# Integrated STEM Unit Planner

# Grade 3 Science

# Move that Toy

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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

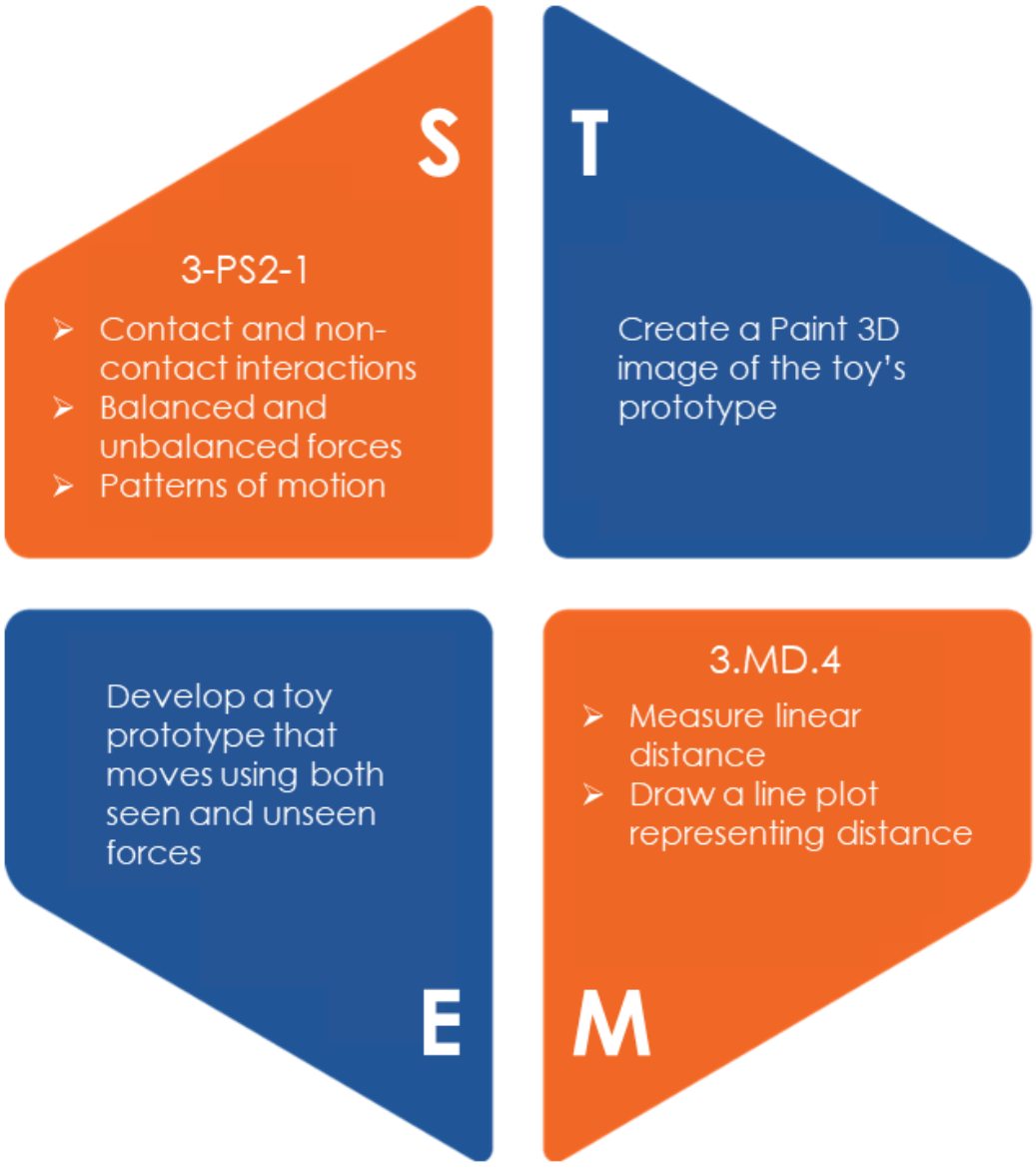
Community Training and Assistance Center (CTAC) is a national not-for-profit organization with a demonstrated record of success in the fields of education and community development. Tracy Unified School District, located in California's Central Valley, serves approximately 15,000 students. Fifty leading 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.

