

HANDS-ON STEAM

Science

Technology

Engineering

Arts

Mathematics



180 Days of PRACTICE

GRADE

K

HANDS-ON STEAM

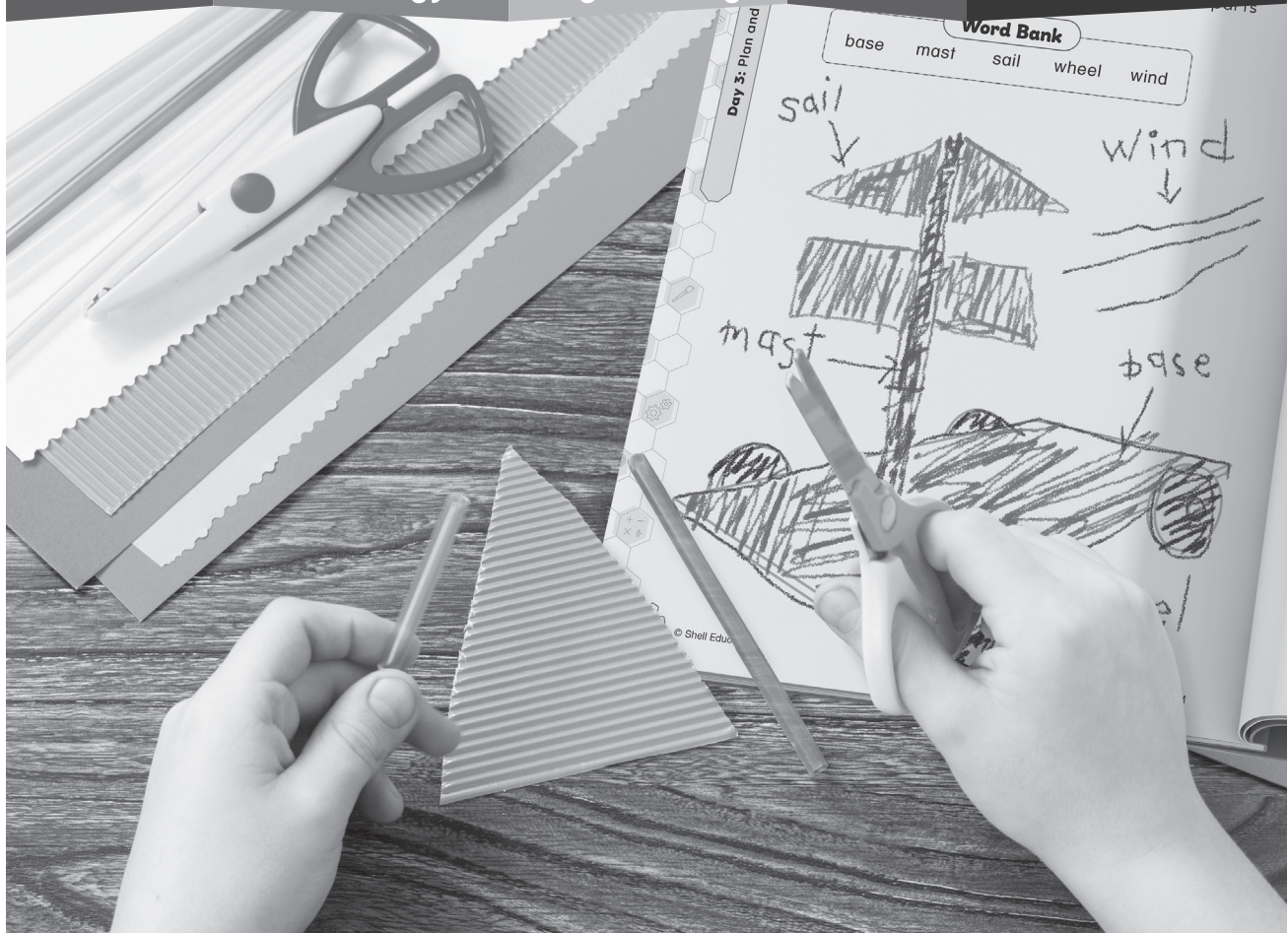
Science

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Mathematics



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Standards

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

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180 Days of Practice

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Research

The Importance of STEAM Education

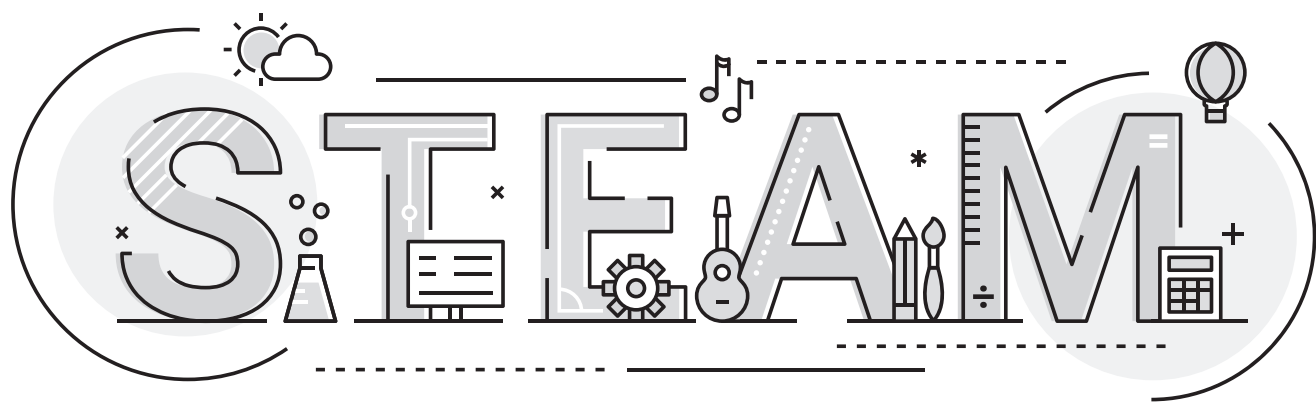
STEAM education is a powerful approach to learning that continues to gain momentum and support across the globe. STEAM is the integration of science, technology, engineering, the arts, and mathematics to design solutions for real-world problems. Students must learn how to question, explore, and analyze natural phenomena. With these skills in hand, students understand the complexity of available information and are empowered to become independent learners and problem solvers.

The content and practices of STEAM education are strong components of a balanced instructional approach, ensuring students are college- and career-ready. The application of STEAM practices in the classroom affords teachers opportunities to challenge students to apply new knowledge. Students of all ages can design and build structures, improve existing products, and test innovative solutions to real-world problems. STEAM instruction can be as simple as using recycled materials to design a habitat for caterpillars discovered on the playground and as challenging as designing a solution to provide clean water to developing countries. The possibilities are endless.

Blending arts principles with STEM disciplines prepares students to be problem solvers, creative collaborators, and thoughtful risk-takers. Even students who do not choose a career in a STEAM field will benefit because these skills can be translated into almost any career. Students who become STEAM proficient are prepared to answer complex questions, investigate global issues, and develop solutions for real-world challenges. Roger W. Bybee (2013, 64) summarizes what is expected of students as they join the workforce:

As literate adults, individuals should be competent to understand STEM-related global issues; recognize scientific from other nonscientific explanations; make reasonable arguments based on evidence; and, very important, fulfill their civic duties at the local, national, and global levels.

Likewise, STEAM helps students understand how concepts are connected as they gain proficiency in the Four Cs: creativity, collaboration, critical thinking, and communication.



Research *(cont.)*

Defining STEAM

STEAM is an integrated way of preparing students for the twenty-first century world. It places an emphasis on understanding science and mathematics while learning engineering skills. By including art, STEAM recognizes that the creative aspect of any project is integral to good design—whether designing an experiment or an object.

Science



Any project or advancement builds on prior science knowledge. Science focuses on learning and applying specific content, cross-cutting concepts, and scientific practices that are relevant to the topic or project.

Technology



This is what results from the application of scientific knowledge and engineering. It is something that is created to solve a problem or meet a need. Some people also include the *use* of technology in this category. That is, tools used by scientists and engineers to solve problems. In addition to computers and robots, technology can include nets used by marine biologists, anemometers used by meteorologists, computer software used by mathematicians, and so on.

Engineering



This is the application of scientific knowledge to meet a need, solve a problem, or address phenomena. For example, engineers design bridges to withstand huge loads. Engineering is also used to understand phenomena, such as in designing a way to test a hypothesis. When problems arise, such as those due to earthquakes or rising sea levels, engineering is required to design solutions to the problems. On a smaller scale, a homeowner might want to find a solution to their basement flooding.

Art



In this context, art equals creativity and creative problem-solving. For example, someone might want to test a hypothesis but be stumped as to how to set up the experiment. Perhaps you have a valuable painting. You think there is another valuable image below the first layer of paint on the canvas. You do not want to destroy the painting on top. A creative solution is needed. Art can also include a creative or beautiful design that solves a problem. For example, the Golden Gate Bridge is considered both an engineering marvel and a work of art.

Mathematics



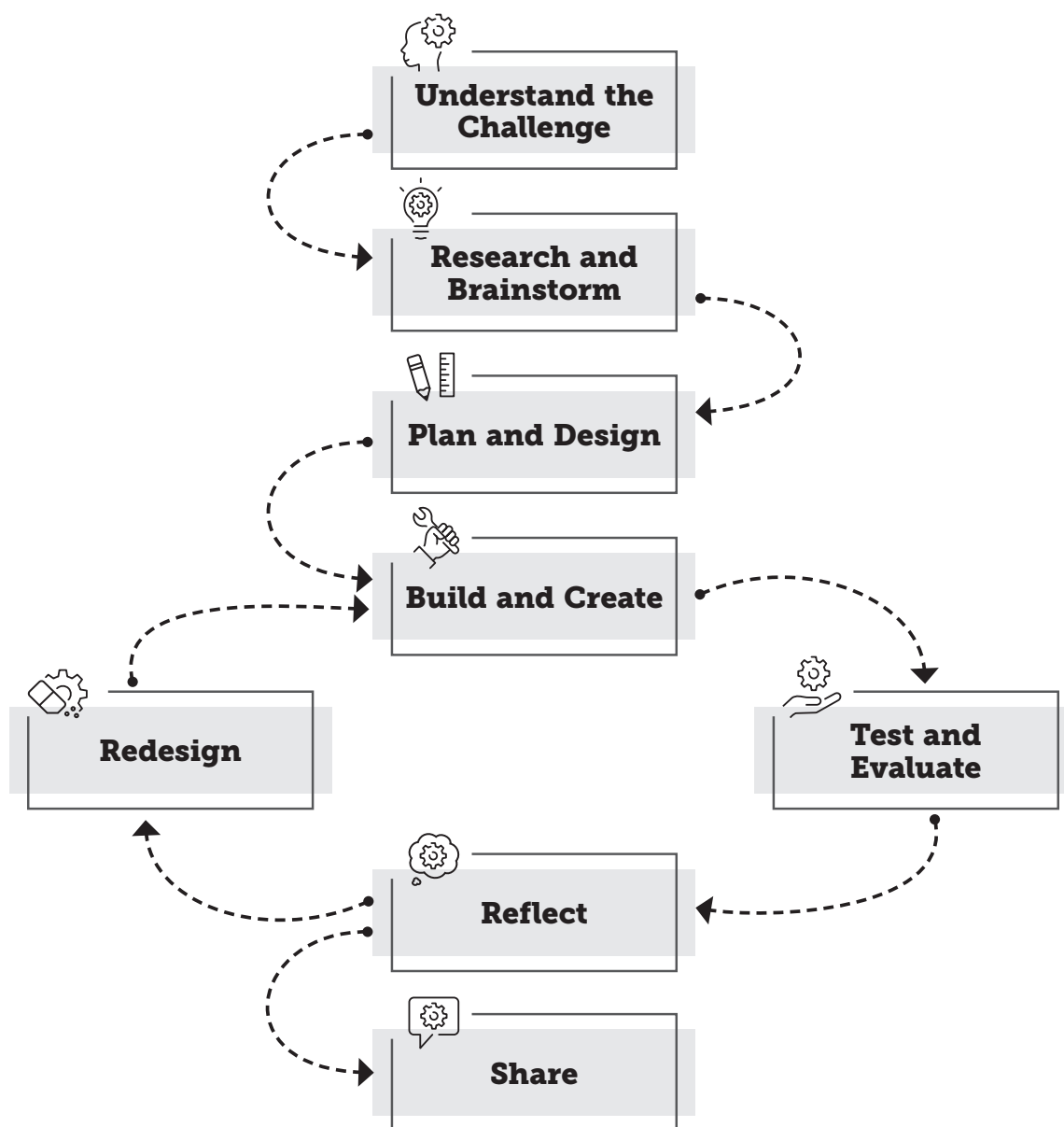
This is the application of mathematics to real-world problems. Often, this includes data analysis—such as collecting data, graphing it, analyzing the data, and then communicating that analysis. It may also include taking mathematical measurements in the pursuit of an answer. The idea is not to learn new math, but rather to apply it; however, some mathematics may need to be learned to solve the specific problem. Isaac Newton, for example, is famous for *inventing* calculus to help him solve problems in understanding gravity and motion.

Research *(cont.)*

The Engineering Design Process

The most essential component of STEAM education is the engineering design process. This process is an articulated approach to problem solving in which students are guided through the iterative process of solving problems and refining solutions to achieve the best possible outcomes. There are many different versions of the engineering design process, but they all have the same basic structure and goals. As explained in Appendix I of NGSS (2013), “At any stage, a problem-solver can redefine the problem or generate new solutions to replace an idea that just isn’t working out.”

Each unit in this resource presents students with a design challenge in an authentic and engaging context. The practice pages guide and support students through the engineering design process to solve problems or fulfill needs.



Research *(cont.)*

How to Facilitate Successful STEAM Challenges

There are some basic rules to remember as your students complete STEAM challenges.

Both independent and collaborative work should be included.

Astronaut and inventor Ellen Ochoa is well-known for working a robotic arm in space. About that experience she said, “It’s fun to work the robotic arm, in part because it’s a team effort.” She recognized that she was getting credit for something amazing that happened because of the collaborative work of hundreds of people.

Students need time to think through a project, both on their own and together with others. It is often best to encourage students to start by thinking independently. One student may think of a totally different solution than another student. Once they come together, students can merge aspects of each other’s ideas to devise something even better.

Failure is a step in the process.

During the process of trying to invent a useful light bulb, Thomas Edison famously said, “I have not failed. I’ve just found 10,000 ways that won’t work.” People are innovating when they are failing because it is a chance to try something new. The STEAM challenges in this book intentionally give students chances to improve their designs. Students should feel free to innovate as much as possible, especially the first time around. Then, they can build on what they learned and try again.

Some students get stuck thinking there is one right way. There are almost always multiple solutions to a problem. For example, attaching train cars together used to be very dangerous. In the late nineteenth century, different solutions to this problem were invented in England and the United States to make the process safer. Both solutions worked, and both were used! Encourage students to recognize that there are usually different ways to solve problems. Discuss the pros and cons of the various solutions that students generate.



Research *(cont.)*

How to Facilitate Successful STEAM Challenges *(cont.)*

Getting inspiration from others is an option.

Students worry a lot about copying. It is important to remind them that all breakthroughs come on the shoulders of others. No one is working in a vacuum, and it is okay to get inspiration and ideas from others. It is also important to give credit to the people whose work and ideas inspired others. Students may see this as cheating, but they should be encouraged to see that they had a great enough idea that others recognized it and wanted to build on it.

The struggle is real—and really important.

Most people do not like to fail. And it can be frustrating not to know what to do or what to try next. Lonnie Johnson, engineer and toy inventor, advises, “Persevere. That’s what I always say to people. There’s no easy route.” Try to support students during this struggle, as amazing innovations can emerge from the process. Further, students feel great when they surprise themselves with success after thinking they were not going to succeed.

Materials can inspire the process.

