Integrated STEM Unit Planner

Grade 5 Science
Drop a Parachute

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PreK-12STEM
Community Training & Assistance Center (CTAC)
Tracy Unified School District

About the Integrated STEM Units

The integrated STEM units are a product of the partnership between Community Training and Assistance Center (CTAC) and Tracy Unified School District (TUSD) in California, funded in part through the Education Innovation and Research (EIR) program of the U.S. Department of Education in 2018. Teacher leaders came together to develop innovative units that align to STEM standards for student learning—namely the Next Generation Science Standards (NGSS) for California Public Schools, the Computer Science Content Standards derived from the national K-12 Computer Science Framework, and the California Common Core State Standards.

Each integrated unit brings together the following:

- an engineering design challenge
- one or more computational artifacts
- core science and math content
- language building opportunities
- engagement supports

Students in each grade level, pre-kindergarten through twelve, engage with the unit for about one or two months as part of their required coursework. The units are integrated and self-contained as a means to provide all students with equitable STEM experiences.

About the Partners

Community Training and Assistance Center (CTAC) is a national not-for-profit organization with a demonstrated record of success in the fields of education and community development. Tracy Unified School District, located in California's Central Valley, serves approximately 15,000 students. Fifty leading teachers from the district contributed to the development of the units. Computer Science integrations resulted with support from the San Joaquin County Office of Education and Bootstrap of Brown University.

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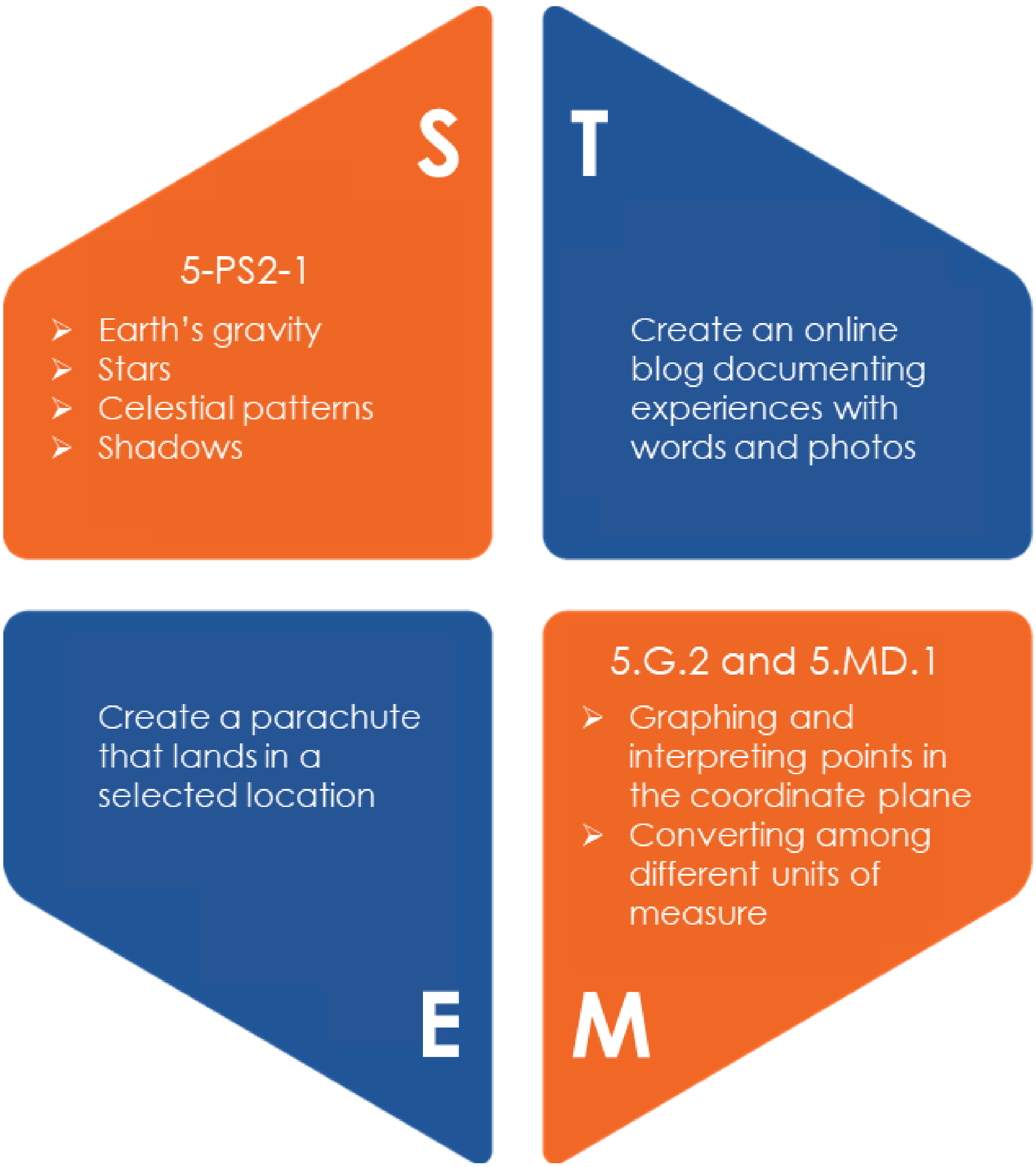
Big Picture