## Terms of Use

# Contents

# Big Picture

## Unit Emblem




### Focal Standard

**3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.** [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving, and balanced forces pushing on a box from both sides will not produce any motion at all.] [*Assessment Boundary: Assessment is limited to one variable at a time: Number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.*]

## Overview

Sequence 1: Teachers engage students with an anchoring phenomenon by showing a video of marbles going uphill. This unit actively engages the student in thinking about the driving essential question: How do forces affect the world around us? The discussion begins by reviewing the difference between balanced and unbalanced forces and how they impact the motion of objects. They will consider how some objects push or pull one another without touching and begin to predict when motion will occur.

The design challenge will be introduced. It is based on students' interest in toys and play things, and incorporates burgeoning knowledge of forces. Students will be asked to develop a toy that moves using seen and unseen forces. The toy cannot be powered by electricity but it must be a moving toy that uses forces. Students will ***ask*** initial questions such as: What kinds of toys are there? And, how do they move?

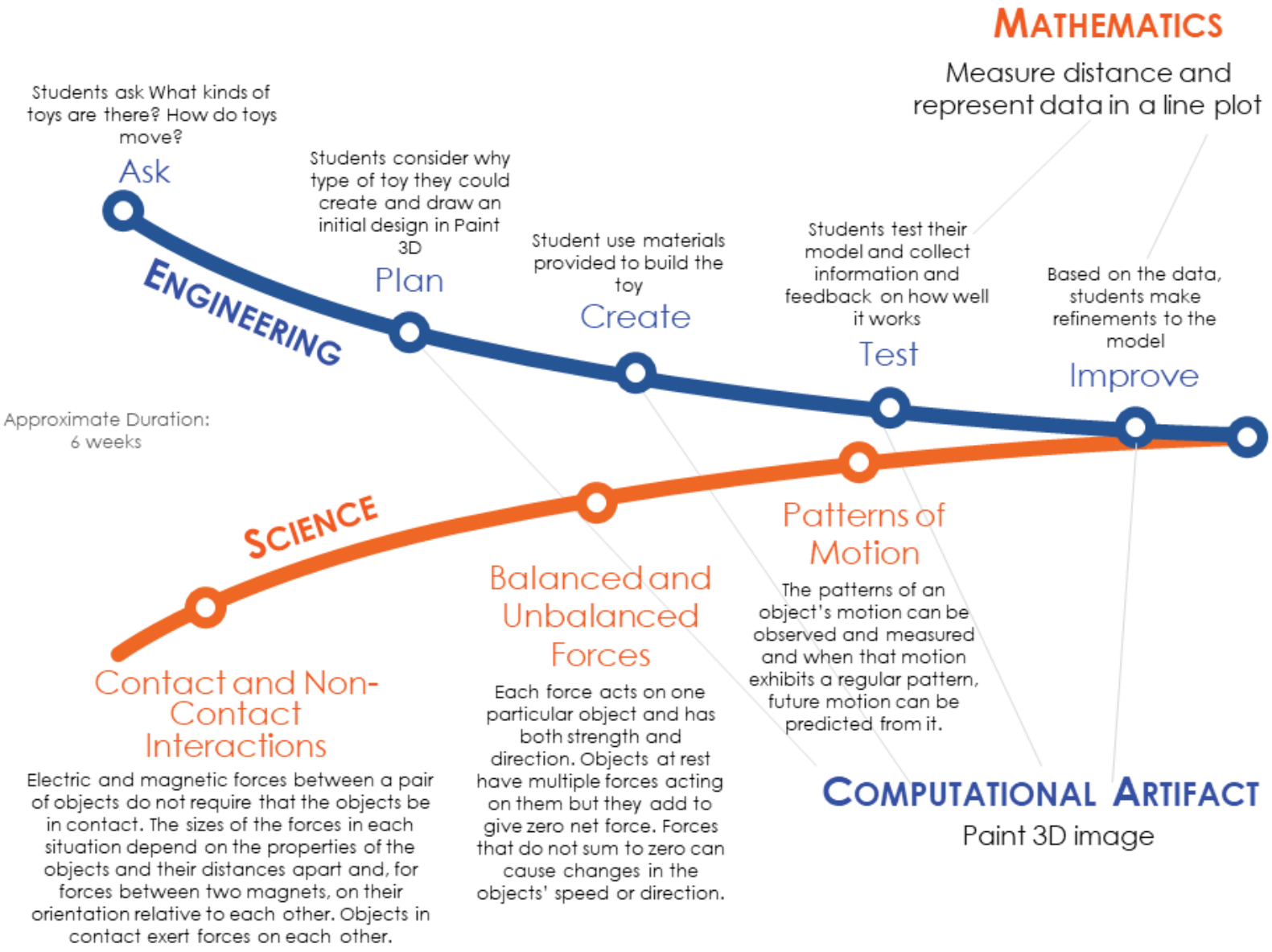
Sequence 2: Students learn to notice patterns in motion. They will use this knowledge to ***plan*** their toy, considering potential forces that could be used to help it move.

