



# Science and Innovation

A Boeing/Teaching Channel Partnership

## CUBESATS Teacher Handbook

## CubeSats

### Day 1: What Are CubeSats?

Grade Level	Grade 5
Lesson Length	One 50-minute session



#### Lesson Overview

The students kick off the module by starting a **KLEWS** chart on satellites. Students revisit their charts over the course of the module. The key components of the **KLEWS** chart are:

**K**—What do we think we **Know**?

**L**—What do we want to **Learn**?

**E**—What is the **Evidence** we have gathered from our research and engineering project?

**W**—What do we still **Wonder** about?

**S**—What **Scientific principles** we have learned?

After completing the **KLEWS** chart, students learn about CubeSats and brainstorm possible payloads. At the end of the lesson, students write a description of their payload, mission, and the ways their CubeSat will positively impact society.



#### Connecting to the Next Generation Science Standards

In this lesson, students make progress toward developing understanding across the following three dimensions:

- **Science and Engineering Practices:** Asking Questions and Defining Problems
- **Disciplinary Core Ideas:** ETS1.A Defining and Delimiting Engineering Problems
- **Crosscutting Concepts:** Influence of Science, Engineering, and Technology on Society and the Natural World

In the following table, the specific components addressed in this lesson are underlined and italicized. The specific connections to classroom activity are stated.

Performance Expectations
<p>This lesson contributes toward building understanding of the following <i>engineering</i> performance expectations:</p> <p><u><i>3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.</i></u></p>
<p><b>Specific Connections to Classroom Activity</b></p> <p>In this lesson, students are introduced to a special type of satellite called <i>CubeSats</i>. Students brainstorm payloads for CubeSats. Students then combine their ideas with NASA's mission ideas to define a specific mission for their CubeSat. Students comment on the criteria and constraints for their mission.</p>

Dimension	NGSS Element	Connections to Classroom Activity
Science and Engineering Practices	<p><b>Asking Questions and Defining Problems</b></p> <ul style="list-style-type: none"> <li>• <i>Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.</i></li> </ul>	Students are introduced to the design problem of creating a CubeSat. Students select a payload and purpose for their CubeSat. In a written description of their mission, students identify the criteria and constraints for their design solution.
Disciplinary Core Ideas	<p><b>ETS1.A: Defining and Delimiting Engineering Problems</b></p> <ul style="list-style-type: none"> <li>• Possible solutions to a problem are limited by available materials and resources (constraints). <i>The success of a designed solution is determined by considering the desired features of a solution (criteria).</i> Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success of how well each takes the constraints into account.</li> </ul>	Students consider the criteria and constraints for their CubeSat mission. As students write their mission plan, they are prompted to think about the desired features of a successful solution. In later lessons, students will continue to revise the criteria and constraints and will test their CubeSats to determine if they met their criteria and constraints.
Crosscutting Concepts	<p><b>Influence of Science, Engineering, and Technology on Society and the Natural World</b></p> <ul style="list-style-type: none"> <li>• <i>Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.</i></li> </ul>	Students learn about an engineer who developed a use for CubeSats that could have many positive impacts on society. The engineer met societal needs to develop a smaller satellite. Students create missions for their CubeSats to positively impact society.



### Basic Teacher Preparation

Throughout the module, students work in design pairs. Select and assign design partners during this lesson. Student should continue to work with their design partner throughout the remainder of the module.

Prior to this lesson, read about the **KLEWS** chart. The chart is a good way to solicit prior knowledge from students and to capture evolving thinking and knowledge from the class as more learning unfolds.

Required Preparation	Links/Additional Information
<input type="checkbox"/> Gather or purchase all required materials for the lesson	Refer to the <b>Materials List</b> below
<input type="checkbox"/> Review suggested teacher preparation resources	Refer to the <b>Suggested Teacher Resources</b> at the end of this lesson



## Materials List

Item	Description/Additional Information	Quantity	Where to Locate/Buy
Chart paper	N/A	1 per student	Available in most schools
Markers	N/A	1 or 2 sets for teacher and students	Available in most schools
Sticky notes	N/A	1 package of various colors	Available in most schools
Science notebooks or loose-leaf paper	N/A	1 per student	Available in most schools

## Day 1: What Are CubeSats?



### Introduction (15 minutes)

Begin the lesson by introducing the **KLEWS** chart, which should look like this:

K—Know	L—Learn	E—Evidence	W—Wonder	S—Scientific Principles
What do we think we already know about satellites and CubeSats?	What do we want to learn about satellites and CubeSats?	What evidence have we gathered?	What do we still wonder about satellites and CubeSats?	What scientific principles have we learned?

Explain to students that today is the beginning of a new module. In this module, they are going to build a special type of satellite called a **CubeSat**. Let students know that in this first lesson they will focus on only three parts of the chart—**K**, **L**, and **W**. However, as the module unfolds, they will come back and revisit the chart to add **Evidence** and list **Scientific Principles**.

Instruct students to work on their own to think of three ideas or statements related to what they already know about satellites and how they work. Have students write each idea or statement on a sticky note.

