Science and Innovation

A Boeing/Teaching Channel Partnership

MISSION TO MARS

Teacher Handbook

Tch Teaching Channel

Mission to Mars

Days 8 and 9: Final Mission—Landing on Mars

Grade Level	Middle School
Lesson Length	Two 50-minute sessions

Lesson Overview

During Days 8 and 9, students design and build a cargo module for their soda bottle rocket. In the process, students identify variables, troubleshoot problems, identify design improvements, and record rocket performance data.

Connecting to the Next Generation Science Standards

On Days 8 and 9, students make progress toward developing understanding across the following three dimensions:

- Science and Engineering Practices: Developing and Using Models, Constructing Explanations and Designing Solutions
- Disciplinary Core Ideas: ETS1.B Developing Possible Solutions, ETS1.C Optimizing the Design Solution, PS2.A Force and Motion
- Crosscutting Concepts: Cause and Effect

In the following table, the specific components addressed in this lesson are underlined and italicized. The specific connections to classroom activity are stated.

<table>
<tr><th colspan="3">Performance Expectations</th></tr>
<tr><td colspan="3">This lesson can be used to contribute toward building understanding of the following engineering performance expectations:
MS-ETS1-4. <u>Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.</u>
This lesson can be used to contribute toward building understanding of the following physical science performance expectations:
MS-PS2-2. <u>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.</u></td></tr>
<tr><td colspan="3">Specific Connections to Classroom Activity
In this lesson, students develop and test a model for a cargo module in the soda bottle rocket. Students consider all of the forces acting on the rocket. Students revise their cargo module designs based on observations from tests.</td></tr>
<tr><th>Dimension</th><th>NGSS Element</th><th>Connections to Classroom Activity</th></tr>
<tr><td>Science and Engineering Practices</td><td>Developing and Using Models
• <u>Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.</u></td><td>Students develop a model cargo module to test the structures that protect the crew. Students use the model to generate data to inform design decisions.</td></tr>
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	Constructing Explanations and Designing Solutions • *Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.*	Students use their knowledge of forces acting on an object to construct cargo modules for rockets.
Disciplinary Core Ideas	**ETS1.B: Developing Possible Solutions** • *A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.* • *Sometimes, parts of different solutions can be combined to create a solution that is better than any of its predecessors.* • *Models of all kinds are important for testing solutions.* **ETS1.C: Optimizing the Design Solution** • *Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.* • *The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.* **PS2.A: Force and Motion** • *The motion of an object is determined by the sum of the forces acting on it;* if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	Students design cargo modules for rockets to test and then modify on the basis of the tests. Students use ideas from different solutions to create a solution that combines multiple elements. For ETS1.C, through an iterative process, students test, refine, and retest their design solutions. As a final task, students develop a model showing all of the forces acting on the rocket and the cargo module.
Crosscutting Concepts	**Cause and Effect** • *Cause and effect relationships may be used to predict phenomena in natural or designed systems.*	Students consider the idea that if they change certain features of the rocket and the cargo module, the rocket will fly or land differently.

Basic Teacher Preparation

Make the parachute (or a couple of them) ahead of time. Students can also make their own parachutes if time permits.

Required Preparation	Links/Additional Information
❑ Gather or purchase the required materials for the lesson	Refer to the Materials List below

❑ Ensure technology is available to project the identified videos	Refer to the Suggested Teacher Resources at the end of this lesson
❑ If desired, prepare the parachute ahead of time	Refer to the Materials List below
❑ Review suggested teacher preparation resources in advance	Refer to the Suggested Teacher Resources section at the end of this lesson

Materials List

Item	Description/Additional Information	Quantity	Where to Locate/Buy
Rocket building and testing materials	All soda-bottle rocket and rocket testing materials should be available in these lessons	As needed	See Materials Lists for Days 5 through 7
Parachute	Each set includes: • Large clear plastic sheet from a dry-cleaning bag, or another large plastic bag • String • Tape	1 parachute minimum, extras better	Materials can be brought from home, or found in most schools
Payload/crew assembly	Each set includes: • Balloon • Water (for filling balloons) • Egg • Large plastic bubble wrap bags • String • Scale • Extra balloons and eggs for breakage	1 set per team	Most items can be brought from home or found in schools. The following items can be bought online: • Balloons [Web Link] • Plastic bubble wrap bags [Web Link]

Day 8: Final Mission—Landing on Mars

Introduction (5 minutes)

In front of the class, hold up the parachute. Ask students what it is and explain how it works. Demonstrate to confirm their predictions.

