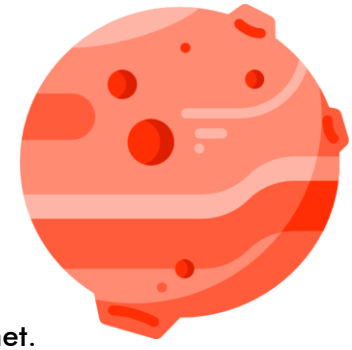
MARSQUAKE CHALLENGE

CHABOT SPACE & SCIENCE CENTER

Did you know Mars has earthquakes? Or rather… Marsquakes? Scientists theorize that these quakes are similar to what we experience here on Earth, however, it is unclear exactly what goes on beneath the surface of Mars to cause them. Volcanic activity, meteor impacts, and planetary shifting are believed to be the source, yet there is still much to learn. In order to search for an answer, scientists are using data collected from the InSight lander to reveal information about the inner-workings of the Red Planet.



InSight will not only help us determine the source of the quakes, but how often and severe they are as well. This information may be helpful to know since NASA is planning to send humans to live on Mars. If the planet experiences extreme quakes, it must be taken into consideration. Habitats must be built and tested against conditions like quakes in order to safely achieve long-term human survival on Mars.

HOW IT WORKS

In this activity, learners will attempt to design model habitats that can withstand a quake on Mars. To begin, build a Marsquake table to simulate the planet's shaking surface. Then, build a habitat and test it to determine whether it can survive the quakes on Mars. Improve, retest, and reevaluate the design as many times as needed until it successfully survives the quakes.

PROCEDURE

BUILD THE MARSQUAKE TABLE

Grab your materials and follow the steps below to build the quake table (see image on page 2 for a visual diagram):

- Cut two pieces of cardboard into same size rectangles.
  - This will be the testing area for your habitats to sit on. The larger the cardboard pieces, the larger the potential build.
- Lay the two pieces on top of each other.
- Loosely wrap a rubber band around the end of the boards to bind them together. Repeat on the other end.
- Wedge 4 ping pong balls in between the two boards, one at each corner.
  - Substitute ping pong balls for tennis balls, rubber balls, or 4 of any same sized spherical objects from home.
- Adjust the rubber bands so they are tightly holding the two boards together and the ping pong balls will not slip out when shaken.
- Give it a test shake.
  - Place one hand on the bottom board to secure it in place. Then, pull the top board to the side and release it.
- This is your simulated Marsquake! The more you shake the top board, the higher intensity quake you are testing against.

DESIGN CHALLENGE

Build a model habitat that can survive a simulated Marsquake.

CRITERIA

You can use any household materials to build, besides tape.

To survive, your habitat must remain standing, without your help, during a "mild" Marsquake*.

If any element of your habitat collapses or falls off, it did not survive.

*A "mild" Marsquake is 3 to 4, moderately rough shakes on the quake table.

SUGGESTED MATERIALS

TABLE

Cardboard
Rubber bands
4 ping pong balls
Scissors

HABITAT BUILD

Blocks
Cardboard
Paper
Pencil or pen
Straws
Popsicle sticks
Rubber bands
Pipe cleaners
Modeling dough
Paper clips
Toothpicks

DESIGN YOUR HABITAT

Grab your building materials. Substitute or skip items as needed, but avoid using tape to maintain a challenge.

- Asses the materials available to you and think up a design for your habitat.
- Sketch or draw your plan on a piece of paper.
- Use some questions, like the ones below, to spark your imagination:
    - *How will you design your habitat to handle the quakes on Mars? What shapes and/or materials can you use?*
    - *How are buildings on Earth designed to survive Earthquakes? What shapes and/or materials do they use?*
    - *Are there any extra features you want to build on to your habitat? Will it have rooms? Will it be more than one story? Where will astronauts live, sleep, or study in your habitat?*
    - *What else might your habitat need to protect astronauts against on Mars?*

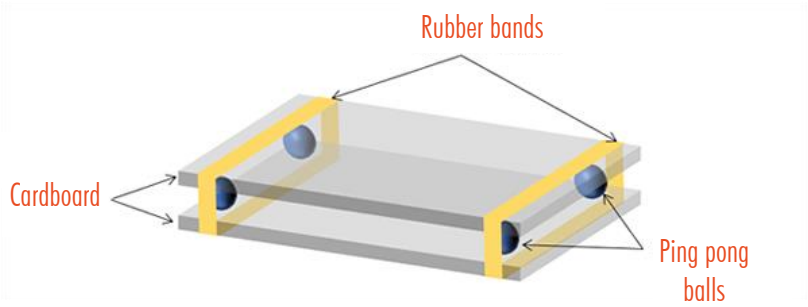


Diagram showing how to build the Quake table.

BUILD YOUR DESIGN

Bring your design to life by building it.