Have students take turns sharing with their science partners what they wrote for the **K** (**Know**) column. After students have shared with their partners, have them place their sticky notes on the class chart.

Gather students near the chart and read the sticky notes. Comments and discussion should follow. Model a “think aloud” approach based on the content of the sticky notes.

Repeat the pair and share process for the **L** (**Learn**) column. Then, have students add their sticky notes to the class chart and read the information. After the **K** and **L** have been reviewed and discussed, consider asking the class to suggest some statements to add to the **W** (**Wonders**) column.



#### NGSS Key Moment

As students share their ideas about satellites, take note of their current understanding of satellites. Adapt instruction according to students' developing conceptions.



#### Helpful Tip

Use different colored sticky notes for the different columns in the KLEWS chart. For more information about KLEWS charts, review the article at [TCA: KLEWS to Explanation-Building in Science](#).



## Whole Group Discussion: CubeSats (10 minutes)

Tell students that in this module they will be designing a special type of satellite called a *CubeSat*.

Show students the [CubeSats Explained](#) video. Also read the accompanying text out loud. Then, show the [JPL's Crazy Engineering CubeSats](#) video. After showing the videos, engage students in a discussion about **payloads**. As a group, develop a shared definition for **payload**. The definition should capture the idea that a payload is the cargo, typically the most important cargo, of a vehicle.



### Video Link

- ▶ CubeSats Explained [\[Web Link\]](#)
- ▶ JPL's Crazy Engineering CubeSats [\[Web Link\]](#)



## Whole Group Discussion: Payloads (15 minutes)

Ask students to brainstorm potential payloads for CubeSats. Students should work with their design partners to brainstorm a list of potential payloads. At this point, accept all responses.

After students have had sufficient time to brainstorm payloads, introduce and show the [Tiny Satellites](#) TED Talk.

After showing the video, lead a discussion about how Will Marshall's company is responding to societal needs and positively impacting society.

Ask students to think about their own payload ideas. How can their ideas meet societal demands or have a positive impact on their community? Have students brainstorm ideas in small groups and then share their ideas in a whole group discussion.

Tell students that NASA is particularly interested in using CubeSats for the following five missions:

- **Radio Communication**
- **Lightening Detection**
- **Lunar (Moon) Imagery**
- **Mars Orbiter**
- **Earth Imagery**



### Video Link

- ▶ Tiny Satellites TED Talk [\[Web Link\]](#)



### NGSS Key Moment

Discussing the impact engineers have on society helps students make progress on the Crosscutting Concept: Influence of Science, Engineering, and Technology on Society and the Natural World



### Helpful Tip

More information about each mission can be found in **Appendix D**, although this information does not need to be shared with students.

Instruct students to combine one of NASA’s missions with their own ideas. For instance, if a group was interested in imaging roads and terrain, they could combine their idea with NASA’s **Earth Imagery** mission.

Instruct students to create their initial mission plans. Students should record their mission ideas and explain how their mission will positively impact society. As they do, students should list possible criteria and constraints for their missions. Students should post their mission plans on chart paper.



## Lesson Close (10 minutes)

Tell students that, in this module, they will work through the engineering design process as they design CubeSats.

Reference the **Engineering Design Process** in **Appendix A** and describe the steps of the process.

Explain that students will be making a model CubeSat, testing for successes and failure, and learning about satellites throughout the module.

At the end of Day 1, assign the homework.



## NGSS Key Moment

Engineers often refer to the *engineering design process* when they discuss their work. In the NGSS, the Science and Engineering Practices are used in place of the engineering design process. Students should understand that the engineering design process is not linear in practice. Rather, engineers engage in all of the steps, often jumping between steps. Students may want to think of the engineering design process as a web of practices.



## Homework

Ask students to interview their parent(s) or guardian(s) by asking:

- ▶ How is your life affected by the use of satellites?
- ▶ Do you have any questions about satellites that we should add to our class chart?



## Assessment

Use student descriptions of mission plans to gage their progress on ETS1.A, Asking Questions and Defining Problems, and the Influence of Science, Engineering, and Technology on Society and the Natural World. Student products should show evidence of progress on all three dimensions. Provide appropriate supports or interventions as necessary. Reference **Appendix B** for suggestions for meeting the needs of all learners.



## Community Connections

Many communities have software or technology companies that may be doing related satellite work. These companies are often willing to suggest a guest speaker. Many urban areas have science centers that have connections related to the topics in this lesson and module.



## Suggested Teacher Resources

Engineering Design Process	CubeSats Teacher Handbook, Appendix A
Meeting the Needs of All Learners	CubeSats Teacher Handbook, Appendix B
Mission Details	CubeSats Teacher Handbook, Appendix D
TCA: KLEWS to Explanation-Building in Science	<a href="#">[Web Link]</a>
CubeSats Explained	<a href="#">[Web Link]</a>
TED Talk: Tiny Satellites	<a href="#">[Web Link]</a>
JPL's Crazy Engineering—CubeSats	<a href="#">[Web Link]</a>