Sequence 3: Students will ***create*** a prototype toy, using available materials. They will collect initial data and measurements on the toy's ability to move and make early adjustments to their plan. The concepts of magnets and magnetism will be introduced, providing another potential method for creating movement of the toy.

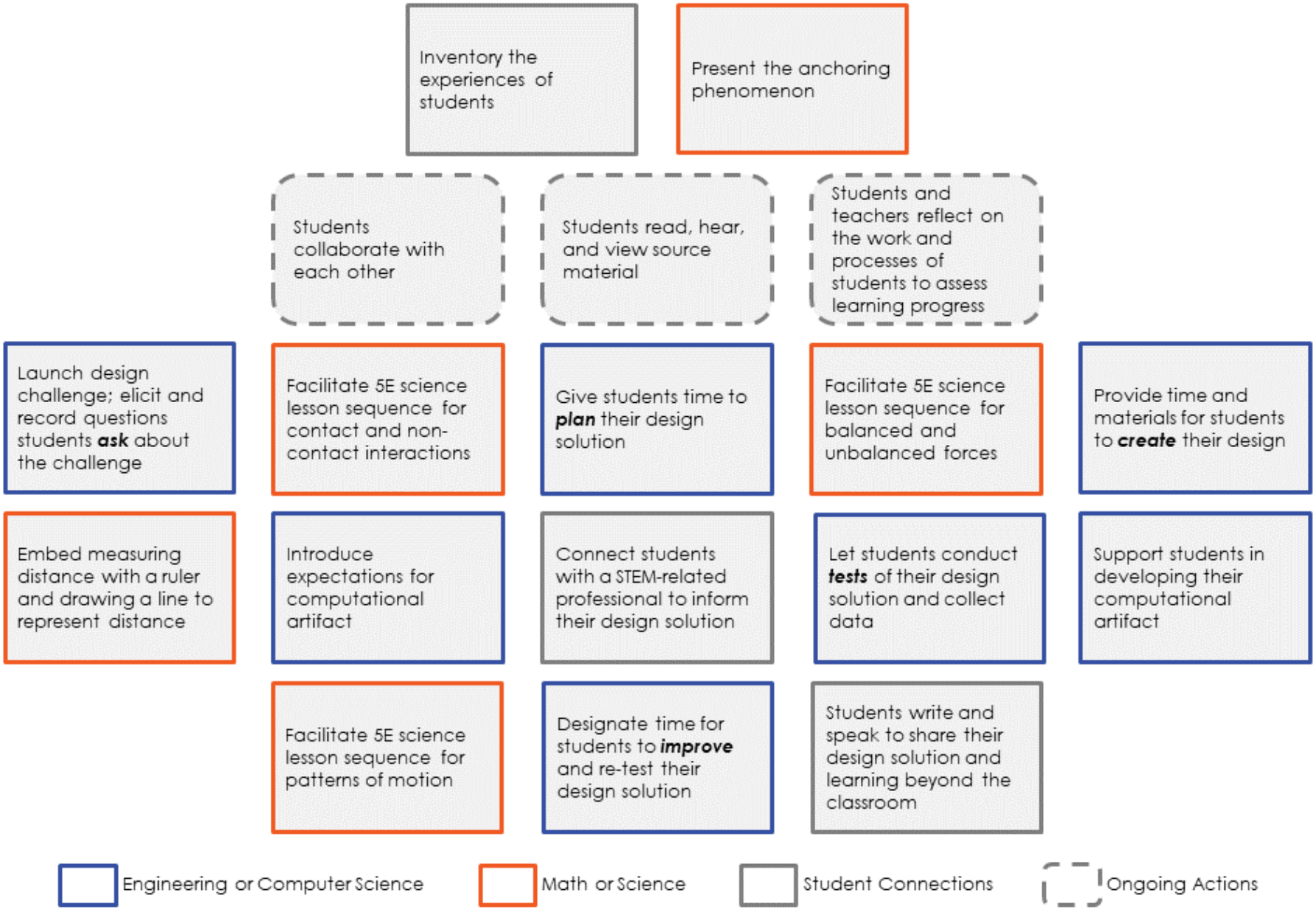
Sequence 4: Students then begin to ***test*** their prototype, collecting data to determine how effective their model is at moving. Students will further their understanding through learning about cause and effect relationships in electric and magnetic interactions of two objects.