Unit Emblem



Focal Standard

5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down. [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [*Assessment Boundary: Assessment does not include mathematical representation of gravitational force.*]

Overview

Sequence 1: Teachers engage students with an anchor phenomenon by showing a video of a first time skydiver (see the video here) (On Route 44, 2013[i]). During the entry event, teachers present the driving essential question: What patterns and forces on Earth can be used to make predictions? This question connects the concepts of all the supporting questions and leads to the design challenge which is to create a parachute that lands in a selected location and to develop a blog page on Weebly.com that documents the design process.

Students ***ask*** questions about the challenge including: How does gravity affect parachutes? How do gravity and air work against each other? What materials are used for parachutes? How does a parachute enable a person to land safely? What factors should be considered when designing a parachute?

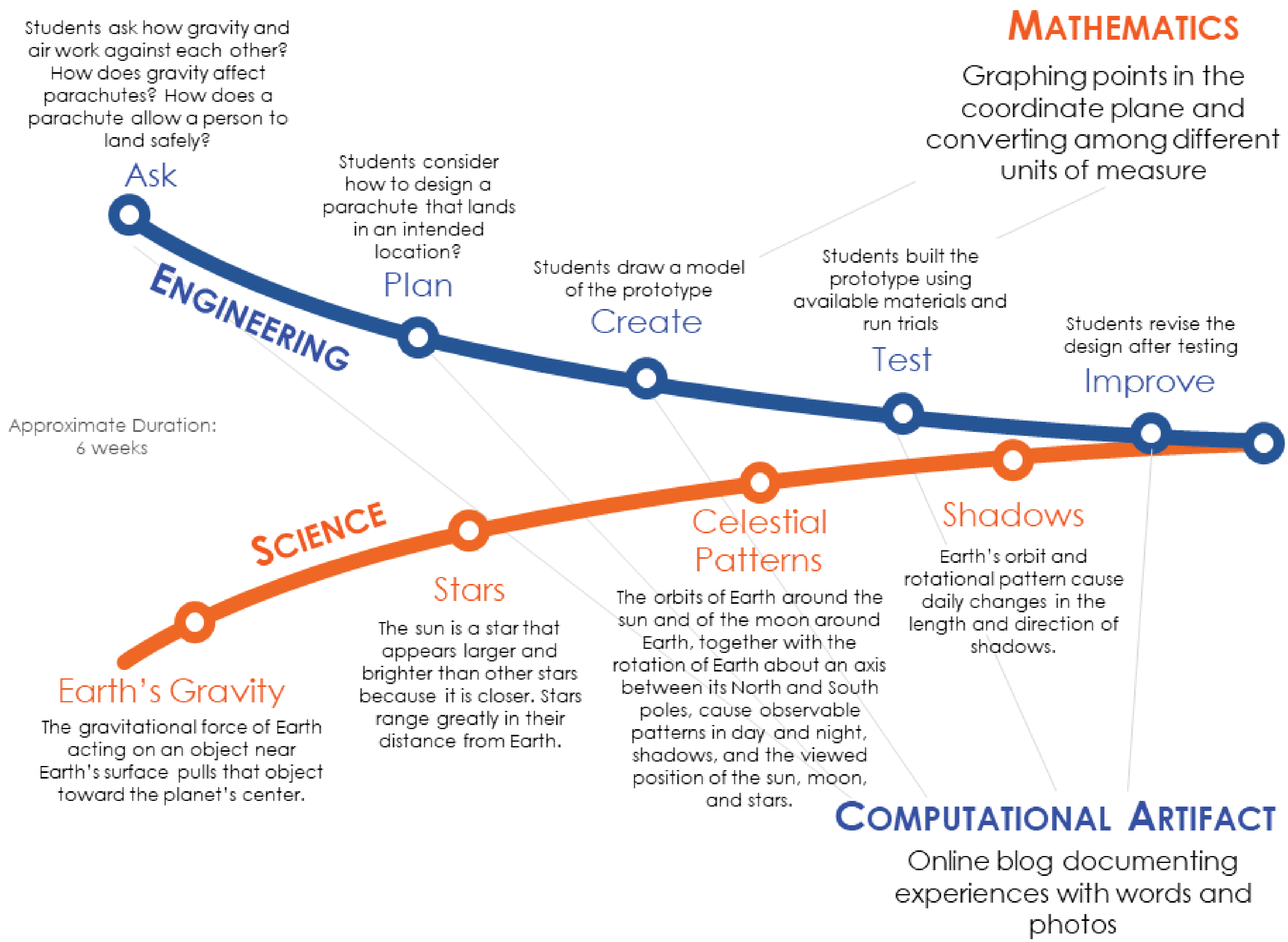
Sequence 2: Students learn about gravitational force on objects that directs them down toward earth. Using knowledge gained about gravitational forces, students will ***plan*** their parachute and draw a model of the prototype. Students label the parts of the parachute and the direction of forces that will act on the parachute.

Sequence 3: Students will work in groups to ***create*** their parachute models, using available materials.

Sequence 4: Students then begin to ***test*** their prototype, collecting data to determine how close their model meets the criteria of landing in a particular location.

