Integrated STEM Unit Planner

Kindergarten Science
Redirect a Moving Ball

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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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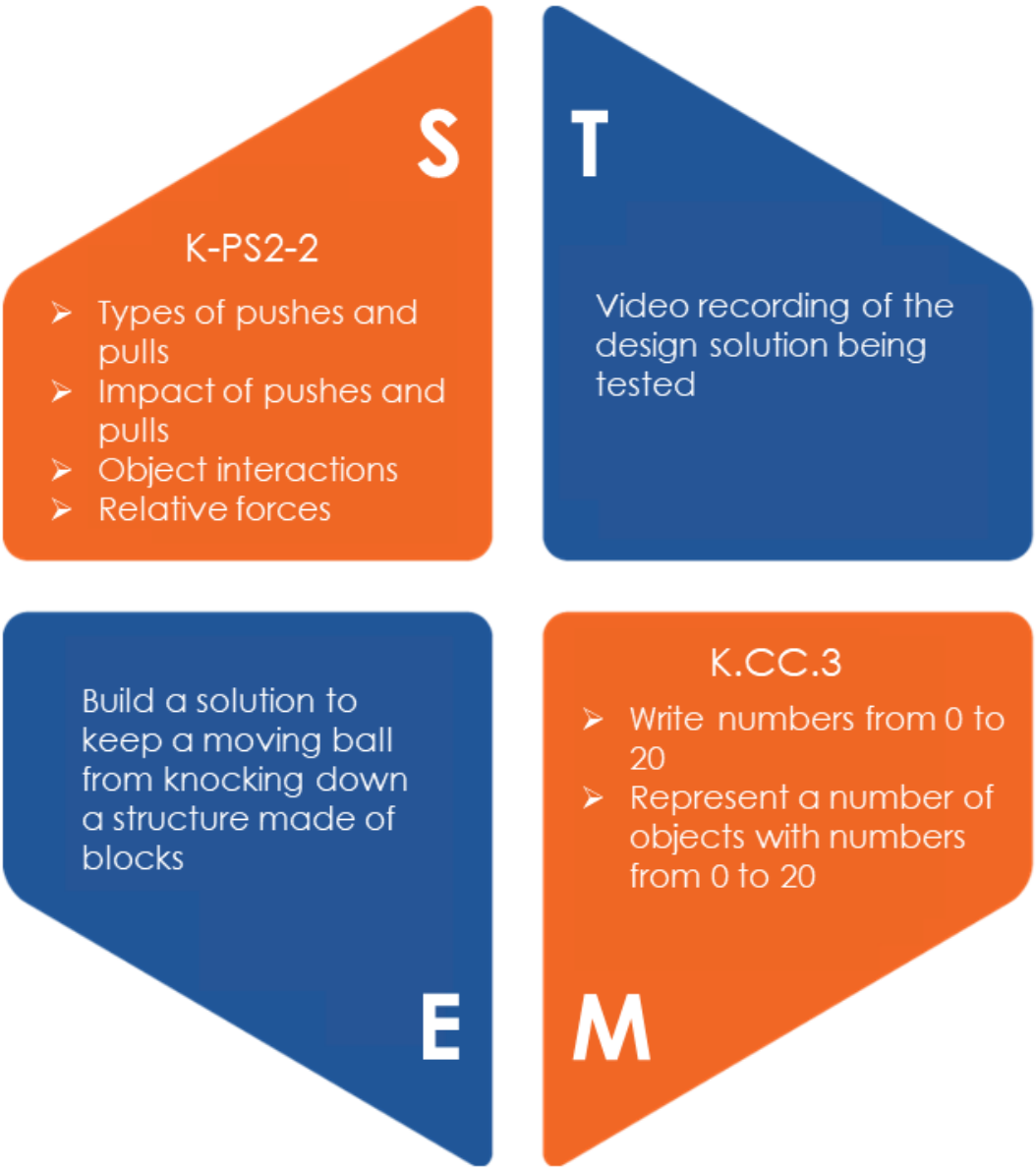
Contents

Big Picture

Unit Emblem



Focal Standard

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [*Assessment Boundary: Assessment does not include friction as a mechanism for change in speed*.]

Overview

Sequence 1: Teachers engage students with an anchoring phenomenon by showing them a video of a wrecking ball demolishing a building (xrp1013, 2008)[i] (https://bit.ly/3pfW2GU). After students watch the video, teachers facilitate students' thinking through an inquiry anchor chart (notice, wonder), which will be revisited throughout the unit.