Sequence 5: Students reflect on their data and revise the plan to ***improve*** their model and then conduct follow-up tests on their improved toy prototypes. Students will complete a Paint 3D drawing of their toy as part of a presentation on the design process.

## Integrated Unit Storyline



## Integrated Unit Wayfinder



# STEM Dive

## Engineering

Design Challenge: Create a toy that moves using both seen and unseen forces.

Type of Engineering: Mechanical Engineering

### The Engineering Design Process (EDP) and Engineering Standards

| EDP Step | Standard and Grade Band End Points from the *Framework* |
|---|---|
| **Ask**<br>*What kinds of toys are there? How do toys move?* | **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.<br>• 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**<br>*Students consider why type of toy they could create and draw an initial design in Paint 3D* | **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.<br>• 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)<br>• 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**<br>*Student use materials provided to build the toy* | |
| **Test**<br>*Students test their model and collect information and feedback on how well it works* | **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.<br>• 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)<br>• 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**<br>*Based on the data, students make refinements to the model* | |

# Computer Science (Technology)

## Computer Science Integrations

### *Description of Student Engagement*

Students create a prototype in Microsoft Paint 3D of their toy.

### *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)

- Image in Microsoft Paint 3D of their toy's prototype

### *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 Paint 3D

### *Standards*

- **3-5.DA.8** Organize and present collected data visually to highlight relationships and support a claim.

## Science

### Focal Standard

**3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.** [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving, and balanced forces pushing on a box from both sides will not produce any motion at all.] [*Assessment Boundary: Assessment is limited to one variable at a time: Number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.*]

### Related Content Standards

**3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.** [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [*Assessment Boundary: Assessment does not include technical terms such as period and frequency.*]

**3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.** [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [*Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students and electrical interactions are limited to static electricity.*]

**3-PS2-4 Define a simple design problem that can be solved by applying ideas about magnets.** [Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]

### Anchoring Phenomenon

Teachers engage students with an anchoring phenomenon by showing marbles going uphill (https://bit.ly/3nEQN2L). (Walsh, 2013)[i]

### 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 |
|---|---|---|
| Contact and Non-Contact Interactions | • Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-3, 3-PS2-4, PS2.B)<br>• Objects in contact exert forces on each other. (3-PS2-1, PS2.B) | 10 |
| Balanced and Unbalanced Forces | • Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1, PS2.A) | 10 |
| Patterns of Motion | • The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2, PS2.A) | 10 |

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

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

# Mathematics

## Description of Student Engagement

Students measure distance their toy travels and create a line plot from the data.