Sequence 5: Students reflect on their data and revise the plan to ***improve*** their model and then conduct follow-up tests on their improved parachutes. Students will complete an online blog about the design and improvement process, sharing details of the process they followed in their oral presentations.

Integrated Unit Storyline



Integrated Unit Wayfinder

- Inventory the experiences of students
- Present the anchoring phenomenon

- Students collaborate with each other
- Students read, hear, and view source material
- Students and teachers reflect on the work and processes of students to assess learning progress

- Launch design challenge; elicit and record questions students ***ask*** about the challenge
- Facilitate 5E science lesson sequence for Earth's gravity
- Give students time to ***plan*** their design solution
- Facilitate 5E science lesson sequence for the study of stars
- Provide time and materials for students to ***create*** their design

- Embed graphing and interpreting points on a plane
- Introduce expectations for computational artifact
- Connect students with a STEM-related professional to inform their design solution
- Let students conduct ***tests*** of their design solution and collect data
- Support students in developing their computational artifact

- Facilitate 5E science lesson sequence for celestial patterns
- Designate time for students to ***improve*** and re-test their design solution
- Facilitate 5E science lesson sequence for shadows
- Students write and speak to share their design solution and learning beyond the classroom

Engineering or Computer Science | Math or Science | Student Connections | Ongoing Actions

STEM Dive

Engineering

Design Challenge: Create a parachute that lands in a selected location.