Students may be stumped about how they are going to build a boat...until you show them that they can use clay. A parachute is daunting, but a pile of tissue paper or plastic bags might suddenly make students feel like they have some direction. On the other hand, materials can also instantly send the mind in certain directions, without exploring other options. For this reason, consider carefully the point at which you want to show students the materials they can use. You might want them to brainstorm materials first. This might inspire you to offer materials you had not considered before.

Some students or groups will need different types of support.

If possible, have students who need additional support manipulate materials, play with commercial solutions, or watch videos to get ideas. For students who need an additional challenge, consider ways to make the challenge more “real world” by adding additional realistic criteria. Or, encourage students to add their own criteria.

How to Use This Resource

Unit Structure Overview

This resource is organized into 12 units. Each three-week unit is organized in a consistent format for ease of use.

Week 1: STEAM Content

Day 1 Learn Content	Students read text, study visuals, and answer multiple-choice questions.
Day 2 Learn Content	Students read text, study visuals, and answer short-answer questions.
Day 3 Explore Content	Students engage in hands-on activities, such as scientific investigations, mini building challenges, and drawing and labeling diagrams.
Day 4 Get Creative	Students use their creativity, imaginations, and artistic abilities in activities such as drawing, creating fun designs, and doing science-related crafts.
Day 5 Analyze Data	Students analyze and/or create charts, tables, maps, and graphs.

Week 2: STEAM Challenge

Day 1 Understand the Challenge	Students are introduced to the STEAM Challenge. They review the criteria and constraints for successful designs.
Day 2 Research and Brainstorm	Students conduct additional research, as needed, and brainstorm ideas for their designs.
Day 3 Plan and Design	Students plan and sketch their designs.
Day 4 Build and Create	Students use their materials to construct their designs.
Day 5 Test and Evaluate	Students conduct tests and/or evaluation to assess the effectiveness of their designs and how well they met the criteria of the challenge.

Week 3: STEAM Challenge Improvement

Day 1 Reflect	Students answer questions to reflect on their first designs and make plans for how to improve their designs.
Day 2 Redesign	Students sketch new or modified designs.
Day 3 Rebuild and Refine	Students rebuild or adjust their designs.
Day 4 Retest	Students retest and evaluate their new designs.
Day 5 Reflect and Share	Students reflect on their experiences working through the engineering design process. They discuss and share their process and results with others.

How to Use This Resource *(cont.)*

Pacing Options

This resource is flexibly designed and can be used in tandem with a core curriculum within a science, STEAM, or STEM block. It can also be used in makerspaces, after-school programs, summer school, or as enrichment activities at home. The following pacing options show suggestions for how to use this book.

Option 1

This option shows how each unit can be completed in 15 days. This option requires approximately 10–20 minutes per day. Building days are flexible, and teachers may allow for additional time at their discretion.

	Day 1	Day 2	Day 3	Day 4	Day 5
Week 1	Learn Content	Learn Content	Explore Content	Get Creative	Analyze Data
Week 2	Understand the Challenge	Research and Brainstorm	Plan and Design	Build and Create	Test and Evaluate
Week 3	Reflect	Redesign	Rebuild and Refine	Retest	Reflect and Share

Option 2

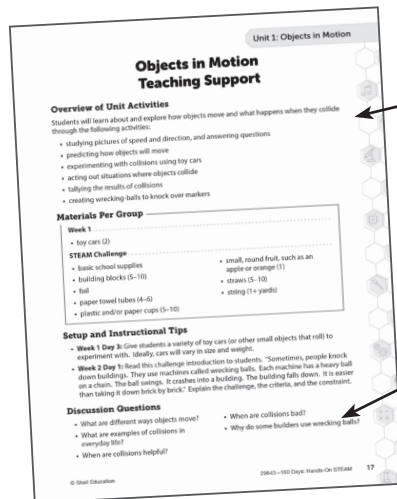
This option shows how each unit can be completed in fewer than 15 days. This option requires approximately 45–60 minutes a day.

	Day 1	Day 2
Week 1	Learn Content Explore Content	Get Creative Analyze Data
Week 2	Understand the Challenge Research and Brainstorm Plan and Design	Build and Create Test and Evaluate
Week 3	Reflect Redesign Rebuild and Refine	Retest Reflect and Share

How to Use This Resource *(cont.)*

Teaching Support Pages

Each unit in this resource begins with two teaching support pages that provide instructional guidance.

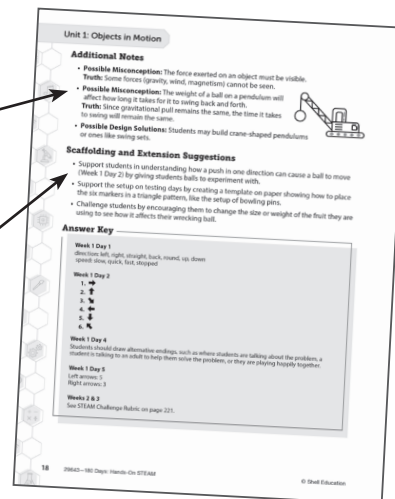


A clear overview of unit activities, weekly materials, safety notes, and setup tips helps teachers plan and prepare efficiently and with ease.

Discussion questions encourage students to verbalize their learning and connect it to their own lives.

Possible student misconceptions and design solutions further take the guesswork out of lesson planning.

Differentiation options offer ways to support and extend student learning.



Materials

Due to the nature of engineering, the materials listed are often flexible. They may be substituted or added to, depending on what you have available. More material options require greater consideration by students and encourage more creative and critical thinking. Fewer material options can help narrow students' focus but may limit creativity. Adjust the materials provided to fit the needs of your students.

