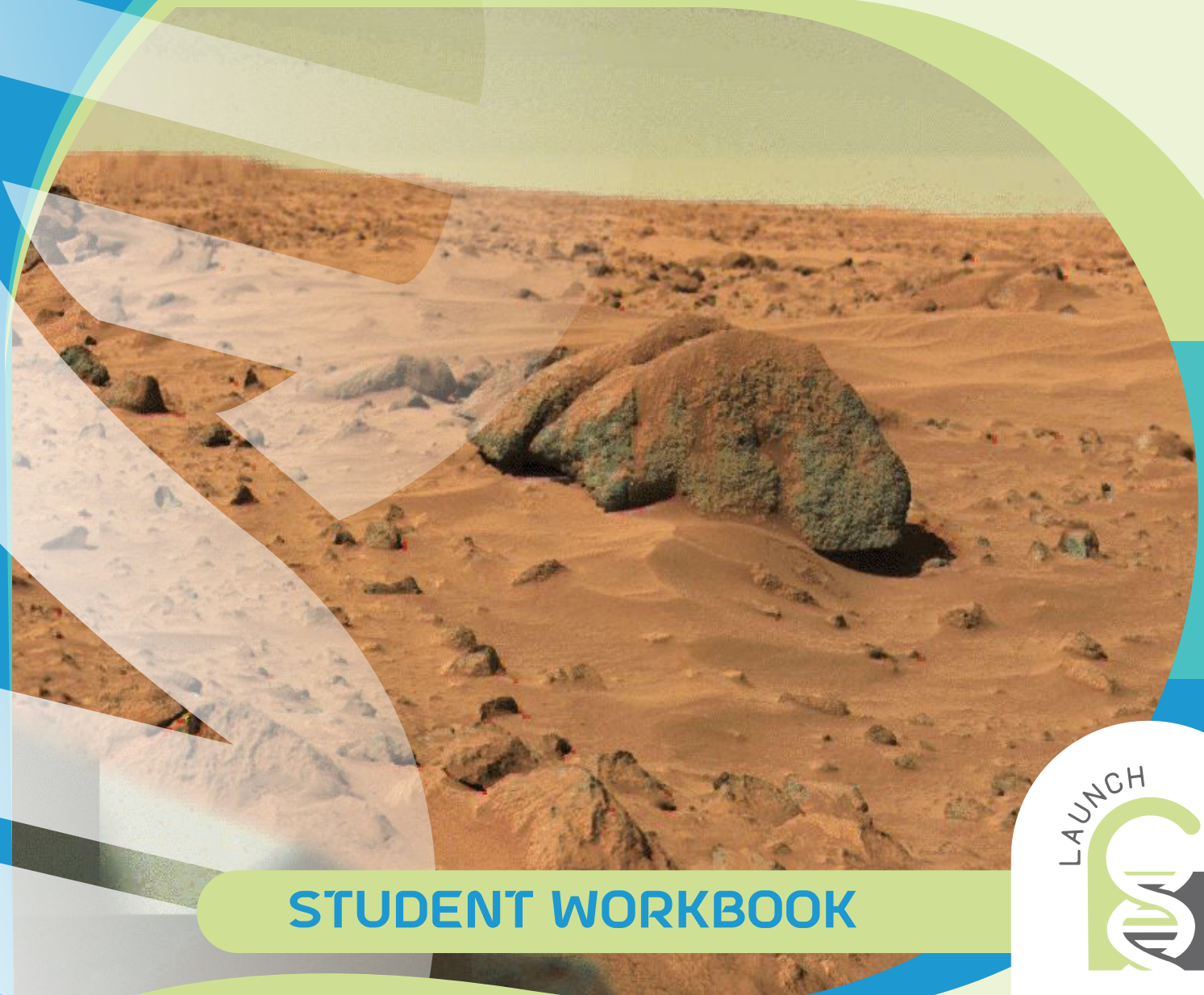
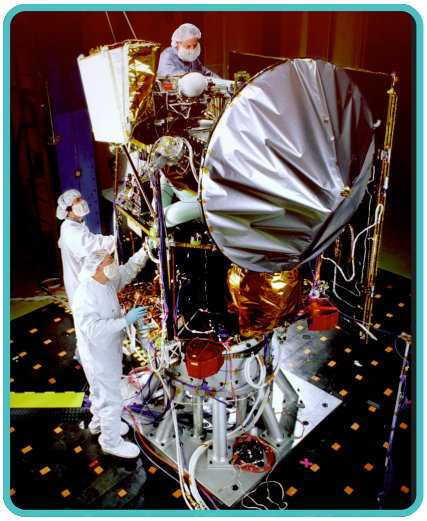
MARTIAN IMPACT



STUDENT WORKBOOK

LAUNCH

The orbiter was not designed to land on Mars, and its sensitive equipment would not survive traveling through the atmosphere, the layer of gases surrounding the planet. Unfortunately, the close approach to Mars meant the orbiter did have to travel through the **atmosphere**, and it was presumably destroyed in the descent.



An administrator at NASA was quoted as saying this about the mistake: "The problem here was not the error; it was the failure of NASA's systems engineering, and the checks and balances in our processes, to detect the error. That's why we lost the spacecraft."[1]

More recent missions to Mars have landed successfully on the planet's surface. However, NASA scientists and engineers must wait for the pre-programmed maneuvers to complete, and only then will the spacecraft transmit confirmation of its landing. This communication wait time is referred to as the "seven minutes of terror." Even if the team receives readings that are off-course at the beginning of the sequence, by the time engineers send back a signal to correct it, the spacecraft is already more than eight minutes off-course.

Flight controllers at NASA had received signals from the MCO within the first few minutes of the maneuver. As the spacecraft traveled around the far side of Mars, it could not transmit status updates back to Earth. Minutes later, NASA flight controllers declared the MCO lost as a result of navigation errors. A team was quickly assembled to analyze the mission failure and determine the fate of the MCO, but they knew it could not be recovered.

THINK ABOUT IT!

1. How do you think the team of scientists and engineers was able to determine their mistakes without transmissions from the MCO?

2. What solutions do you think were developed to prevent future problems like this at NASA?

FEEL THE FORCE

Shot From a Cannon

If the computers aboard NASA's Mars Polar Lander had potential issues, then should NASA have built the spacecraft to withstand a greater impact? Let's try some crash tests and learn about **collisions,** events in which two objects hit each other with a lot of force over a short amount of time.

For this experiment, you will compare the impact of an aluminum cylinder and a steel cylinder, both of which are included in your kit. If you need to tell them apart, the aluminum cylinder has less mass than the steel cylinder.

WHAT YOU NEED:

FROM THE KIT:

- Box the kit comes in
- Density cylinders: steel and aluminum
- Rubber band, thick
- Tape measure

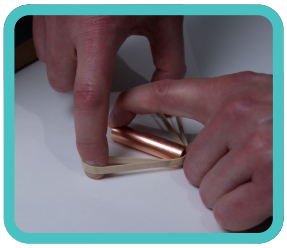
WHAT TO DO:

1. Place the empty box on a smooth surface like a kitchen floor or large table. If using a table, place the box about 10–15 cm from the edge.
Note: Do not do this activity on a glass tabletop.

2. Lay the tape measure beside the box so that the 0 cm end is at the edge of the box closest to you.

PREDICT:

Which of the cylinders will move the box furthest when launched into the box? Explain your reasoning.

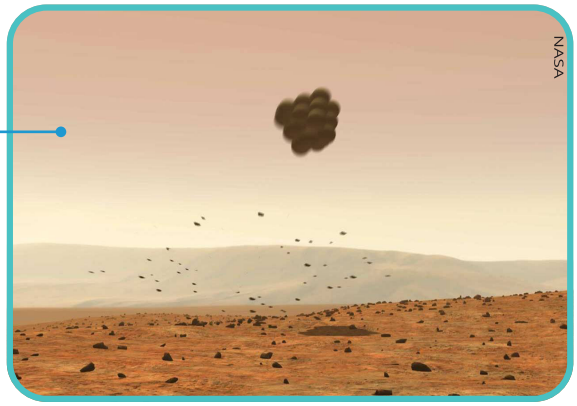


3. Wrap the rubber band around your thumb and index finger. Place your thumb and index finger on the table to create a launch device.

If the time is increased, then the momentum will be reduced because the impulse happens over a longer period of time. Let's jump back to Earth to think about this problem. Imagine you jump off a table and land on solid ground. This impact happens almost immediately, you change momentum quickly, and the force of your body hitting the ground hurts. If you jumped from the same height onto a trampoline, your impulse with the trampoline is over more time in contact with the trampoline. There is a lot less force on your body.

What if you jumped from that same height into a pool of water? You would enter the water and slow down gradually as the water resists the movement. The water slows your momentum to zero over a longer time. The overall force on your body is decreased when the velocity is decreased over a longer time.

Engineers try to slow the momentum of spacecraft so that the object can make maneuvers more easily. The Spirit rover arrived on the Martian surface in a bubble-like balloon, landing with a cushioned bounce increasing the time of impulse to reduce the force. The landing of the Spirit rover was around 25 m/s, while the Mars 2020 mission landed with the help of guided thrusters around 2.5 m/s.



THINK ABOUT IT!

1. Describe one type of collision that reduces the force by increasing the time the object is in contact and slowing its momentum.

2. What are the advantages of a mission that can land carefully on the surface of Mars, compared to the airbag crash landing?

LAUNCH

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Kit	SU-MARTIM
Instructions	SU-MARTIMS
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