Next, tape an egg to the parachute, and ask students what would happen if you threw it into the air. *Would the egg break when it lands on the ground? Why or why not?* Ask students to explain how this egg and parachute demonstration relates to astronauts landing on Mars. Explain that space capsules need to have sufficient safety equipment and slow enough speed to protect the people who are landing.

If time allows and you have the necessary cleaning supplies, throw the toy into the air again with the egg attached. Have students explain why the egg broke even though the parachute filled with air. Relate what happened with the parachute to what students know about the properties of gases.

Show students another egg, and ask them to compare it to a person and expensive equipment that have to be delivered safely to Mars (and back to Earth). Ask them how they might protect the egg if it is launched with their soda bottle rocket.

NGSS Key Moment

To further extricate ideas related to the sum of the forces acting on the egg, have students draw a force diagram showing the different forces acting on the egg and explaining why the egg broke.

Whole Group Discussion: Landing on Mars (15 minutes)

To develop the concepts and understandings required for today's engineering challenge, show students the Rocket Project Part 2: Water Bottle Rocket Flight Tests and Rocket Project Part 3: Recovery Development and Test videos. After students watch the videos, present the design criteria and constraints for the next engineering challenge, in which students design an addition to their rocket.

Video Links

- Rocket Project Part 2: Water Bottle Rocket Flight Tests [YouTube Link]
- Rocket Project Part 3: Recovery Development and Test [YouTube Link]

Design Criteria and Constraints

- The rocket must be capable of withstanding launch stress without falling apart.
- The rocket must hold an egg and its deceleration device (parachute, air bag, or another device). A water balloon will be used instead of an egg until the last test flight.
- The water balloon/egg and its device must separate from the bottle rocket.
- The water balloon/egg must land without breaking.
- The time limit for design, build, and test is one class period. (Students will be given another class period to modify and retest.)

Design Work: Team Build (15 minutes)

Show students the materials for their crew and cargo capsules. Let the teams start building.

Design Work: Testing (15 minutes)

Take students outside to test their devices. Have students document their flight and landing data in their notebooks. Discuss what went well and what problems arose. Also, have students identify any observed differences in the flights. Let them know that they will be modifying their devices and testing them again in the next class session.

Helpful Tip

When students go outside, consider taking a trash bag to discard any broken water balloons. Also take extra water balloons and tape in case any are dropped on the way to the launch site.

Day 9: Final Mission—Landing on Mars

Introduction (5 minutes)

Discuss the variables students observed during the Day 8 flights. Discuss how students can change their designs to ensure that the balloon does not break. Have students explain the effect these changes might have on the rocket performance and the crew and cargo landing.

Design Work: Rebuild and Test (30 minutes)

Give students the materials they need to modify their rockets. Head outside to conduct another test launch. If possible, bring materials outside so students can make additional modifications while they wait for other launches. Use an altimeter to document the flight height or a stopwatch to record flight duration. Make sure the teams record today's new flight data. Have students write brief summaries of their modifications and the effects.

Lesson Close (15 minutes)

Using their final designs, have students develop models showing all the forces acting on their rocket and cone during the launch. The model should show several points in time. Students should incorporate their final designs, the model of forces acting on their rocket, and justifications for the design into their NASA letters.

Assessment Opportunities

Final student models showing the forces acting on the rocket can be used to assess student progress on PS2.A. Reference Appendix B for suggestions for meeting the needs of all learners.

Community Connections

These three days present opportunities for parent engineers or engineers from the community to assist and comment as students test and modify rockets. If additional adults are available, consider setting up two or three launchers so teams can conduct multiple trials.

Suggested Teacher Resources

Meeting the Needs of All Learners	Mission to Mars Teacher Handbook, Appendix B
Rocket Project Part 2: Water Bottle Rocket Flight Tests	[YouTube Link]
Rocket Project Part 3: Recovery Development and Test	[YouTube Link]