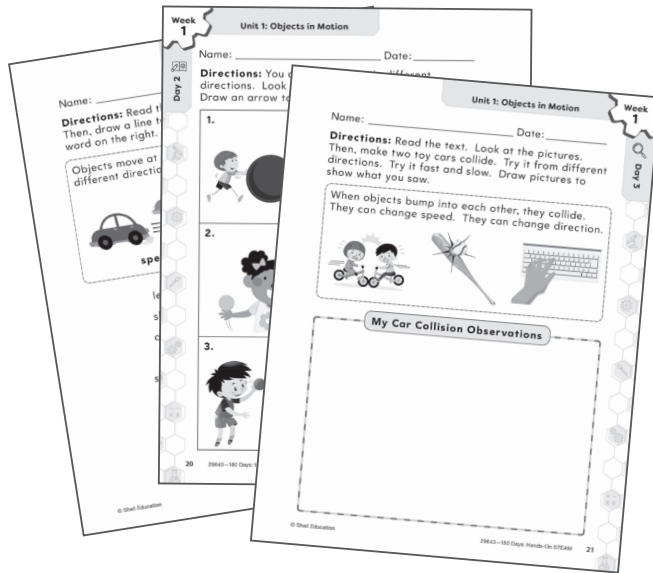
Approximate amounts of materials are included in each list. These amount suggestions are per group. Students are expected to have basic school supplies for each unit. These include paper, pencils, markers or crayons, glue, tape, and scissors.

How to Use This Resource *(cont.)*

Student Pages

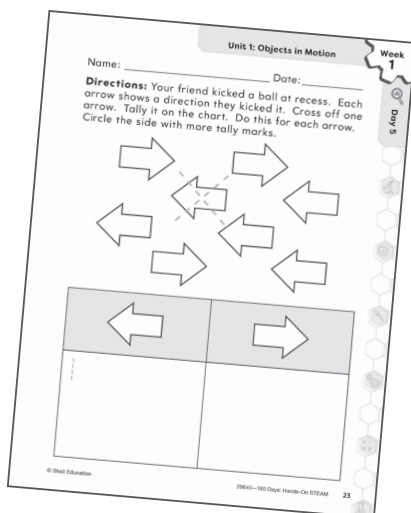
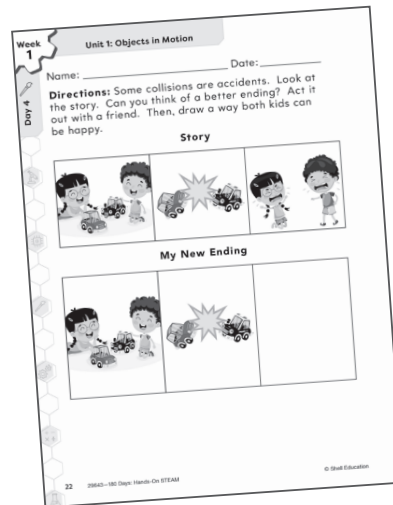
Be sure to read aloud all text on student pages, and support comprehension as needed. At this level, students may need additional support brainstorming or designing solutions for the STEAM Challenges. See the differentiation suggestions on the Teaching Support Pages for additional ways to support students.

Students begin each unit by learning about and exploring science-related content.



Activities in **Week 1** help build background science content knowledge relevant to the STEAM Challenge.

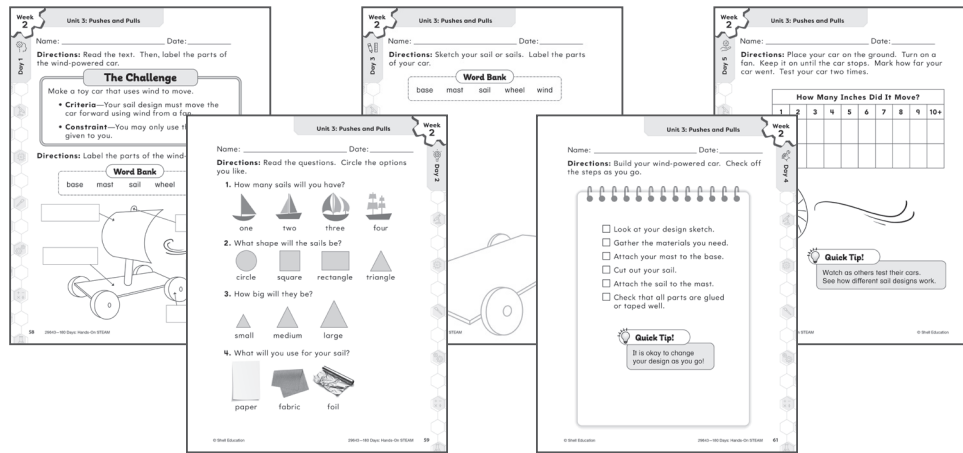
Creative activities encourage students to connect science and art.