Type of Engineering: Aerospace Engineering

The Engineering Design Process (EDP) and Engineering Standards

EDP Step	Standard and Grade Band End Points from the *Framework*
Ask *What are the criteria? Constraints? Materials?*	**3-5-ETS1-1.** 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. • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)
Plan *Design parachute prototype and label the parts and directions of forces on the parachute*	**3-5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
Create *Use materials to build parachute prototype*	
Test *Collect data on effectiveness of parachute design*	**3-5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3) • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)
Improve *Make adjustments and revise parachute to better meet the goal*	

Computer Science (Technology)

Computer Science Integrations

Description of Student Engagement

Students create an online blog documenting their experiences in the design challenge with words and photos.

Computational Artifact

Definition: Anything created by a human using a computational thinking process and a computing device. A computational artifact can be, but is not limited to, a program, image, audio, video, presentation, or web page file. (Source: College Board, 2016)

- Students create a blog detailing their thought process and steps in the design challenge in Microsoft Sway.

Hardware

Definition: The physical components that make up a computing system, computer, or computing device. (Source: MDESE, 2016)

- Computer

Software (includes programs, applications, websites, etc.)

Definition: Programs that run on a computing system, computer, or other computing device. (Source: k12cs.org)

- Microsoft Sway or similar

Standards

- **3-5.NI.5** Describe physical and digital security measures for protecting personal information.
- **3-5.NI.6** Create patterns to protect information from unauthorized access.
- **3-5.AP.11** Create programs that use variables to store and modify data.
- **3-5.AP.12** Create programs that include events loops and conditionals.
- **3-5.AP.14** Create program by incorporating smaller portions of existing program, to develop something new or add more advanced features.

Science

Focal Standard

5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down. [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [*Assessment Boundary: Assessment does not include mathematical representation of gravitational force*.]

Related Content Standards

5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in the length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns in the sky could include the position and motion of Earth with respect to the Sun and select stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.]*

5-ESS1-1 Support an argument that differences in the apparent brightness of the Sun compared to other stars is due to their relative distance from Earth. [Clarification Statement: Absolute brightness of stars is the result of a variety of factors Relative distance from Earth is one factor that affects apparent brightness and is the one selected to be addressed by the performance expectation.] [*Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, and stage)*.]

Anchoring Phenomenon

Teachers engage students with an anchoring phenomenon by showing the video of skydiving seen here.

Content Outline

Below is a content outline for the science content in this unit. It includes the key concepts within the unit along with an approximate number of days it would take to facilitate a sufficient amount of student learning experiences. For each key concept, key learnings appear, which come from the grade band endpoints in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (source: https://www.nextgenscience.org/framework-k-12-science-education). The storyline begins with an anchoring phenomenon.

Key Concept	Key Learnings	# of Days
Earth's Gravity	• The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1, PS2.B: Types of Interactions)	20 days (ongoing, start first week)

Key Concept	Key Learnings	# of Days
Stars	• The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1, ESS1.A: The Universe and Its Stars)	5 days
Celestial Patterns	• The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2, ESS1.B: Earth and the Solar System)	30 days (ongoing, start first week*)
Shadows	• The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2, ESS1.B: Earth and the Solar System)	30 days (ongoing, start first week*)

*Students should be observing the position of the sun, moon, and stars throughout the year to see seasonal and annual patterns in addition to daily patterns.

Science and Engineering Practices	Crosscutting Concepts
1. **Asking questions and defining problems** 2. **Developing and using models** 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations and designing solutions 7. **Engaging in argument from evidence** 8. Obtaining, evaluating, and communicating information	1. **Patterns** 2. **Cause and effect** 3. **Scale, proportion, and quantity** 4. **Systems and system models** 5. Energy and matter 6. Structure and function 7. Stability and change

Note. Bolded items are called out specifically in the standards cluster for this unit.

Mathematics

Description of Student Engagement

Students graph the drop locations of their parachutes on the coordinate plane (first quadrant). Students also convert linear units as they measure the drop height and distance from the target where the parachute lands.

Standards for Mathematical Content

5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

5.MD.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

Standards for Mathematical Practice

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

MP.3 Construct viable arguments and critique the reasoning of others.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

MP.6 Attend to precision.

MP.7 Look for and make use of structure.

MP.8 Look for and express regularity in repeated reasoning.

Note. Bolded items are emphasized in this unit.