During the entry event, teachers will present the essential driving question: How can you make an object move? Throughout the unit, students will consider additional questions of how you can make an object move faster or slower, make it start and stop, and move it in a different direction.

Students will begin by learning about the types of pushes and pulls. The design challenge will be introduced: to create a solution for keeping a ball from knocking down a structure. Students will ***ask*** questions such as: How can a ball knock down a structure? What makes it better at wrecking the structure? How can we make the ball go faster?

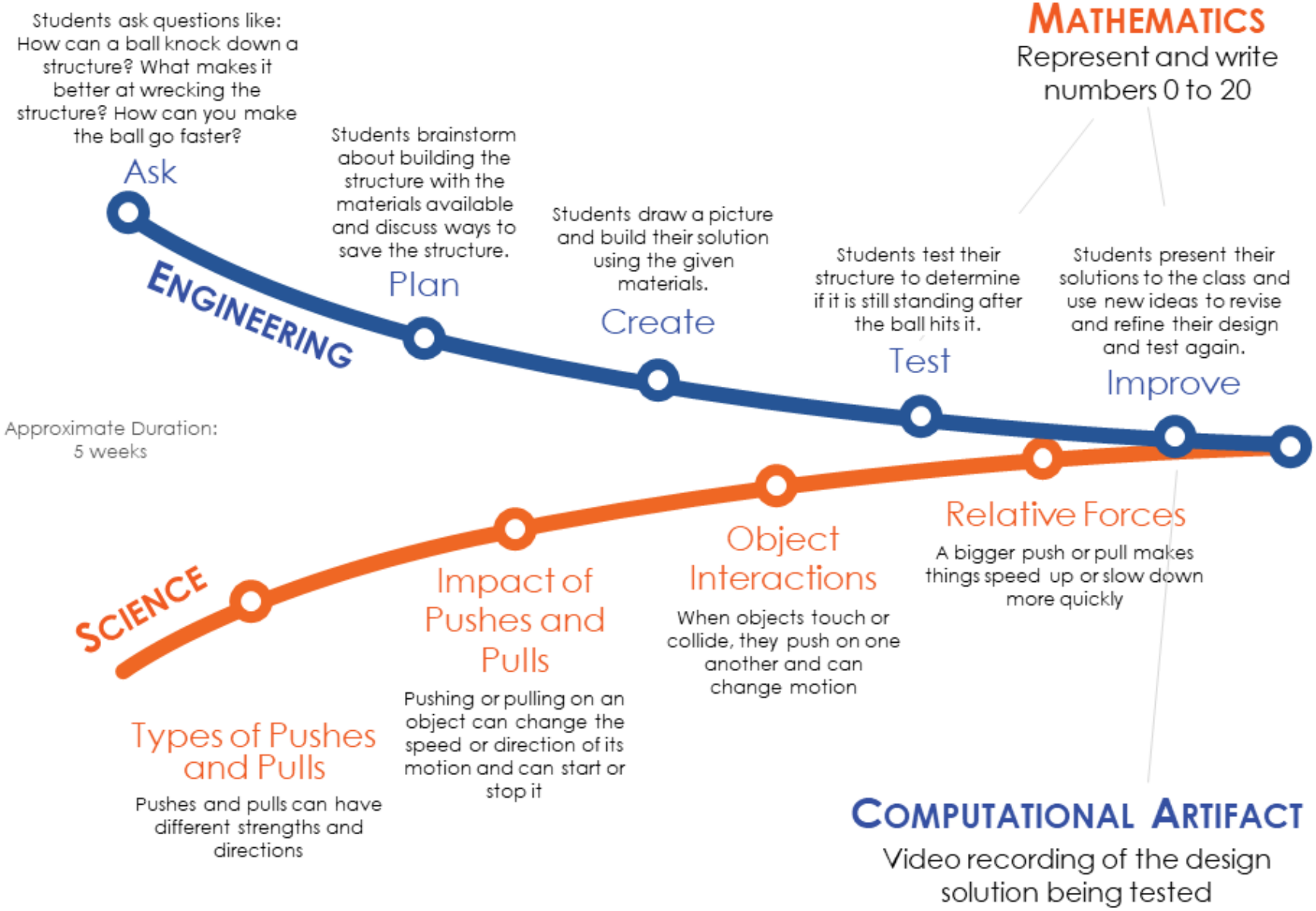
Sequence 2: Students will learn more about how pushes and pulls can impact objects. Students will sketch out ideas for their tool by drawing a picture in their sense-making notebook and will begin to ***plan*** their model.