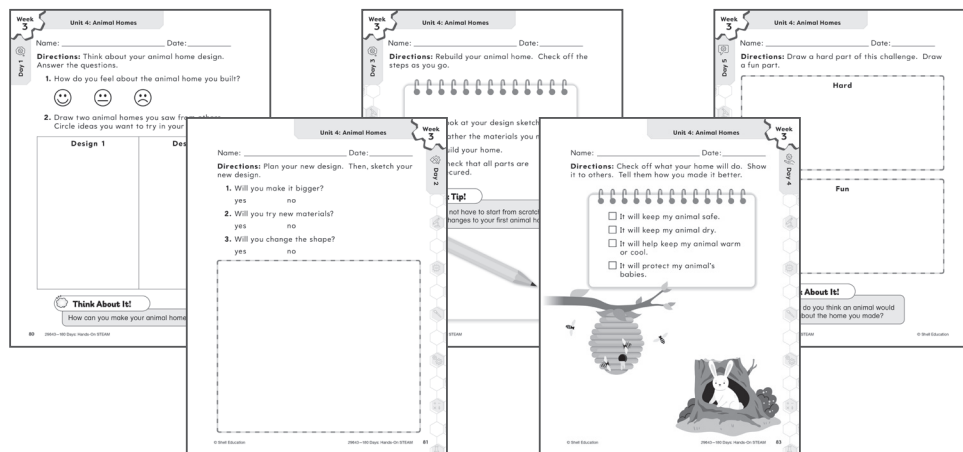
Graphs, charts, and maps guide students to make important mathematics and real-world connections

How to Use This Resource (cont.)

Student Pages (cont.)



Week 2 introduces students to the STEAM Challenge. Activities guide students through each step of the engineering design process. They provide guiding questions and space for students to record their plans, progress, results, and thinking.



Week 3 activities continue to lead students through the cycle of the engineering design process. Students are encouraged to think about and discuss ways to improve their designs based on their observations and experiences in Week 2.



Quick Tip!

Staple all the student pages for each unit together, and distribute them as packets. This will allow students to easily refer to their learning as they complete the STEAM Challenges.

How to Use This Resource *(cont.)*

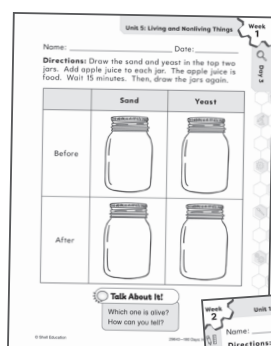
Assessment Options

Assessments guide instructional decisions and improve student learning. This resource offers balanced assessment opportunities. The assessments require students to think critically, respond to text-dependent questions, and utilize science and engineering practices.

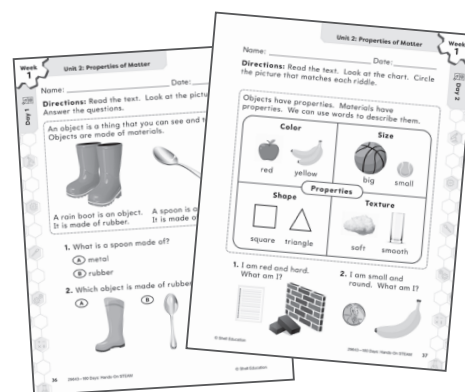
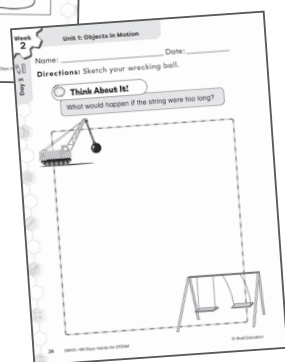
Progress Monitoring

There are key points throughout each unit when valuable formative evaluations can be made. These evaluations can be based on group, paired, and/or individual discussions and activities.

- **Week 1** activities provide opportunities for students to answer multiple-choice and short-answer questions related to the content. Answer keys for these pages are provided in the Teaching Support pages.



- **Talk About It!** graphics on student activity sheets offer opportunities to monitor student progress.

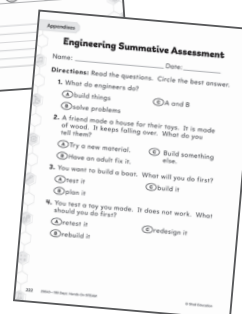
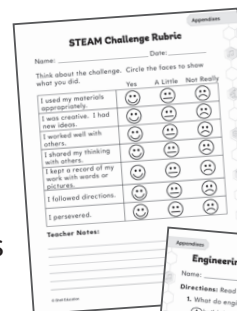


- **Week 2 Day 3: Plan and Design** is when students sketch their first designs. This is a great opportunity to assess how well students understand the STEAM challenge and what they plan to create. These should be reviewed before moving on to the Build and Create stages of the STEAM Challenges.

Summative Assessment

A rubric for the STEAM Challenges is provided on page 221. It is important to note that whether students' final designs were successful is not the main goal of this assessment. It is a way to assess students' skills as they work through the engineering design process. Students assess themselves first. Teachers can add notes to the assessment.

A short summative assessment is provided on page 222. This is meant to provide teachers with insight into how well students understand STEAM practices and the engineering design process.



Standards Correlations

Shell Education is committed to producing educational materials that are research and standards based. To support this effort, this resource is correlated to the academic standards of all 50 states, the District of Columbia, the Department of Defense Dependent Schools, and the Canadian provinces. A correlation is also provided for key professional educational organizations.

To print a customized correlation report for your state, visit our website at www.tcmpub.com/administrators/correlations and follow the online directions. If you require assistance in printing correlation reports, please contact the Customer Service Department at 1-800-858-7339.

Standards Overview

The Every Student Succeeds Act (ESSA) mandates that all states adopt challenging academic standards that help students meet the goal of college and career readiness. While many states already adopted academic standards prior to ESSA, the act continues to hold states accountable for detailed and comprehensive standards. Standards are designed to focus instruction and guide adoption of curricula. They define the knowledge, skills, and content students should acquire at each level. Standards are also used to develop standardized tests to evaluate students' academic progress. State standards are used in the development of our resources, so educators can be assured they meet state academic requirements.

Next Generation Science Standards

This set of national standards aims to incorporate science knowledge and process standards into a cohesive framework. The standards listed on page 16 describe the science content and processes presented throughout the lessons.

TESOL and WIDA Standards

In this book, the following English language development standards are met: Standard 1: English language learners communicate for social and instructional purposes within the school setting. Standard 3: English language learners communicate information, ideas and concepts necessary for academic success in the content area of mathematics. Standard 4: English language learners communicate information, ideas and concepts necessary for academic success in the content area of science.

Standards Correlations *(cont.)*

Each unit in this resource supports the following NGSS Scientific and Engineering Practices and Engineering Performance Expectations for K–2.

Scientific and Engineering Practices	Engineering Performance Expectations
Asking Questions and Defining Problems	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.
Developing and Using Models	
Planning and Carrying Out Investigations	
Analyzing and Interpreting Data	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.
Constructing Explanations and Designing Solutions	
Engaging in Argument from Evidence	Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
Obtaining, Evaluating, and Communicating Information	

This chart shows how the units in this resource align to NGSS Disciplinary Core Ideas and Crosscutting Concepts.

Unit	Disciplinary Core Idea	Crosscutting Concept
Objects in Motion	PS2.A: Forces and Motion PS3.C: Relationship Between Energy and Forces	Cause and Effect
Properties of Matter	PS1.A: Structures and Properties of Matter	Patterns; Energy and Matter
Pushes and Pulls	PS2.A: Forces and Motion PS2.B: Types of Interactions PS3.C: Relationship Between Energy and Forces	Cause and Effect
Animal Homes	ESS2.E: Biogeology	Patterns; Systems and System Models
Living and Nonliving Things	LS1.C: Org. of Matter and Energy Flow in Organisms	Patterns
The Five Senses	LS1.D: Informations Processing PS4.A: Wave Properties	Structure and Function
Plants	LS1.C: Org. of Matter and Energy Flow in Organisms	Patterns; Structure and Function
Earth's Resources	ESS3.A: Natural Resources	Cause and Effect; Systems and System Models
Reduce, Reuse, Recycle	ESS3.C: Human Impacts on Earth Systems	Patterns; Systems and System Models
Severe Weather	ESS3.B: Natural Hazards	Cause and Effect; Systems and System Models
Warmth from the Sun	PS3.B: Conservation of Energy and Energy Transfer	Cause and Effect
Wind	ESS2.D: Weather and Climate	Cause and Effect; Systems and System Models

Objects in Motion

Teaching Support

Overview of Unit Activities

Students will learn about and explore how objects move and what happens when they collide through the following activities:

- studying pictures of speed and direction, and answering questions
- predicting how objects will move
- experimenting with collisions using toy cars
- acting out situations where objects collide
- tallying the results of collisions
- creating wrecking-balls to knock over markers

Materials Per Group

Week 1

- toy cars (2)

STEAM Challenge

- | | |
|------------------------------------|--|
| • basic school supplies | • small, round fruit, such as an apple or orange (1) |
| • building blocks (5–10) | • straws (5–10) |
| • foil | • string (1+ yards, 1+ meters) |
| • paper towel tubes (4–6) | |
| • plastic and/or paper cups (5–10) | |

Setup and Instructional Tips

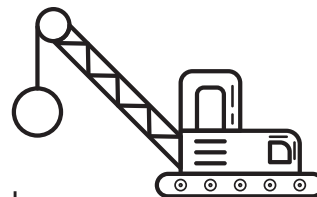
- **Week 1 Day 3:** Give students a variety of toy cars (or other small objects that roll) to experiment with. Ideally, cars will vary in size and weight.
- **Week 2 Day 1:** Read this challenge introduction to students. “Sometimes, people knock down buildings. They use machines called wrecking balls. Each machine has a heavy ball on a chain. The ball swings. It crashes into a building. The building falls down. It is easier than taking it down brick by brick.” Explain the challenge, the criteria, and the constraint.

Discussion Questions

- | | |
|---|--|
| • What are different ways objects move? | • When are collisions bad? |
| • What are examples of collisions in everyday life? | • Why do some builders use wrecking balls? |
| • When are collisions helpful? | |

Additional Notes

- **Possible Misconception:** The force exerted on an object must be visible.
Truth: Some forces (gravity, wind, magnetism) cannot be seen.
- **Possible Misconception:** The weight of a ball on a pendulum will affect how long it takes for it to swing back and forth.
Truth: Since gravitational pull remains the same, the time it takes to swing will remain the same.
- **Possible Design Solutions:** Students may build crane-shaped pendulums or ones like swing sets.



Scaffolding and Extension Suggestions

- Support students in understanding how a push in one direction can cause a ball to move (Week 1 Day 2) by giving students balls to experiment with.
- Support the setup on testing days by creating a template on paper showing how to place the six markers in a triangle pattern, like the setup of bowling pins.
- Challenge students by encouraging them to change the size or weight of the fruits they are using to see how it affects their wrecking balls.

Answer Key

Week 1 Day 1

direction: left, right, straight, back, round, up, down
speed: slow, quick, fast, stopped

Week 1 Day 2

1. →
2. ↑
3. ↘
4. ←
5. ↓
6. ↙

Week 1 Day 4

Students should draw alternative endings, such as where students are talking about the problem, a student is talking to an adult to help them solve the problem, or they are playing happily together.