English Language Arts and Development

Reading Standard: Key Idea and Details

RI.5.3 Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.

Writing Standard: Text Types and Purposes

W.5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

- **W.5.2.D** Use precise language and domain-specific vocabulary to inform about or explain the topic.

Writing Standard: Research to Build and Present Knowledge

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

Speaking and Listening Standard: Comprehension and Collaboration

SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 5 topics and texts*, building on others' ideas and expressing their own clearly.

- **SL.5.1.A** Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
- **SL.5.1.B** Follow agreed-upon rules for discussions and carry out assigned roles.
- **SL.5.1.C** Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
- **SL.5.1.D** Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.

Speaking and Listening Standard: Presentation and Knowledge of Ideas

SL.5.4 Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

- **SL.5.4.a** Plan and deliver an opinion speech that: States an opinion, logically sequences evidence to support the speaker's position, uses transition words to effectively link opinions and evidence (e.g., consequently, and therefore), and provides a concluding statement related to the speaker's position.
- **SL.5.4.b** Memorize and recite a poem or section of a speech or historical document using rate, expression, and gestures appropriate to the selection.

Unit Vocabulary

The following terms reflect the core vocabulary students should understand and use in this unit.

- **air resistance**: As an object, like a plane, moves through the sky, there is friction as the air moves over the surfaces of the object. Air resistance is sometimes called drag and is influenced by both the speed of the object and the amount of surface of the object. Larger objects meet more air resistance because they have more surface area. (Source: adapted from NASA[1]: https://go.nasa.gov/3DZpA07)

- **apparent brightness**: A viewer from Earth looking at the stars judges the apparent brightness of a star by comparing one star to another. This brightness can be impacted by distance of the star from the Earth as well as the size of the star.

- **celestial**: Celestial means of, or relating to the sky or visible heavens. (Source: https://www.merriam-webster.com/dictionary/celestial)

- **constellation**: A constellation is any of 88 named groups of stars forming patterns. (Source: https://www.merriam-webster.com/dictionary/constellation)

- **force**: A force is a pull or a push that causes an object to speed up or slow down in a particular direction. (Sourced from NASA: https://go.nasa.gov/3tJolxC)

- **graphical**: Graphical means represented by or relating to a graph. (Source: https://dictionary.cambridge.org/us/dictionary/english/graphical)

- **gravitational pull**: Earth's gravity comes from all its mass. All its mass makes a combined gravitational pull on all the mass in your body. That's what gives you weight. And if you were on a planet with less mass than Earth, you would weigh less than you do here. (Sourced from NASA: https://go.nasa.gov/3l8nXEO)

- **gravity**: Gravity is the force by which a planet or other body draws objects toward its center. The force of gravity keeps all of the planets in orbit around the sun. (Sourced from NASA: https://go.nasa.gov/3l8nXEO

- **luminosity**: Luminosity is the rate at which a star or other object emits energy, usually in the form of electromagnetic radiation. (Sourced from NASA: https://go.nasa.gov/3trlyJp)

[1] NASA = National Aeronautics and Space Administration

- **parachute**: A parachute is a device for slowing the descent of a person or object through the air that consists of a fabric canopy beneath which the person or object is suspended. (Source: https://www.merriam-webster.com/dictionary/parachute)

- **pattern**: A pattern is the regular and repeated way in which something is done [or something appears]. (Source: https://www.merriam-webster.com/dictionary/pattern)

- **relative distance**: Relative distance is the space between two locations or two objects comparing to a common starting point. For example, we can measure the relative distance of the planets Earth and Mercury from a common point, the Sun.

- **season**: A season is one of the four quarters into which a year is commonly divided. (Source: https://www.merriam-webster.com/dictionary/season)

- **shadow**: A shadow is the dark figure cast on a surface by a body that is between the surface and the light. (Source: https://www.merriam-webster.com/dictionary/shadow)

- **skydiving**: Skydiving is the sport of jumping from an airplane and typically executing a prolonged free fall before deploying a parachute. (Source: https://www.merriam-webster.com/dictionary/skydiving)

- **spherical**: Something spherical is like a sphere in being round, or more or less round, in three dimensions. Apples and oranges are both spherical, for example, even though they're never perfectly round. (Source: https://www.merriam-webster.com/dictionary/spherical)

- **telescope**: A telescope is a tool that astronomers use to see faraway objects. Most telescopes, and all large telescopes, work by using curved mirrors to gather and focus light from the night sky. (Sourced from NASA: https://go.nasa.gov/3he5u8C)

Assessment Tools

Student Experience Inventory

Teachers can use the following prompts with students prior to the beginning of the unit or early in the unit in order to learn about students' experiences that relate to the unit. Teachers can make informed instructional decisions based on this learning, enabling tailored opportunities for students to make their own meaning.

Student Prompts

1. Name an object or two that you have seen fall. What do you remember about the motion of the fall?

2. What have you noticed about stars and other objects in the night sky?

3. Have you seen a shadow of yourself outside in the daytime? What was it like? Is your shadow always the same?

Aligned Learnings

1. Responses to this item provide insight into students' experiences with gravity.
   5-PS2-1

2. Responses to this item provide insight into students' experiences with stars.
   5-ESS1-1

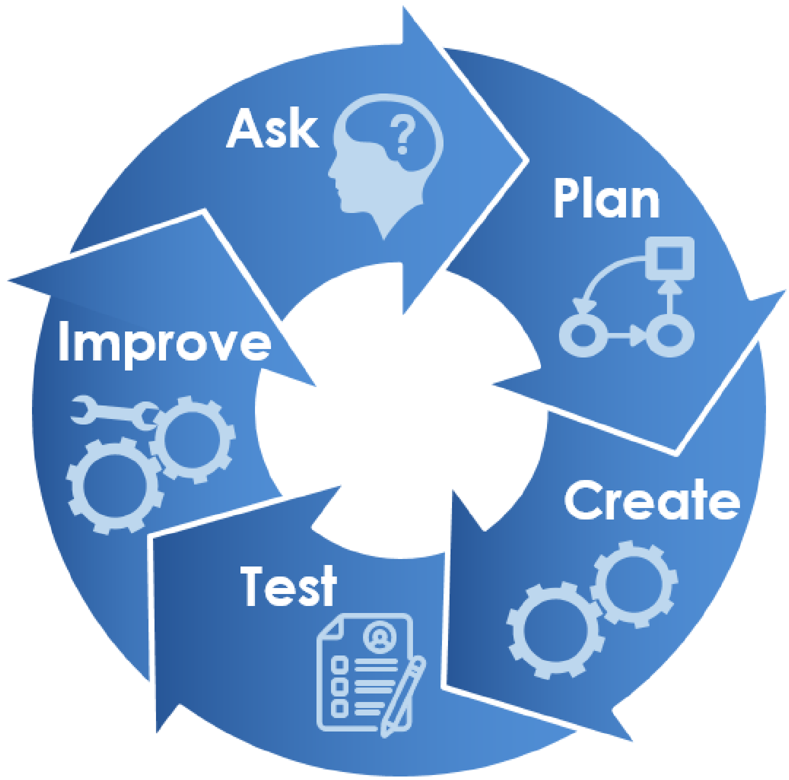
3. Responses to this item provide insight into students' experiences with shadows.
   5-ESS1-2

Student Self-Assessment of Engineering

Improve:
Here is what would make my design better and why…

Ask:
Here is what I am wondering about before I plan my design…

Plan:
Here are my design ideas for the project…



Test:
Here are the data I collected…

Create:
Here is what I think about what I made compared to what I planned, and here is what I think will happen when I test it…

I am doing the work of an aerospace engineer.

One-Point Design Challenge Rubric

Criteria serve as a primary reference point throughout the engineering design process. Teachers use the criteria **to communicate expectations** and **to guide students**. With teacher guidance, students use the criteria to inform and reflect on their work.

