Objectives

In this unit students will:

- Explore the James Webb Space Telescope (JWST) and understand its mission.
- Develop understanding of how JWST is protected while travelling to its final destination in space.
- Create ideas of how JWST can be protected from vibrations caused during space travel.
- Understand the work of environmental test engineers.

The big questions

- When the James Webb Space Telescope is launched what are the forces that act on it?
- How could these forces damage the telescope?
- How can we protect JWST from being damaged on launch?

Background

When JWST is first sent from Earth towards its eventual destination to orbit the sun at L2 (1.5million km away) it will be carried aboard an Ariane 5 rocket. When any rocket is launched there is a huge amount of force needed to allow the rocket to 'lift off' and makes its journey out of the Earth's atmosphere. There are massive vibrations during launch that the rocket and its payload must survive. Students are going to consider how an aerospace engineer can design and test a system of stopping JWST from getting damaged on launch.

Curriculum Links

Design & Technology KS3 PoS

- Make

- select from and use a wider, more complex range of materials, components and ingredients, taking into account their properties

- Technical knowledge

- understand and use the properties of materials and the performance of structural elements to achieve functioning solutions

1 Resources

Per Student:

- JWST Flight Test Vibration Worksheet

Per team of 3 students:

- 40g Pringles® Tube (or similar)
- Ball Point Pen
- Strong Glue
- 1 Egg per Team (Hen's or Small Chocolate)
- Blu-Tac
- Cotton Wool
- Stopwatch
- 70g Pringles® Tube (or similar)
- Motor, with Power Supply and Eccentric Cam
- Plastic Tray
- Selection of Elastic Bands
- Roll of Foil
- Modelling Wire
- Weighing scales

2 Starter

Slide 1:

Students are shown a range of objects items that are designed to reduce severity of impacts and / or vibrations. They should be encouraged to make links between the protective properties of the items shown and explain how they perform when they are in use.

3 Introduction

Slide 4 & 5:

To check previous knowledge of JWST show the telescope again now it has been identified through the session objectives. Some of the basic facts about JWST and its mission can then be shown and discussed.

Slide 6 & 7:

Students discuss their knowledge of forces and how they might apply to a rocket launch. Students should be made aware of how vibrations are caused as the upwards and downwards force oppose each other, they can be questioned for ideas on where more vibration could be caused (e.g. from the sound of the rocket).

Slide 8 & 9:

Students are shown how JWST (in its folded form) is housed inside Ariane 5's payload fairing. Students need to consider and share their initial thoughts on how JWST might be protected by the vibrations discussed previously.

4 Activity

Slide 11 & 12:

Working as an environmental test engineer, students are to develop a solution to protect JWST from vibrations as it is transported into space. They will first produce ideas on sketches of what could be used to protect JWST while it is housed inside the payload fairing. Students should be encouraged to be creative with their ideas, and to explain as annotation and when feeding back. They need to also consider limitations such as the weight of the protection system and how this could affect fuel consumption of the launch.

Slide 13 & 14:

Students are asked to continue in their role as a vibrations engineer and develop their idea for a protection system further, through use of a simple model, where the delicate JWST is represented by an egg (hens or small chocolate) inside of a 70g Pringles® tube (or similar) that is put through testing on a shaker plate. Students are given limited materials (this can be differentiated accordingly) to produce their model, the success of the model is initially measured by the egg not being broken under vibrations testing, and then should all tested models be successful on the lightest overall protection system.

Slide 15-21:

Guidance is given on building the shaker plate for vibrations testing, this could be prepared prior to the session, or is included here as an extended part of the session with students constructing their own shaker plates.

Slide 22 & 23:

Further guidance is given on how to construct then test the students' protection system model.

5 Plenary

Slide 24 & 25:

The completed and tested payload protection systems should be analysed by students, considering if they succeeded in protecting their payload (the egg) for one minute of vibration and then on their overall weight. To find the weight of each protection system the payload fairing (Pringles tube) with the protection system and egg inside should be found, this should then be subtracted from the weight of the payload fairing and egg only.

Slide 26:

Further background information on the work of a vibrations engineer can be discussed.

6 Follow up session

Slide 27:

If a large number of students have produced successful protection systems further extreme vibrations can be simulated by drop testing the payload fairing model while loaded with the egg. The payload fairing model can be dropped from increasing heights, 1m at a time, until the egg is under enough force to break, or further height cannot be achieved safely.

Protecting JWST - Design Ideas

JWST needs to sit inside the payload fairing (this is the nose part of the Ariane 5 rocket where JWST will be held while it is launched). It opens up in space to allow JWST to be released and carry on its journey into deeper space. While it is inside the payload fairing it needs protecting from the massive vibrations caused by the Ariane 5 as it is launched.

Produce a design for how JWST can be protected while in the payload fairing, your design should include:

- A sketch, including: JWST, the payload fairing and the protection system.
- Annotations to explain the protection system.
- An evaluation of how successful you think your system would be.

Evaluation: