Lesson Overview	Career Highlight
Students learn how the life cycle of satellites and the Falling Star probes depend on the orbit, velocity, altitude and density of the atmosphere and how scientists and engineers work in teams using critical thinking, data, scientific modeling, and inquiry as a team to engineer satellites.	Highlight all careers within The Aerospace Corporation which consist of teams of Engineers and Scientists. **Space Science Applications Laboratory Scientist** **Vehicle Design and Innovation Engineer**

STEM Course Connections	21st Century Skills
Elementary Engineering Elementary Earth Science Elementary Physical Science	Collaboration Communication Critical Thinking

Engineering Activity	
Science and Engineering Practice	Students will build a probe, drop a probe and measure the amount of time in the air. Students will analyze and compare the time data.

Materials
● Access for students to use computers/ tablets ● Google Slides/ PowerPoint ● YouTube Access for class videos ● Access to NASA.gov ● Scientist Visitor Slide Deck - *share with scientist before class* ● Teacher Slide Deck ● Student Handout ● Access to CelesTrak ● Access to The Value of Space ● Access to "Going into Action the AeroCube-10" ● Access to "How We Use Space More Than We Think"

- Print 2 Classroom Sets of Probe Template on cardstock- Paper not strong enough to keep shape when built
- Make Falling Star kits with the following supplies:
  - Parachute cord (Different strings): dental floss, thread, yarn, string, shoelace
  - Drag (Create holes): center hole, slits, off set left, combinations
  - Materials for Parachute: Different types of paper napkin, tissue, paper towel, computer paper

Essential Questions

1. What are satellites used for?
2. What is the life cycle of a satellite?
3. How do scientists and engineers work together in teams to create satellites?
4. What is the effect of drag on a satellite?

Prerequisite Knowledge

- Students understand density and how it applies to gas and air
- Students understand Earth has layers of atmosphere that extends to space
- Students understand that drag is a force that works opposite the direction of motion

Mission Prep - Day 1
What is the life cycle of a satellite?

ENGAGE (10 mins) - *Thinking About The Sky*

- Teacher poses the following questions and prompts to the class and allows students a few minutes to respond to each in their Student Handout (section A).
  - What do you **think** you see when you look up at the sky during the day?
  - What do you **think** you see when you look up at the sky at night?
  - Draw a **picture** of what you **think** the sky looks like at **night**.
- Students share their answer with the class and student can do a gallery walk of their pictures
- Possible extension for teacher to take class outside and look up, compare and contrast students observations on their handout drawings versus what the students observe outside. Teacher has students bring their Student Handout outside to compare

EXPLORE (10 mins) - *Thinking About Orbits*

- Teacher poses the question and allows the students a few minutes to respond to each in their Student Handout (section B).
  - What do you **think** uses **technology** that is in the **sky**?
  - What do you **think** it means to **orbit** another object?
  - How many **objects** do you **think** are up in **orbit** around the **Earth** at the same time?
- Students share out their answers and the teacher can make a list of the student responses on the board to record the students' thinking.
- Teacher goes to "Let's watch *The Value of Space*" Click on the website and scroll to the first video, watch
- Students respond in Student Handout (section B).
  - How much do you **think you use** outer space?

- Let's talk about the things that use space technology.
    - Satellites that bring you TV, cell phones, internet, weather information, the ability to "check-in" a location on your phone, the GPS in your watches, phones, and tracking your DoorDash, food, getting help to places and finding emergencies.
- Teacher talks about the layers between Earth and space. What do you think the different layers are between things that live on Earth and space?
    - Teacher makes connections between the ways the geosphere, biosphere, hydrosphere, and atmosphere interact. *Examples of geosphere are the rocks, soil, sediment, the biosphere is where all the living things including humans exist. The biosphere is where humans create technology to study the geosphere, hydrosphere and atmosphere. The hydrosphere is all the water and ice. The atmosphere is air and different densities of air that make go all the way to space.*
- Teacher does a demonstration to explain what orbit means. Select one student to represent Earth and three other students for satellites. Student stands in the middle and three other students stand one arm length away from the "Earth." Each of the three students should walk in a progressively larger circle from the "Earth" similar to bullseye target rings. All students walk around the center "Earth" student at the same speed. Teacher asks the question:
    - What do you notice about the number of times the outside students were able to "orbit" the Earth student?
        - The student closest to the Earth student will be able or orbit more times at the same speed compared to other students who are farther away from "Earth" student
        - *Teacher makes the connection if all objects are traveling the same speed, the closer to Earth the object is, the more revolutions the object will make compared to higher (further) orbits.*
    - Teacher makes the connection that a satellite is an object that orbits another object.

EXPLAIN (15 mins) - *Satellites Everywhere*

- Students use computers and go to CelesTrak. Give students time to explore the website about tracking satellites
- Teacher poses the question and gives students time to answer Student Handout (section C):
    - What do you **notice** about the **satellites**?
    - How **long** do you think these **satellites** and objects have **orbited** Earth?
    - How **small** do you **think** the smallest **satellite** is?
    - Why do you **think** there are so **many satellites**?
    - What are the different **colors** of **satellites** (dots)?
    - Try to click on a **satellite** (dot), what happens when you **click** it and what do you **notice** about it?

ELABORATE (10 mins) - *The Falling Stars*

- Teacher shows the video about "How We Use Space More Than We Think" asks:
- Teacher explains the "Life Cycle of a Satellite" and that all satellites go through this process to bring people the information they need.
    - **Develop/Build (What are we making)** - working together as a team scientists identify what data is needed, engineers design system to collect data (What)
    - **Launch (How will we get there)** - engineers mainly focus on getting off of Earth (How)
    - **On Orbit Ops (Why is this data important)** - engineers operate satellites to make measurements and scientists figure out what the data means (Why)
    - **Decommissioning/Re-entry (Where will it go)** - mainly engineers (but scientists make tools and models to predict re-entry and where it will come back into Earth's atmosphere) (Where)

- Teacher connects students' ideas to the CelesTrak, orbits and satellites. Teacher shows the picture of CubeSat. Teacher explains the CubeSat is a small satellite a little larger than a shoebox. The Falling Star is the AeroCube-10 is a CubeSat that can hold 28 smaller probes inside of the satellite! These probes are small, they are about the size of your fist and they all release from the CubeSat at the same time. Teacher has students go to the Student Handout (section D) and try to draw their idea of the Falling Star.
- Teacher explains the AeroCube-10 is actually one satellite about the size of a basketball that holds 28 smaller Probes (The Falling Stars) inside. Then when the satellite reaches the right orbit, the AeroCube-10 (basketball size satellite) will open and release the little 28 Probes at the same time. The small Probes "fall" back to Earth from space and measure the density of the atmosphere.
- Teacher connect with the students the Probes can be collecting information anywhere from 50 - 600 miles above Earth as they re-enter the atmosphere.
- After a few months the Falling Stars will start their descent and re-entry to Earth's atmosphere. Teacher emphasizes *space is exciting and there are still many things that are unknown on Earth and in space. Falling Stars is just one of many ways to study and use space technology to learn about Earth.* Have students fill out on Student Handout (section D)
  - ***Which part of the Life Cycle of a Satellite is this? Develop/ Build
- Opportunity for The Aerospace Corps volunteer to talk about the Falling Stars and the connection between the different job roles. Volunteers add connection between scientists and engineers working to design probes and CubeSats help measure the atmosphere.

EVALUATE (5 mins) - *Vocabulary Enhancement*

- Teacher revisits the Student Handout (section D)and has students answer:
  - What did you learn today about orbits and satellites?
  - What is different and what is the same from your original answers on your student handout?
  - Students fill in the vocab and draw pictures

Aerospace Team - Day 2
How do scientists and engineers make probes?

ENGAGE (10 mins) - *Aerospace is a Team*

- Teacher asks students what their favorite teams are whether it's from sports, personal experiences or anything that represents a team. Teacher gives time for students to write on Student Handout (section: E)
- Teacher explains and makes connections to students that aerospace is a team sport, and between the connections of scientists and engineers (Aerospace Corp highlight career video here) "Going into Action the AeroCube-10" and highlight the need for problem solving from the engineer and collaboration with the scientist to get the best possible solution as a team. Teacher asks class to brainstorm and have a discussion:
  - What is a time that you collaborated or worked with someone one? What was it like?
  - What is a way to build and solve problems together similar to career video?

EXPLORE (25 mins) - *Making the Falling Star*

- Teacher cut out the probe and distributes supplies for each student to create their own Falling Star Probe. Probe Template Class should take 15-25 minutes to *carefully* cut out and assemble Probe Template. Teacher asks students:
  - ***Which part of the Life Cycle of a Satellite is this? Develop/ Build
- Teacher tells everyone to hold the Falling Star Probe at the same height. After the teacher tells students to drop their probe. Teacher asks students and facilitates a discussion on:

  - If you try dropping your Falling Star Probe, what do you notice?
  - ***Which part of the Life Cycle of a Satellite is this? Launch
- Have students verbally share observations about what was similar and what was different between the Probes? Ask the class why do you **think** so? What did you observe about your probe compared to your classmates? Have students record their thinking on the Student Handout (section: F)
  - ***Which part of the Life Cycle of a Satellite is this? On Orbit Ops
- Teacher repeats the same dropping Probe steps but had Students stand at different heights and drop their probe. Have students write down observations in Student Handout (section: F) when dropped

EXPLAIN (5 mins) - *Connection the Life Cycle of a Falling Star*

- Teacher How can your probes be similar to CelesTrak if the ground was like Earth and your probes are "falling" towards Earth?
- Satellites re-enter Earth's atmosphere as they get closer to Earth, they gain speed. Teachers can show the connection of re-entry, descent from orbit, increasing speed and dropping altitude with using a tetherball and show a demo as the tetherball gets closer to pole the speed of the ball increases, and the "orbit" or length of the rope or "altitude" decreases. Teachers can use YouTube videos of tetherball rotating around if no supplies are available.

ELABORATE (5 mins) - *Falling Stars Team*

- Teacher facilitates a student discussion about their ideas about the connections between their probes and the Falling Stars and how they could model the re-entry to Earth and what could affect the re-entry (orbital environmental features). Teacher records the students' thoughts on the board.
- Teacher revisits how the Aerospace Corporation is a team and everyone has a different role to create new solutions to learn about the Earth and space. (Space Science and Applications Researcher and Vehicle Design and Innovation Engineer)
- Ask students the questions and discuss together as a class and have students record Student Handout (section: G)
  - Did you do this all together?
  - Did you need someone to talk to?
  - Did someone in the class have an idea that you tried?
  - What do you think could be things that change how a Falling Star returns and re-enters Earth's atmosphere? (Orbital environmental atmospheric features)
- The Teacher shares how the Falling the Star is a special micro satellite that collects information and data in the atmosphere. The Teacher asks the students to discuss how this experience connects to the Life Cycle of Satellite.

EVALUATE (5 mins) - *Falling Stars Team*

- Teacher has students write an exit ticket reflection on the Student Handout (section: G)about:
  - What did you learn about working together?
  - What was it like working on your own?
  - How can this help you work on creating a new design?
  - Which part of the Life Cycle of a Satellite do you like best so far and why?
- Career Opportunity: Aerospace Corporation can connect and share the different jobs and career paths that work with the science and engineering behind all the aerospace.

Exploration - Day 3
How does drag affect a satellite?

ENGAGE (5 mins) - *Falling Stars Engineered*

- Teacher revisits concepts learned from the prior lesson. Students brainstorm together as a class. Students can record in Student Handout (section: H)
  - How can you make it fall slowly?
  - How can you control how it falls?

EXPLORE (30 mins) - *Falling Stars Experiment*

- Teacher assigns students to work in teams of two different roles: scientist and engineer (Rebecca and Jerry). Teacher explains the team will choose one of the two goals to work on
  - Goal #1 Falling Star falls the slowest speed (the greatest amount of drag, the longest time in seconds in air)
  - Goal #2 Falling Star falls (descent to re-entry) to a specific target location. Teachers mark an "X" on the classroom floor for students to try to hit.
- Teacher shares the two job roles: Lead Scientist, Lead Engineer. Students are aware of the types of jobs and role responsibilities. And the teacher shares the below information.
  1. Lead Scientist: records all of the groups' ideas and presents the ideas to the class
  2. Lead Engineer: collects the materials for the experiments based on the team Goal.
- Teacher explains to students that all students in the group can contribute to anything, but it is the lead role to make sure the tasks are accomplished and finished. Teacher hands out a new Probe Template. Teacher instructs students to fill out their team roles, design, and information on the Student Handout (section: H) Remake their probes, one per team (cut out new ones). Tell students to fill out the information. Ask students to consider where and how they will attach their parachute to the space probe. When the team creates an idea, have students draw out their ideas and show the teacher in order to get supplies from the Falling Stars kits.
- Teacher make Falling Star kits with the following supplies:
  - Parachute cord (Different strings): dental floss, thread, yarn, string, shoelace
  - Drag (Create holes): center hole, slits, off set left, combinations
  - Materials for Parachute: Different types of paper napkin, tissue, paper towel, computer paper
  - *Teacher should determine the graphs that they want students to create before allowing the flexibility to manipulate all variables. Consider having some groups test specific variables or work through all options together as a class.*
- Teacher times all the groups from when the probe is released until it first touches the ground or desired target. Students record their drop time on Student Handout (section: I)
- Teacher and student create class scatter plot draw and plot out the results and students record the results on Student Handout (section: I)
  - Examples for scatter graph axis labels each Goal
    - Goal 1: Number of Strings versus Drop Time, Type of Material versus Drop Time, Number of Holes versus Drop Time
    - Goal 2: Number of Strings versus Drop Time, Type of Material versus Drop Time, Number of Holes versus Drop Time
    - *Remember to choose only one variable to test at a time.*

EXPLAIN (5 mins) - *Falling Stars Explained*

- Teacher leads discuss with class about the following questions:
  - Who dropped the fastest?
  - Who dropped the slowest?