Approaches Expectations *Notes on how to improve the project*	**Meets Expectations** *Criteria indicating success*	**Exceeds Expectations** *Notes on how project goes beyond expectations*
	Engineering Students participate in the 5-part engineering design process, use data, and make thoughtful improvements to their design. (3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3)	
	Computer Science Students create an online blog to document their experience using words and pictures. (3-5.NI.5, 3-5.NI.6, 3-5.AP.11, 3-5.AP.12, 3-5.AP.14)	
	Collaboration Students give and receive input with kindness and honesty. (SL.5.1)	
	Communication Students speak and write about their ideas clearly using accurate vocabulary (W.5.2, W.5.2.D). I can share thoughts, read, and listen to learn from others. (SL.5.4)	
	Science Students use knowledge of gravity and other factors to design a parachute that lands in a desired location. (5-PS2-1)	

Engagement

Community and Career Connections

During the unit, students engage with STEM professionals who can inform students' work at some point during the engineering design process. The interaction with STEM professionals serves a few purposes:

- Expose students to STEM as it applies in various careers
- Enrich student learning through collaborating with STEM professionals
- Help students see themselves doing the actual work of STEM

Below are a few potential STEM-related professionals that align to one of California's 15 industry sectors for Career and Technical Education:

- **Rocket Scientist** (Engineering and Architecture)
- **Skydiving Instructor** (Hospitality, Tourism and Recreation)
- **Airplane Pilot or Air Force Pilot or Paratrooper** (Public Services or Transportation)

The interactive experience will ideally be co-constructed by the teacher and professional. In coordinating with the professional, a few questions appear below that can be used to guide the planning and live interaction with students:

- **Rocket Scientist** (Engineering and Architecture)
    - What kinds of vehicles (satellites, rockets) or processes (communication with satellites) do you oversee?
    - Do you design things, troubleshoot problems with rockets, etc., or do you oversee the larger process of getting satellites or rockets launched?
    - What kind of math and science knowledge do you use on a daily basis?
    - How did you decide on this career? What kind of education or training did you receive?
    - What is the most important thing you learned early on that helps you in your job?
- **Skydiving Instructor** (Hospitality, Tourism and Recreation)
    - What are the steps to learning how to skydive?
    - What factors do you consider when deciding if it is safe to jump on any given day?
    - Are there any tools that you would use before you made a jump? What are they and what do they measure?
    - What aspects of the parachute do you inspect before a jump?
    - How do you train someone to be ready to skydive solo?
- **Airplane Pilot, Air Force Pilot or Paratrooper** (Public Services and Transportation)
    - What kinds of work do you do on a daily basis?
    - What are key tools and knowledge required for your job?
    - What types of airplanes do you usually work with daily?
    - What kind of science and math is involved in doing your job?
    - How did you get involved in this type of work?

Materials List

The items in the materials list below reflect total quantities for a class of 32 students, allowing for 8 groups of 4 students.

Permanent Equipment (classroom totals):

- ☐ 96 washers (5/15 inch, ¾ inch outside diameter)
- ☐ 32 measuring soft tapes
- ☐ 32 protractors
- ☐ 10 Styrofoam balls small (for modeling the moon)
- ☐ 10 Styrofoam ball large (for modeling Earth)

Consumable Equipment (classroom totals):

- ☐ 96 sheets of tissue paper
- ☐ 128 sheets of newsprint
- ☐ 96 square napkins
- ☐ 32 meters of string
- ☐ 32 rolls of clear tape
- ☐ 32 straws
- ☐ 64 pieces sidewalk chalk
- ☐ 96 plastic shopping bags (from home or site)
- ☐ 96 paper towels (from home or site)

Distance Learning Modifications

In distance learning, the design challenge will be conducted by students individually at home. Student collaboration will need to occur remotely with a modified materials list.

Modified Materials List (student totals):

- ☐ 3 sheet tissue paper
- ☐ 4 sheets of newsprint
- ☐ 3 square napkins
- ☐ 1 meter of string
- ☐ 1 roll of clear tape
- ☐ 3 washers
- ☐ 1 measuring tape

Endnotes

[i] On Route 44. (2013, August 11). *First time skydiving*. YouTube. https://www.youtube.com/watch?v=WocwDTsIvQE