## Standards for Mathematical Content

**3.MD.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units— whole numbers, halves, or quarters.

## 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.3.1** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

### Writing Standard: Text Types and Purposes

**W.3.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

- **W.3.2.a** Introduce a topic and group related information together; include illustrations when useful to aiding comprehension.
- **W.3.2.b** Develop the topic with facts, definitions, and details.
- **W.3.2.c** Use linking words and phrases (e.g., also, another, and, more, but) to connect ideas within categories of information.
- **W.3.2.d** Provide a concluding statement or section.

### Speaking and Listening Standard: Comprehension and Collaboration

**SL.3.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 3 topics and texts*, building on others' ideas and expressing their own clearly.

- **SL.3.1.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.3.1.b** Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion).
- **SL.3.1.c** Ask questions to check understanding of information presented, stay on topic, and link their comments to the remarks of others.
- **SL.3.1.d** Explain their own ideas and understanding in light of the discussion.

**SL.3.3** Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.

### Vocabulary: Language Acquisition and Use

**L.3.4.**b Determine the meaning of the new word formed when a known affix is added to a known word (e.g., agreeable/disagreeable, comfortable/uncomfortable, care/careless, heat/preheat).

## Unit Vocabulary

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

- **attract**: To attract is to draw to or toward something else. (Source: https://www.merriam-webster.com/dictionary/attract).
- **balanced forces**: Forces are balanced when the amount of force on opposite sides of an object are the same. When this occurs, the object does not move.
- **cause**: A cause is a reason for an action or condition. (Source: https://www.merriam-webster.com/dictionary/cause)
- **contact interaction**: In contact interaction, two objects have contact, touch one another, and there is/are changes(s) in the structure, motion and other qualities of the objects.
- **effect**: An effect is an event, condition, or state of affairs that is produced by a cause. (Source: https://www.merriam-webster.com/dictionary/effect)
- **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[1]: https://go.nasa.gov/3tJolxC)
- **friction**: Friction is the force that causes a moving object to slow down when it is touching another object. (Source: https://www.merriam-webster.com/dictionary/friction)
- **invisible forces**: Invisible forces can influence objects but we cannot see them. For example, we cannot see magnetism, but we can see what a magnet does. And, we cannot see gravity, but it is a force that keeps objects on the ground, rather than floating freely.
- **iron**: Iron is a heavy type of metal that is very common, occurs naturally in blood, and is used to make steel and in many products. (Source: https://www.merriam-webster.com/dictionary/iron)
- **magnet**: A magnet is a piece of material (as of iron, steel, or alloy) that is able to attract iron. (Source: https://www.merriam-webster.com/dictionary/magnet)

[1] NASA = National Aeronautics and Space Administration

- **magnetic**: An object or structure is magnetic if it possesses an extraordinary power or ability to attract, or it is of or relating to a magnet. (Adapted from: https://www.merriam-webster.com/dictionary/magnetic)

- **motion**: Motion is an act, process, or instance of changing place. (Source: https://www.merriam-webster.com/dictionary/motion)

- **non-contact interaction**: Non-contact interaction occurs when an object is influenced by a force that is not physically apparent. For example, we are pulled down by gravity after we jump up into the air.

- **poles**: Poles are either extremity of an axis of a sphere and especially of the earth's axis (i.e., the North and South Poles). Poles are also either of the two terminals of an electric cell, battery, generator, or motor. (Adapted from: https://www.merriam-webster.com/dictionary/pole)

- **prototype**: A prototype is an original model on which something is patterned. Also it can be a first full-scale and usually functional form of a new type or design of a construction (such as an airplane). (Source: https://www.merriam-webster.com/dictionary/prototype)

- **pulls**: Pulls are forces that draws one body toward another. (Source: https://www.merriam-webster.com/dictionary/pulls) Magnets pull objects toward them and humans may drag objects toward them.