  - Who get got closest to their target for greatest accuracy
  - Who do you think had more drag and why?
  - Which group had the slowest speed? Teachers make connections to drag in the atmosphere.
- Teacher discusses the teams for Goal #2 with controlling the descent to specific location and making connection to orbital environmental features (drag, re-entry, density, atmosphere, and descent.

ELABORATE (5 mins) - *Falling Stars Elaborated*

- Teacher reconnect students learning, Falling Star Probes Experiment to CelesTrak, tracking orbits, and reentry. Teacher asks students to write their answers on Student Handout (section: I)
  - What changed the probes falling?
  - What new ideas do you have about satellites?
- Teacher can show the (Aerospace Career Video about engineering Falling Stars)

EVALUATE (5 mins) - *The Life Cycle of a Falling Star*

- Teacher discusses with the class what they observed about drag, types of design and parachutes. Record students' ideas on the board. Teacher ask the class the following questions and students write their answers on Student Handout (section: I):
  - How can this experiment be similar to the real design and partnership of scientists and engineers working together like they do Aerospace Corp?
  - Is there any evidence for your ideas working?
  - What were the ideas that gave us the best results?
  - Write reflection on how do you use space on a daily basis?
  - What is the life cycle of a falling star?
  - How do teams work together to put objects into space?
  - In your own words describe what you did for each part of the Life Cycle of a Satellite:
    - Develop/Build:
    - Launch:
    - On Orbit Ops:
    - Decommissioning/Re-entry:
- Teacher has the class turn to a partner and share, then share with their class their final thoughts.

Distance Learning Suggestions

Teachers can use Google Slides, Google Docs, Zoom breakout rooms, Menti, Jamboards, or Pear Deck to collect responses, or create visuals for lessons.

- **Teacher** makes sure to turn on Closed Captions for Video

CA NGSS Standards

4-PS3-2 Energy: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

5-ESS2-1 Earth's System: Develop a model using an example to describe the ways the geosphere, hydrosphere, biosphere, and the atmosphere interact.

4-PS3-3 Energy: Ask questions and predict outcomes about the change in energy that occur when objects collide.

4-PS3-4 Energy: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

3-5-ETS1-1 Engineering Design: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials time or cost.

Resources

Center for Near Earth Object Studies. (n.d.). *Close Approach Data* [Data Set]. Jet Propulsion Laboratory California Institute of Technology. Retrieved August 3, 2020, from https://cneos.jpl.nasa.gov/ca/

Center for Near Earth Object Studies. (n.d.). [NASA/JPL NEO Deflection App]. Jet Propulsion Laboratory California Institute of Technology. Retrieved August 3, 2020, from https://cneos.jpl.nasa.gov/nda/nda.html

Flipgrid. (n.d.). Microsoft. Retrieved August 3, 2020, from https://info.flipgrid.com/

Google Drawings. (n.d.). Google. Retrieved August 3, 2020, from https://docs.google.com/drawings/

Google Slides. (n.d.). Google. Retrieved August 3, 2020, from https://www.google.com/slides/about/

Jamboard. (n.d.). Google Suite. Retrieved August 3, 2020, from https://gsuite.google.com/products/jamboard/

Jet Propulsion Laboratory California Institute of Technology. [JPLraw]. (2020, April 27). *Web Tutorial: How to Navigate the CNEOS Website* [Video]. YouTube. https://www.youtube.com/watch?time_continue=17&v=UA6voCyCW1g&feature=emb_logo

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Pear Deck for Google Slides. (n.d.). Pear Deck. Retrieved August 3, 2020, from https://www.peardeck.com/googleslides

San Diego County Office of Education. (2020). *Next Generation Science Standards.* San Diego County Office of Education Science Resource Center. https://ngss.sdcoe.net/

Seesaw. (n.d.). Seesaw. Retrieved August 3, 2020, from https://web.seesaw.me/