, how would your overall design concept perform on the entry phase to Earth? To Mars?

Follow the latest developments and research at:
http://www.nasa.gov/mission_pages/tdm/ldsd/index.html

TEMPLATE

Cut out larger triangle and fold on inner lines to create a pyramid shape. Put weights inside pyramid shape and tape up sides. You might need to adjust the weight of your capsule during testing, so be sure to not use too much tape.