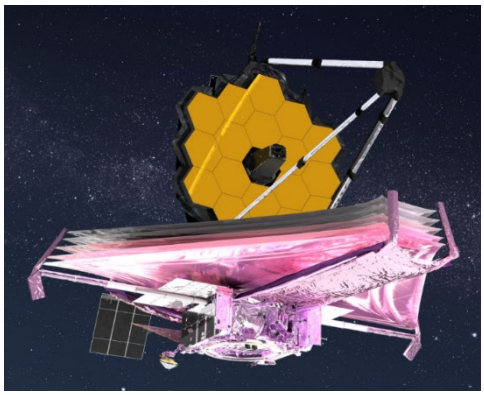
Views from Space

STEM Challenge 2022

Program Description

Students will work in groups to design, build, and test a telescope that stays within a budget, perform various required tasks, and survive a series of challenges. Be sure to check out the **Expansion Activities** and **Careers** sections at the end.

Background & Task



The James Webb Space Telescope (JWST) was developed in partnership with the European Space Agency, the Canadian Space Agency, and the National Aeronautics & Space Administration and its partners. The JWST is the newest and best way for scientists to observe outer space. It will study every phase of the universe – from the very beginning to the formation of planetary systems like ours. The large mirror has 18 separate pieces that unfolded and adjusted into position after the telescope launched and moved into place. The telescope has 4 instruments – cameras and spectrometers – that have detectors that can record faint signals. The JWST has a tennis-court sized sun shield and a cryocooler to keep its systems from overheating.

The challenge is to design a similar telescope that can perform specified tasks and survive the elements while staying under budget.

Time

30 minutes – 45 minutes

Activities

- **Introduction:** Learn vocabulary and key concepts relating to the exercise
- **Activity 1:** *Plan It* - Students will review design choices for their telescope prototypes within a given budget
- **Activity 2**: *Build It* - Students will choose materials to construct their designs
- **Activity 3:** *Test It* – Students will test their designs against our parameters to see if it is successful
- **Analysis and Reflection Questions**: Students will evaluate their designs and form conclusions based on their findings

Materials

- Mission Proposal Worksheet and Handouts
- Pencil/Pen

Introduction

Divide into groups of 2 or more students. Groups will have 10 minutes for an introduction of the challenge and 15 minutes to make their choices on telescope prototypes. Any additional time will be spent on testing and analysis.

Vocabulary

- Cryocooler: The cooling device for the Mid-Infrared Instrument, or MIRI, one of the James Webb Space Telescope's four instruments. The MIRI requires a lower operating temperature than Webb's other instruments, the cryocooler accommodates this requirement.
- Integrated Science Instrument Module (ISIM): the structure that holds Webb's four science instruments.
- Low earth orbit (LEO): an orbit that is relatively close to Earth's surface.
- Payload Capacity: maximum amount of weight a vehicle can safely carry.
- Primary mirror: made up of 18 hexagonal segments that work together as a single, 6.5-meter mirror. The mirror segments are made of beryllium, a very lightweight and strong material. Each mirror segment is mounted on a hexapod with actuators that enable fine adjustments to each segment in six degrees of freedom: x and y position, piston, tip, tilt and clocking. An additional actuator at the center of each primary mirror segment provides radius of curvature control. This system enables controllers to finely time all 18 segments to work as one large mirror.
- Secondary mirror: dissects the light from the primary mirror to where it can be controlled by Webb's instruments. The secondary mirror is moveable and can be adjusted to focus on the telescope.
- Solar Array: converts sunlight into the power needed to operate the science instruments and the spacecrafts subsystems.
- Spacecraft Bus: provides the necessary support functions for the operation of the observatory. It contains six major spacecraft subsystems: Electrical Power Subsystem, Altitude Control Subsystem, Communication Subsystem, Command and Data Handing Subsystem, Propulsion Subsystem, and the Thermal Control Subsystem.
- Sunshield: its five Kapton-based layers keep the infrared light (or heat) from the Sun, Earth, and Moon, as well as the spacecraft bus electronics, from reaching Webb's mirrors and science instruments.

Activity 1: *Plan It*

Now that we have reviewed some vocabulary and key concepts, it is time to plan the telescope prototype!

With a given budget of $5 billion, students will need to consider different options for their telescope mission proposal. They will have to choose between the type of rocket, project deadline, and six different parts of their telescope. Choices can have effects on weight and/or the cost of the project so choose wisely!

Activity 2: *Build It*

After reviewing the options thoroughly, students should complete the "Mission Proposal" worksheet by writing down their choices.

Activity 3: *Test It*

Even the best laid plans can have a few hiccups when it comes to completion. Student proposals will now be tested for viability through the following six trials:

Trial 1: Can your rocket carry the weight of your telescope?

Trial 2: Is your mission proposal under budget (less than $5 billion)?

Trial 3: While selecting an earlier project deadline reduces labor costs, mistakes often occur when things are rushed, and workers become disgruntled. All project deadlines before July 19, 2024, face a union strike from its workers and must double their additional labor cost. Is your proposal still under budget?

Trial 4: During construction of the mirrors, there was a worldwide shortage of titanium beryllide material and prices skyrocketed. If your telescope requires this resource, double the original cost of the material. Is your proposal still under budget?

Trial 5: During one of your rocket tests, something went wrong with the fuel and blew up the entire rocket! You must pay an additional cost for relaunch. Add the cost of your chosen rocket to your total budget. Is your budget still under $5 billion?

Trial 6: Congratulations, your rocket has launched, but it experienced unusually high turbulence exiting the atmosphere. Did you choose either Kapton or Kevlar for your Sunshield?

If the answer is no to any of the above questions, your mission proposal has been declined and the project has been scrapped by the current administration.

Analysis & Reflection Questions

1. Was your proposal successful? Why or why not? What would you change if anything?

2. In reality the James Webb Space Telescope went over budget, was behind on all its project deadlines, and was almost scrapped. Why and what do you think caused the increased costs and delays?

3. Why are missions like the James Webb Space Telescope important to humans?

EXPANSION ACTIVITIES

The James Webb Telescope faced some incredible STEM Challenges of its own! Check out the below QR Codes/Weblinks to learn more about them!

Mirror Design

Keeping Things Cold

Vibration Design

CAREERS

Below are some of the STEM careers involved with the development of satellites and telescopes!

- Project Manager: Assist leading the development, launch, and commissioning of projects or missions.
- Lead Engineer: leads a team of Engineers and Technicians to oversee the smooth and efficient running of specified equipment and has oversight over each phase of maintenance.
- Lead Scientist: setting goals and objectives, delegating tasks, establishing guidelines, and overseeing the progress and performance of other scientists and workers in a laboratory.
- Planetary Scientist: Planetary scientists work to improve our understanding of the planets, satellites, and smaller bodies in the solar system.
- Exoplanet Scientist: discover and characterize planetary systems and Earth-like planets around nearby stars.
- Mission Systems Engineer: Oversee system engineering and technical execution of hardware/software system development projects.