- Work individually or as a group.
- Adult support is encouraged, as some learners may need help with tools and construction of their design.
- You may build directly onto the quake table, or build on a flat surface that can be used to transport your habitat to the testing area when ready.

TEST YOUR HABITAT

Once you are ready to test your habitat, place it on the quake table for testing. NOTE: You do not have to wait until you are finished to test your design. You may test it, or elements of it, during any stage of the build.

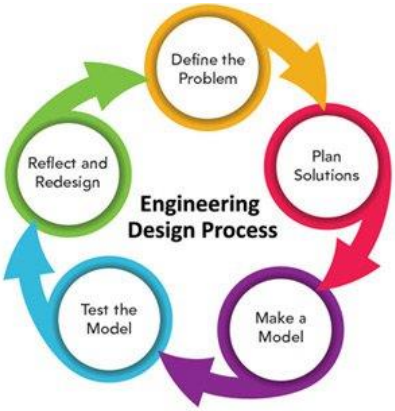
- Simulate a mild Marsquake by shaking, tapping, or tugging on the top board 3 to 4 times in a row.
    - You can control the quake however you want, just make sure to hold the bottom board in place while testing.
- Observe the habitat's behavior during and after the quake.
- Determine whether your habitat survived or not:
    - If it remained standing without collapsing or falling apart, then it survived.
    - If it collapsed or elements of it fell apart, then it did not survive.
- Based on your results, evaluate and determine which parts of your habitat could be improved to strengthen the structure. Use the questions below for guidance:
    - *How did your habitat behave during the quake?*
    - *Does it need to be stronger and sturdier? Or does it need to be more flexible and fluid?*
    - *Does only one piece/area need to be improved? Or does the whole thing?*
    - *What can you change or replace to address these needs?*

REDESIGN AND REPEAT TO IMPROVE YOUR HABITAT

Make changes as needed to your habitat's design. Then, test it on the quake table again!

- Determine whether it survived or not.
- Assess whether improvements from the first round were helpful.
- Evaluate and determine if there are more improvements that can be made. Redesign and build those improvements, then test again.

Repeat the cycle over and over until you have created a habitat that can successfully remain standing during a Marsquake. Then, use one of the extension activities on the next page to continue the fun, or make up your own challenge!



EXTENSION ACTIVITIES

Use one of the prompts below to start a new challenge. Start small, then increase the conditions (height, quake, or size) with each round of testing. Once you've reached the limit that your habitat cannot withstand, design a solution for it.

- *What is the tallest habitat you can build? Test it under a moderate Marsquake to see if it survives.*
- *What is the most intense Marsquake you can create with the shake table? Try building a habitat that can survive it at its most intense.*
- *How complex can you make your habitat while still making it quake-proof? Try adding rooms, extra features, and other additions of your choice then test them against a moderate Marsquake to see if it survives.*

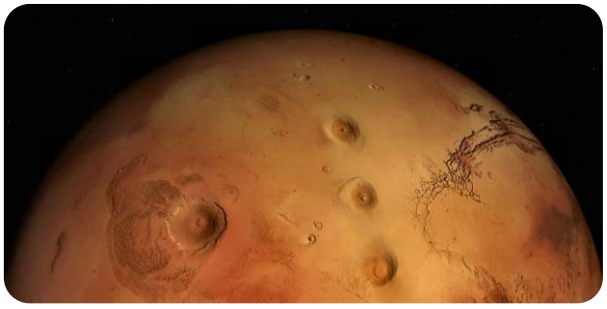
BACKGROUND INFORMATION

HOW DO WE KNOW MARSQUAKES ARE HAPPENING?

Mars is a rocky planet like Earth, so scientists can expect similar geographic phenomena to occur. By comparing satellite imagery of Mars to Earth, scientists have been searching for signs that indicate a seismic history. One such example is the magnetic striping on Mars' southern region, which reveal that there may have been slow movement of the planet's crust at one time. Another example is Valles Marineris, the "Grand Canyon of Mars", which may have grown wider and deeper as quakes shook through its walls. These small but convincing indicators have led scientists to believe that Marsquakes are happening. At what rate and severity, however, is still to be determined.

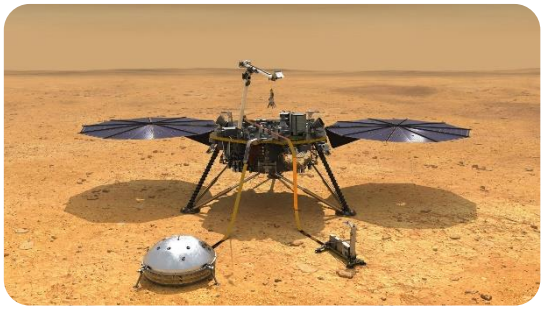
WHAT COULD BE THE CAUSE OF MARSQUAKES?

The exact cause of Marsquakes still remains a mystery. However, current theory points to meteor impacts, planetary shrinkage, sub-surface shifting, or volcanic activity. Volcanic activity is likely, considering Mars is home to the largest known volcanoes in our solar system. One volcanic plateau alone contains several massive shield volcanoes, including Olympus Mons. These volcanoes could create events powerful enough to send rumblings across the planet when active. The current status of the volcanoes is unknown, but signs show of an active past.



Tharsis Region of Mars. The three volcanoes in a row are known as Tharsis Montes. To the bottom left is Olympus Mons, the largest known volcano in the solar system.

NASA's InSight mission patch, illustrating the core of Mars revealed.



NASA's InSight lander, illustrated sitting on the surface of Mars with its seismometer (bottom left) and digging mole (bottom right) set up.

HOW ARE WE STUDYING MARSQUAKES NOW?

NASA is currently relying on their robotic lander, named InSight, to help collect data that will reveal more about the nature of Marsquakes. InSight stands for Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport. This lander, which arrived on Mars in 2018, is equipped with advanced tools designed for drilling, measuring quakes, and scanning deep below the surface of Mars to study its inner core. Its mission is to help scientists learn more about the rocky planets, how they may have formed, and how they may change over time.

InSight is also tracking Marsquakes. Each time the surface shakes, InSight's seismometer (a tool that measures the shaking of a quake) collects data to send back to Earth. Scientists will use that to determine how often and how intense Mars' quakes are. It will also determine what the source of the quakes may be, depending on the movement's behavior, direction, and intensity.

WHAT HAS INSIGHT TOLD US SO FAR?

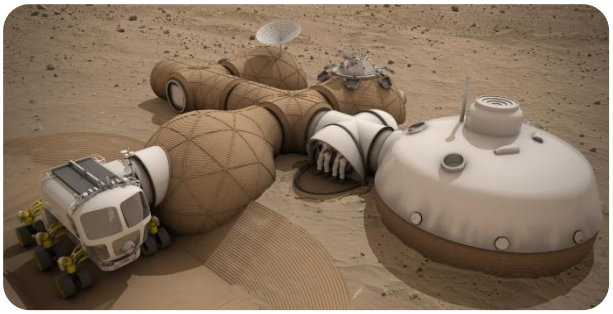
In December of 2020, NASA released an update, summarizing what InSight's data has told us so far. Faint rumblings appear to be normal, with most quakes detected at a magnitude of 3.7 or below. This was surprising to scientists, who had predicted to see more. This could mean that Mars is less seismically active than predicted, or that it is simply experiencing less quakes at this time.

InSight's mission has recently been extended through December of 2022. Collecting more, long-term data will lead to a better understanding of Mars' seismic status and interior structure overall. Read the report and find more information about InSight on NASA's website: https://mars.nasa.gov/news/8817/3-things-weve-learned-from-nasas-mars-insight/?site=insight

WHAT IS A HUMAN HABITAT?

A habitat is a structure that provides everything a plant or animal needs to survive, such as food, shelter, water, and air. If NASA is going to send humans to Mars, they will need to design and build habitats that not only provide the basics for survival, but also protect them against the harsh conditions. On Mars, 95% of the atmosphere is Carbon Dioxide gas, the average temperature is -81°F (-60°C), and planet-wide dust storms blot out the sun for weeks at a time. This environment is not necessarily welcoming to humans.

Scientists, engineers, and architects are already working together to come up with ideas for habitats that will allow astronauts to survive on Mars. These early ideas will evolve as new technology becomes available and, eventually, models of these designs will be built and tested against simulated conditions to determine whether they will be able to survive. Even the best scientists and engineers in the world have to start somewhere, and sometimes it just takes a little bit of imagination and grit to come up with a groundbreaking solution.



This is an idea for a 3-D printed Mars habitat, created by a team of designers and architects, and submitted to NASA for a habitat design challenge.

NGSS STANDARDS, CONCEPTS, AND PRACTICES

NEXT GENERATION SCIENCE STANDARDS (NGSS)

K-2-ETS1-1: Questions are asked, observations are made, and information is gathered about a situation people want to change. A simple problem is defined and solved through the development of a new or improved object or tool.

K-2-ETS1-2: Sketches, drawings, and physical models are developed to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3: Data from two or more tests is analyzed to compare the strengths and weaknesses of how different models designed to solve the same problem perform.

3-5-ETS1-1: A simple problem reflecting a need or want that includes specified criteria for success and defined constraints.

3-5-ETS1-2: Multiple solutions to a problem are generated and compared based on how likely each is to meet the criteria and constraints of the problem.

NGSS CROSS CUTTING CONCEPTS

Cause and Effect: cause and effect relationships are identified and tested.

Structure and Function: structures are designed to serve a particular function by taking into account properties of different materials, and how materials can be shaped and used.

NGSS SCIENCE AND ENGINEERING PRACTICES

Asking Questions and Defining Problems

Developing and Using Models

Constructing Explanations and Designing Solutions

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