Sequence 3: Students will consider the materials available and begin to ***create*** their structure as they continue to learn about interactions between objects and how one might change the motion of another.

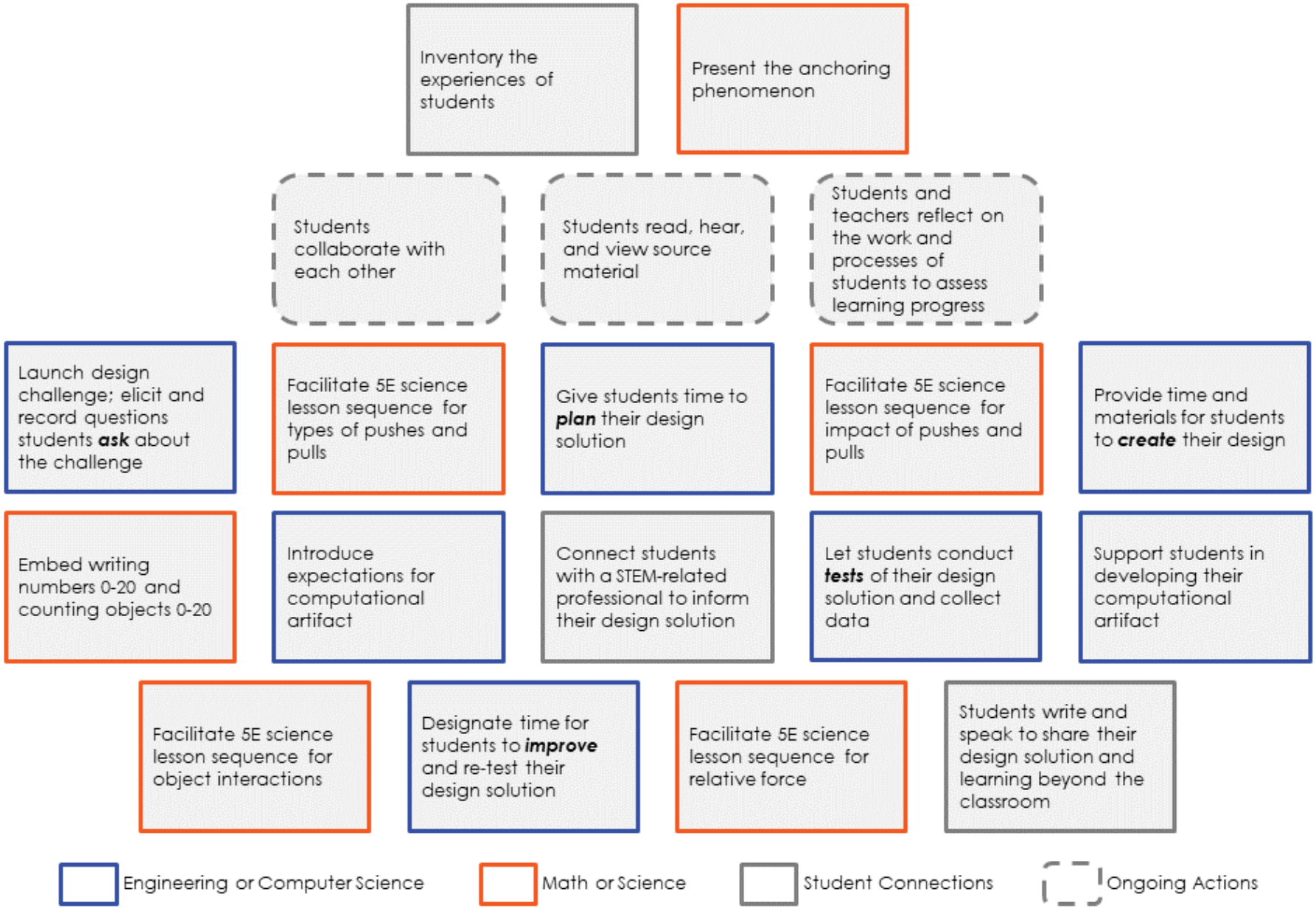
Sequence 4: Students will learn about relative force. Students will ***test*** the effectiveness of their design by conducting multiple tests of their structure with various balls and angles of the ramp.

Sequence 5: Students will reflect on how effective their structure was at avoiding destruction by looking at their trials and will revise the plan to ***improve*** their model.

Integrated Unit Storyline



Integrated Unit Wayfinder



STEM Dive

Engineering

Design Challenge: Build a solution to keep a moving ball from knocking down a structure made of blocks

Type of Engineering: Materials Engineer

The Engineering Design Process (EDP) and Engineering Standards

EDP Step	Standard and Grade Band End Points from the *Framework*
Ask *How can a ball knock down a structure? What makes it better at wrecking the structure? How can you make the ball go faster?*	**K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. • A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) • Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) • Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)
Plan *Students brainstorm about building the structure with the materials available and discuss ways to save the structure.*	**K-2-ETS1-2.** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2)
Create *Students draw a picture and build their solution using the given materials.*	
Test *Students test their structure to determine if it is still standing after the ball hits it.*	**K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs. • Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)
Improve *Students present their solutions to the class and use new ideas to revise and refine their design and test again.*	

Computer Science (Technology)

Computer Science Integrations

Description of Student Engagement

Students will capture the testing of their design solution by video recording the ball coming at the structure of blocks.

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)

- Video recording of the design solution being tested against the structure made of blocks

Hardware

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

- Computer with video recorder

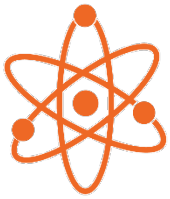
Software (includes programs, applications, websites, etc.)

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

- Video software

Standards

- **K-2.DA.7** Store, copy, search, retrieve, modify, and delete information using a computing device, and define the information stored as data.
- **K-2.DA.8** Collect and present data in various visual formats.
- **K-2.DA.9** Identify and describe patterns in data visualizations, such as charts or graphs, to make predictions.
- **K-2.CS.2** Explain the functions of common hardware and software components of computing systems.



Science

Focal Standard

K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.* [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.] [*Assessment Boundary: Assessment does not include friction as a mechanism for change in speed*.]

Related Content Standards

K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.] [*Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets*.]

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Anchoring Phenomenon

Teachers engage students with an anchoring phenomenon by showing them a video of a wrecking ball demolishing a building. (https://bit.ly/3pfW2GU)

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
Types of Pushes and Pulls	• Pushes and pulls can have different strengths and directions (K-PS2-1, K-PS2-2)	5
Impact of Pushes and Pulls	• Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it (K-PS2-1, K-PS2-2) • A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (secondary)(K-2.ESS1)	5
Object Interactions	• When objects touch or collide, they push on one another and can change motion (K-PS2-1)	5
Relative Forces	• A bigger push or pull makes things speed up or slow down more quickly. (secondary) (K-PS2-1)	5

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 will count and report the number of blocks that remain standing in each of their trials with their structure.

Standards for Mathematical Content

K.CC.3 Write numbers from 0 to 20. Represent a number of objects with a written numeral 0-20 (with 0 representing a count of no objects).

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 Ideas and Details

RI.K.1 With prompting and support, ask and answer questions about key details in a text.

RI.K.3 With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text.

Reading Standard: Integration of Knowledge and Ideas

RI.K.9 Use a combination of drawing, dictating, and writing to narrate a single event or several loosely linked events, tell about the events in the order in which they occurred, and provide a reaction to what happened.

Writing Standard: Text Types and Purposes

W.K.3 Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.

Writing Standard: Research to Build and Present Knowledge

W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them).

Speaking and Listening Standard: Comprehension and Collaboration

SL.K.1 Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups.

- **SL.K.1.a** Follow agreed-upon rules for discussions (e.g., listening to others and taking turns speaking about the topics and texts under discussion).
- **SL.K.1.b** Continue a conversation through multiple exchanges.

Language: Conventions of Standard English

L.K.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

- **L.K.1.c** Form regular plural nouns orally by adding /s/ or /es/ (e.g., dog, dogs; wish, wishes).
- **L.K.1.e** Use the most frequently occurring prepositions (e.g., to, from, in, out, on, off, for, of, by, with).
- **L.K.1.f** Produce and expand complete sentences in shared language activities.

L.K.2 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

- **L.K.2.a** Capitalize the first word in a sentence and the pronoun I.
- **L.K.2.b** Recognize and name end punctuation.
- **L.K.2.c** Write a letter or letters for most consonant and short-vowel sounds (phonemes).
- **L.K.2.d** Spell simple words phonetically, drawing on knowledge of sound/letter relationships.

Language: Vocabulary Acquisition and Use

L.K.5 With guidance and support from adults, explore word relationships and nuances in word meanings.

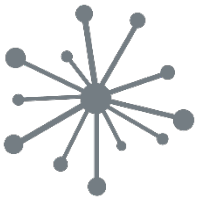
- **L.K.5.a** Sort common objects into categories (e.g., shapes, foods) to gain a sense of the concepts the categories represent.
- **L.K.5.b** Demonstrate understanding of frequently occurring verbs and adjectives by relating them to their opposites (antonyms).
- **L.K.5.c** Identify real-life connections between words and their use (e.g., note places at school that are colorful).
- **L.K.5.d** Distinguish shades of meaning among verbs describing the same general action (e.g., walk, march, strut, prance) by acting out the meanings.

Unit Vocabulary

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

- **change**: To change is to make someone or something different. (Source: https://www.merriam-webster.com/dictionary/change)
- **collide**: To collide means to crash together or to crash into something. (Source: https://www.merriam-webster.com/dictionary/collide)
- **direction**: Direction is the course or path on which something is moving or pointing. (Source: https://www.merriam-webster.com/dictionary/direction)
- **fast**: Fast means moving or able to move quickly. (Source: https://www.merriam-webster.com/dictionary/fast)
- **force**: Force is physical strength, power, or effect. (Source: https://www.merriam-webster.com/dictionary/force)
- **object**: An object is something that may be seen or felt. (Source: https://www.merriam-webster.com/dictionary/object)
- **pull**: A pull is a force that draws one body toward another. (Source: https://www.merriam-webster.com/dictionary/pull)
- **push**: A push is a steady applying of force in a direction away from the body from which it comes. (Source: https://www.merriam-webster.com/dictionary/push)
- **ramp**: A ramp is a sloping passage or roadway connecting different levels. (Source: https://www.merriam-webster.com/dictionary/ramp)
- **slow**: Slow means not moving quickly or not able to move quickly. (Source: https://www.merriam-webster.com/dictionary/slow)
- **softer push**: A softer push occurs when someone or something applies a lower level of force while attempting to move another object.
- **speed**: Speed is the rate of motion. (Source: https://www.merriam-webster.com/dictionary/speed)
- **stronger push**: A stronger push occurs when someone or something applies a higher level of force while attempting to move another object.
- **structure**: A structure is something (such as a house, tower, bridge, etc.) that is built by putting parts together and that usually stands on its own. (Source: https://www.merriam-webster.com/dictionary/structure)
- **tower**: A tower is a building or structure that is higher than its length or width, is higher than most of what surrounds it, and may stand by itself or be attached to a larger structure. (Source: https://www.merriam-webster.com/dictionary/tower)

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

(If needed, some potential experiences that may get students to share include swings, wagons, dominos, and yo-yos.)

1. Name an object that you have moved lately.
    a. How did you move it?
    b. Could you make it go faster or slower? How?
2. Name an object that moves you (physically).
    a. How does it make you move?
    b. Can it make you go faster or slower? How?
3. Tell about a time you saw things two things collide (hit together) at the same time.

