
Vibration Design Testing



Ariane V launch vehicle

Background

The James Webb Space, (JWST) will make observations of distant stars and planets. It will be launched on an Ariane 5 rocket in 2020 from French Guiana. It is a highly technical design which has taken many years to be designed and made. It has been an international collaboration involving North America, Canada and Europe.

This video provides an overview of the JWST:

https://www.youtube.com/watch?v=KaHzj_wYhcl&t=0s&list=PLcy1hEnsejK22GOXkFNRGzjEUwyRDuVpj&index=8

To reach its destination in space, it must be able to withstand the forces that occur during launch. This vibration testing was carried out in NASA's Goddard Space Flight Center in Maryland. Here the telescope was subjected to the forces that it will feel during launch by vibrating it from five to 100 times per second. These tests were carried out in order to ensure the spacecraft will survive the ride into space.

Overview

In this activity children design and make a model telescope to be launched into space. They carry out vibration tests, then modify their structures to ensure that they can withstand a simulated launch.

Curriculum areas

> Design and Technology

Vibration Design Testing

Big questions

How do telescopes get into space?

How do designers and engineers test products to ensure they will do the job that they are designed to do?

Resources

 An egg, boiled or hollow chocolate for the introduction

 Each group will need: Modelling materials such as: empty crisps tube, (or similar), straws, lolly sticks, tooth picks, aluminium foil, cardboard, paper, recycled boxes, plastic pots, bubble wrap, glue, sticky tape.

 Images of the James Webb Space Telescope

Safety

Make sure children are aware of how to hold the tubes with the lids securely sealed, so nothing is thrown with force around the classroom. Make sure they shake or throw their tubes in an area that is not close to other children. Have a testing zone!

Introduction

Ask the children what they already know about the James Webb Space Telescope. If they haven't carried out any of the previous activities. Show slide 2 and ask them what they think it is and why? Explain that it is a very powerful telescope that will collect infrared radiation, (heat) from distant stars and galaxies. It will orbit the sun at a point 100 million miles away from the Earth. Ask how the JWST will get into space? It will launch in an Ariane V rocket in 2019.

Show the video of a rocket launch: <https://www.youtube.com/watch?v=YHw4fY26ORM>

Ask them to come up with words that explain the launch thinking about all of their senses. Explain that as the rocket launches they will be a very high forces acting upon it. There will also be a lot of shaking! Bicycles, cars, boats, planes, bike racks on cars, baby and car seats, almost anything that will need to withstand some kind of force/movement will have been vibration tested to see that it will withstand the forces placed upon them during movement. Why are they tested in this way? (Safety, to ensure that they don't break, to make sure they last).

In the same way any structures that are sent into space will have to withstand forces a launch. They do this using a vibration test, where the design is shaken to simulate launch. They may do this test many times to make sure the valuable telescope doesn't break.

Demonstration

Show them an egg and say this egg represents the telescope. They will be designing and making their own model telescopes. Place the egg inside an empty crisp tube. Ask them how we can simulate the vibrations/ shaking that happen during a launch?

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They hopefully will suggest shaking the tube/throwing it to another person. What do they think will happen to the egg inside the tube if we launch the rocket? Take their ideas, then try some of them out? Open the tube and see if the 'egg rocket' is still intact and has to cracks. Ask if the same thing could happen to the JWST during launch? Ask them why?

Explain that designers and engineers carried out many tests to make sure that the JWST will not get damaged during its launch. The telescope has taken a long time and is very expensive to launch into space, so it is important that these tests are carried out. This clip shows the JWST being prepared for vibration testing. The team working on this test are folding the telescope, into the shape it will be in when it is inside the rocket.

<https://www.youtube.com/watch?v=baldjmGjJ2k>

Credit: NASA's Goddard Space Flight Center/Michael P. Menzel

This video is public domain and along with other supporting visualizations can be downloaded from the Scientific Visualization Studio at: <http://svs.gsfc.nasa.gov/12546>

Activity

Tell the children that they are going to work like designers to design and make a model telescope to be launched into space. They then carry out vibration tests, to ensure that their designs can withstand a launch from earth into space. They need to choose the materials to make their model and come up with their own ideas for carrying out a vibration test. NB. The test need to be rigorous, as the structures will be put under a lot of stress during launch and designers need to know their structures will not break!

Their model should be similar in structure to the JWST, but not an exact replica. It should be:

Made of at least three separate parts that are joined together: a folding mirror, a secondary mirror and a sunshield. Their final design must fit into a rocket, (crisps tube) and withstand launch.

Children can come up with their own way of testing if their telescope can withstand launch, but shaking the tube and throwing it to a friend should provide enough vibrations to test the strength of their designs. They could also test their designs to find out the maximum number of vibrations their structures can withstand before breaking or investigate the intensity/speed of the shaking and how that affects the structure.

Once they have built their models then they should be tested for their ability to sustain the vibrations of launch. If their model breaks apart during the test, then children should modify their designs. Children should be encouraged to change their designs/materials used as they go along, so that they come up with the best possible structure.

When they have completed several tests, they should feedback to other groups. They should be encouraged to say what they have changed from their original design and why. Ask them to share ideas with other groups and also to listen to the solutions other children came up with. Ask them if they think they would like to modify their design further now they have seen other designs.

A design template is provided, but children may find it easier to work on a large sheet of paper using headings from the template.

Explain to the children that they have been working like design engineers, working together to solve problems that they have found in their designs. Tell them that the James Webb space telescope involved a large number of people from different parts of the world working together to come up with the best design solutions.

Further links

James Webb Space Telescope, NASA site: <https://jwst.nasa.gov/index.html>

James Webb Space Telescope, ESA: <http://sci.esa.int/jwst/>