Week 1 Day 5

Left arrows: 5
Right arrows: 3
The left side should be circled.

Weeks 2 & 3

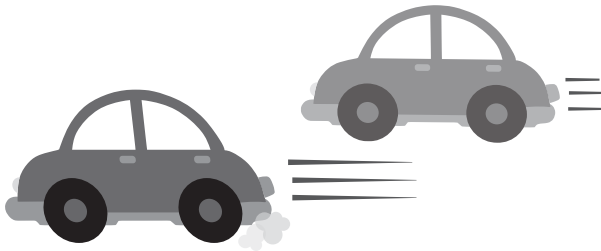
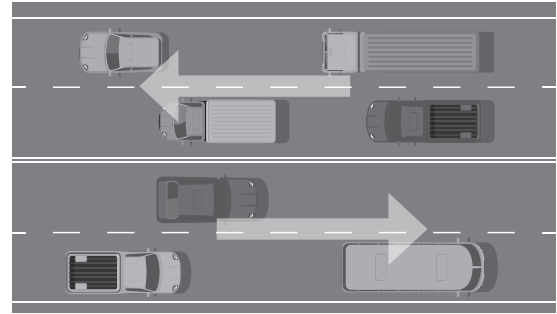
See STEAM Challenge Rubric on page 221.



Name: _____ Date: _____

Directions: Read the text. Look at the pictures. Then, draw a line to match each word on the left to a word on the right.

Objects move at different speeds. Objects move in different directions.

**speed****direction**

left

slow

quick

right

straight

fast

stopped

back

up

down

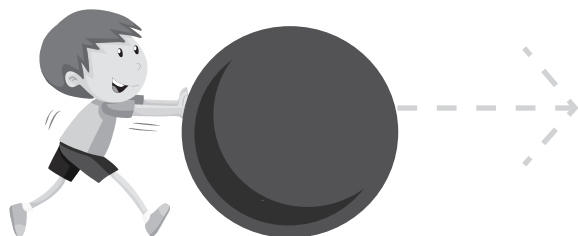
speed**direction**



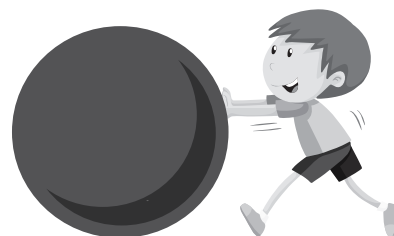
Name: _____ Date: _____

Directions: You can push things in different directions. Look at the person moving each ball. Draw an arrow to show which way the ball will move.

1.



4.



2.



5.



3.



6.

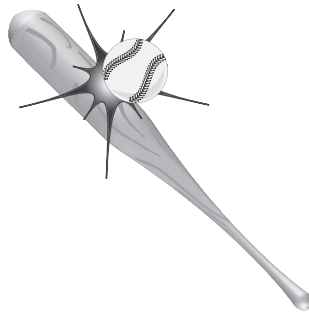
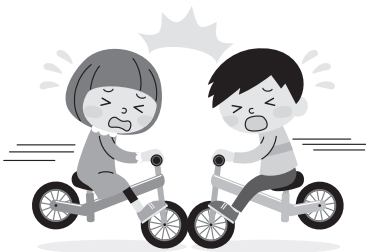




Name: _____ Date: _____

Directions: Read the text. Look at the pictures. Then, make two toy cars collide. Try it from different directions. Try it fast and slow. Draw pictures to show what happened.

When objects bump into each other, they collide. They can change speed. They can change direction.



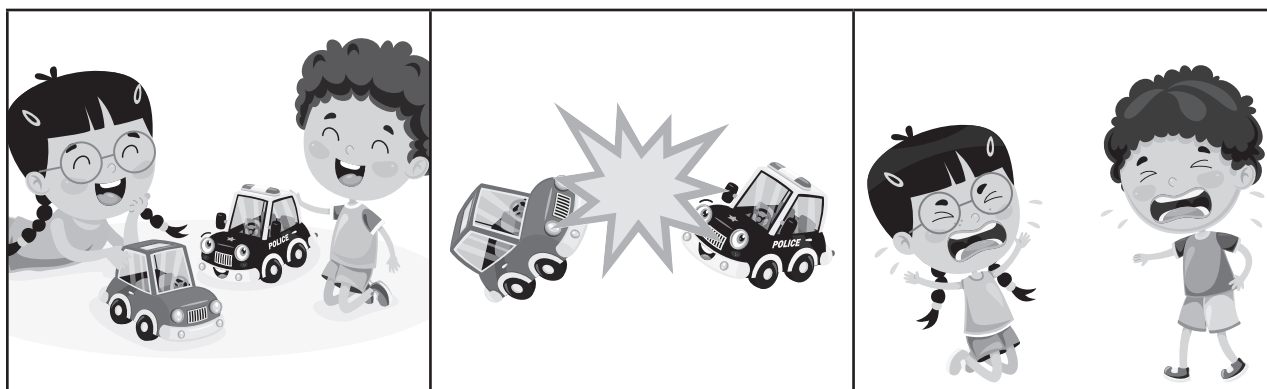
My Car Collision Observations



Name: _____ Date: _____

Directions: Some collisions are accidents. Look at the story. Can you think of a better ending? Act it out with a friend. Then, draw a way both kids can feel better.

Story



My New Ending