Aligned Learnings

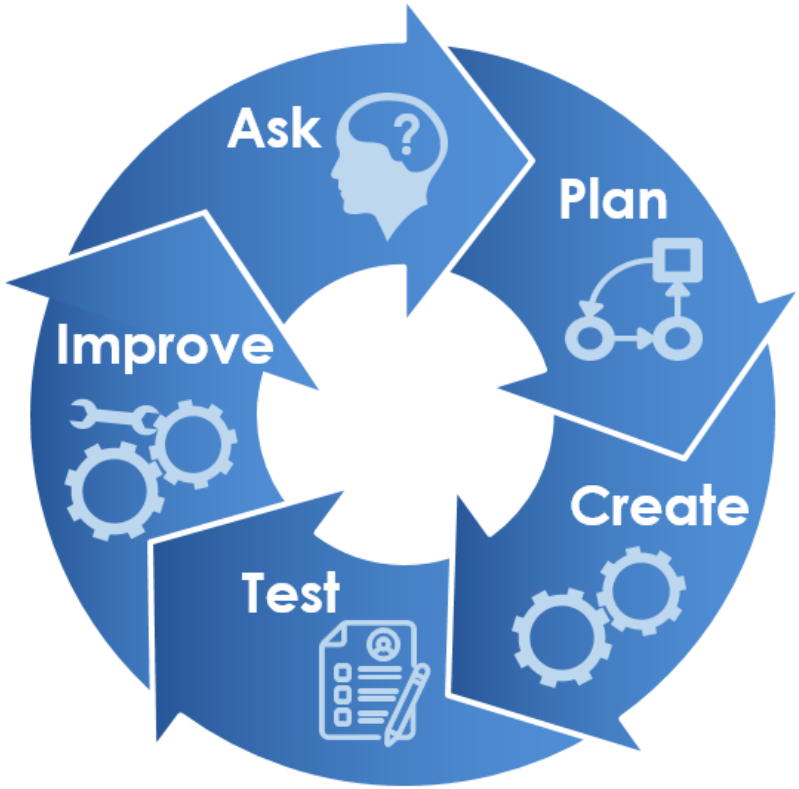
1. Responses to these items provide insight into students' experiences with motion they control. K-PS2-1, K-PS2-2
2. Responses to these items provide insight into students' experiences with motion they are controlled by. K-PS2-1, K-PS2-2
3. Responses to these items provide insight into students' experiences with collisions. K-PS2-2

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 a materials 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. (K-2-ETS1-1, K-2-ETS1-2, K-2-ETS1-3)	
	Computer Science Students make a video testing their design solution against the structure of blocks. (K-2.DA.7, K-2.DA.8, K-2.DA.9, K-2.CS.2)	
	Collaboration Students contribute and support others with honesty and kindness (SL.K.1)	
	Communication Students speak and write about their ideas clearly using accurate vocabulary (W.K.3). Students will share thoughts, read, and listen to learn from others. (SL.K.1)	
	Science Students learn about pushes and pulls, impacts between two objects and how the amount of force influences the reactions. (K-PS2-1, K-PS2-2)	

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:

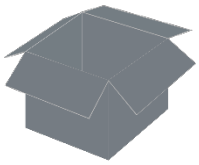
- Expose students to STEM as it applies in various careers
- Enrich student learning through collaborating with STEM professionals
- Help students see themselves doing the actual work of STEM

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

- **Automobile Mechanic or Designer** (Transportation)
- **Construction Worker (backhoe or earth mover)** (Building and Construction Trades)
- **Athlete (weightlifter)** (Hospitality, Tourism, and Recreation)

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:

- **Automobile Mechanic or Designer** (Transportation)
  - Can you describe the difference between a front wheel drive and a rear wheel drive car?
  - Are front wheel drive and rear wheel drive better for certain kind of driving conditions? Does which type of car it is affect steering or braking?
  - How does the design of a car body impact how fast it can go?
  - Do tires make a difference in how well a car drives? In what way?
- **Construction Worker (backhoe or earth mover)** (Building and Construction Trades)
  - What is the difference between a backhoe, excavator, and tractor? Can the same person operate all three kinds of machines or usually only one kind?
  - Which ones push dirt and which ones pull it or pick it up and move it?
  - When you see a construction site, why does everyone seem to push all the dirt to one side? When there is a big pile of dirt, where does it go?
  - What is the hardest kind of earth or rock to move?
- **Athlete (weightlifter)** (Hospitality, Tourism, and Recreation)
  - Which is harder, lifting a weight or pushing a weight?
  - When you are using a barbell (may need an explanation of that for students), is there a difference in how much effort you make lifting or pulling up the weight and when you push it up over your head?
  - What is a "spotter" and why are they important to you?
  - How do you build up to lifting heavier and heavier weights?



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:

- ☐ 400 blocks (e.g., 1 inch wooden cubes) (50 per group)
- ☐ 32 plastic balls
- ☐ 32 tennis balls
- ☐ 32 marbles

Consumable Equipment (from home or site as available):

- ☐ cardboard (for ramps)
- ☐ other useable material

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):

- ☐ 50 (1 inch) wooden cubes
- ☐ 1 plastic balls
- ☐ 1 tennis ball
- ☐ 1 marble

Endnotes

[i] Xrp1013 (2018, August 12). *LG & E Building vs. wrecking ball.* YouTube. https://www.youtube.com/watch?v=Rx28g0aqflk