- **pushe**s: Pushes are forces that move (someone or something) forward or away from you. (Source: https://www.merriam-webster.com/dictionary/pushes)

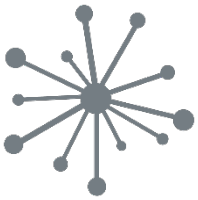
- **reaction**: Reaction is resistance or opposition to a force, influence, or movement. (Source: https://www.merriam-webster.com/dictionary/reaction)

- **reaction force**: When one object pushes against another, that object pushes back equally. When you kick a ball, the force of the kick is met with another force, which is the force of the air pushing back.

- **repel**: To repel is to force away or apart. (Source: https://www.merriam-webster.com/dictionary/repel)

- **unbalanced forces**: When forces are unbalanced, that means the opposing forces are not the same in magnitude — one is stronger than the other. An object is subject to unbalanced forces when a force applied in one direction exceeds the force that is applied in another direction. (Source: https://bit.ly/3FOki8i )

# 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. What kind of toys do you play with?
2. What kinds of things do you push or pull?
3. What kinds of things have you seen hit together? What happened?
4. Have you ever played with magnets? What did you notice?
5. Have you ever gotten an electrical shock? What happened?

### Aligned Learnings

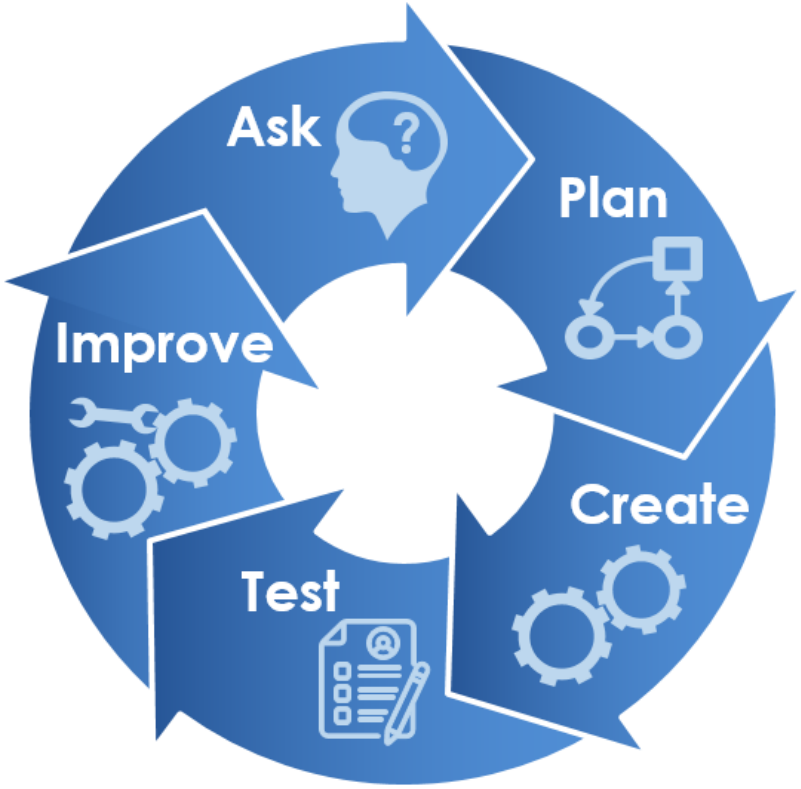
1. Responses to this item provide insight into students' experiences with toys and how they move. 3-PS2-1, 3-PS2-2, 3-PS2-3, 3-PS2-4
2. Responses to this item provide insight into students' experiences with forces. 3-PS2-1, 3-PS2-2
3. Responses to this item provide insight into students' experiences with balanced and unbalanced forces. 3-PS2-1, 3-PS2-2
4. Responses to this item provide insight into students' experiences with magnets. 3-PS2-3, 3-PS2-4
5. Responses to this item provide insight into students' experiences with static electricity. 3-PS2-3, 3-PS2-4

## 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 mechanical 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**<br>*Notes on how to improve the project* | **Meets Expectations**<br>*Criteria indicating success* | **Exceeds Expectations**<br>*Notes on how project goes beyond expectations* |
|---|---|---|
| | **Engineering**<br>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**<br>Students create an image of their toy's prototype in Paint 3D. (3-5.DA.8) | |
| | **Collaboration**<br>Students give and receive input with kindness and honesty. (SL.3.1) | |
| | **Communication**<br>Students speak and write about their ideas clearly using accurate vocabulary (W.3.2). I can share thoughts, read, and listen to learn from others. (SL.3.3) | |
| | **Science**<br>Students provide evidence of the effects of balanced and unbalanced forces on the movement of an object, determine cause and effect relationships in interactions, and provide evidence that patterns in motion can predict future motion. (3-PS2-1, 3-PS2-2, 3-PS2-3, 3-PS3-4) | |

# 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:

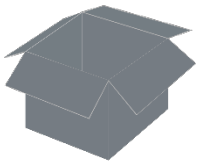
- Expose students to STEM as it applies in various careers
- Enrich student learning through collaborating with STEM professionals
- Help students see themselves doing the actual work of STEM

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

- **Computer programmer or Gaming developer** (Information and Communication Technologies)
- **Product Developer** (Business and Finance)
- **Park or Playground Designer** (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:

- **Computer programmer or Gaming developer** (Information and Communication Technologies)
  - What kinds of programs or games do you design?
  - How do you make objects move on the screen?
  - How do you decide what actions the icons should be able to do?
  - Do you develop these programs or games by yourself or does a group complete the work? Are some people specialized in some part of the development process?
  - What is the hardest part of developing a new game or program? Why?
- **Product Developer** (Business and Finance)
  - What kind of data do you collect to decide what product to create or what product to promote more?
  - How do you turn that data into decisions about next steps for your company?
  - What parts of the company do you interact with regularly and what role do you play in helping them meet their job responsibilities?
  - What does a typical day on the job look like?
  - What is one problem you are currently facing in your day-to-day work?
- **Park or Playground Designer** (Hospitality, Tourism, and Recreation)
  - How do you decide what kinds of playground equipment should be included in a park?
  - What role does data collected from the public play in your designs?
  - What are some precautions you take to protect the environment in your designs?
  - What are key tools and knowledge required for your job?
  - What is one problem you face in your day-to-day 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):

- ☐ 18 rulers with track (3 per group)
- ☐ 50 marbles

### Consumable Equipment (classroom totals):

- ☐ 130 unfinished wooden spools
- ☐ 96 dowels (.25 x 6 inches)
- ☐ 64 disc magnets
- ☐ 180 pipe cleaners
- ☐ 200 rubber bands
- ☐ 200 paper straws
- ☐ 96 paper plates
- ☐ 96 paper cups
- ☐ 160 sheets of construction paper
- ☐ 160 sheets of notebook or copy paper
- ☐ 4 rolls of string
- ☐ 750 paper clips
- ☐ 8 magnet wands
- ☐ 16-18 bar magnets (1.5 inch)
- ☐ 500 brads (paper fasteners)

### From Student Homes as Available:

- ☐ toilet paper tube(s)
- ☐ paper towel tube(s)
- ☐ water bottle(s)
- ☐ paper cup(s)
- ☐ milk cap(s)
- ☐ food tray(s)
- ☐ cardboard in any sizes, shapes
- ☐ milk caps

## 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):

- ☐ 4 spools
- ☐ 3 dowels
- ☐ 2 disc magnets
- ☐ 2 pipe cleaners
- ☐ 5 rubber bands
- ☐ 5 paper straws
- ☐ 3 paper plates
- ☐ 3 paper cups
- ☐ 5 sheets construction paper
- ☐ 5 sheets of notebook paper or copy paper
- ☐ 1 yard of string
- ☐ 10 paper clips
- ☐ 5 brads

## Endnotes

[i] Walsh, J. (2013, March 9). *Magnext iCoaster Demonstration.* YouTube. https://www.youtube.com/watch?v=bDqEOz3wB_Q