Shell Education

180 Days of PRACTICE

GRADE 3

HANDS-ON STEAM

Science | Technology | Engineering | Arts | Mathematics

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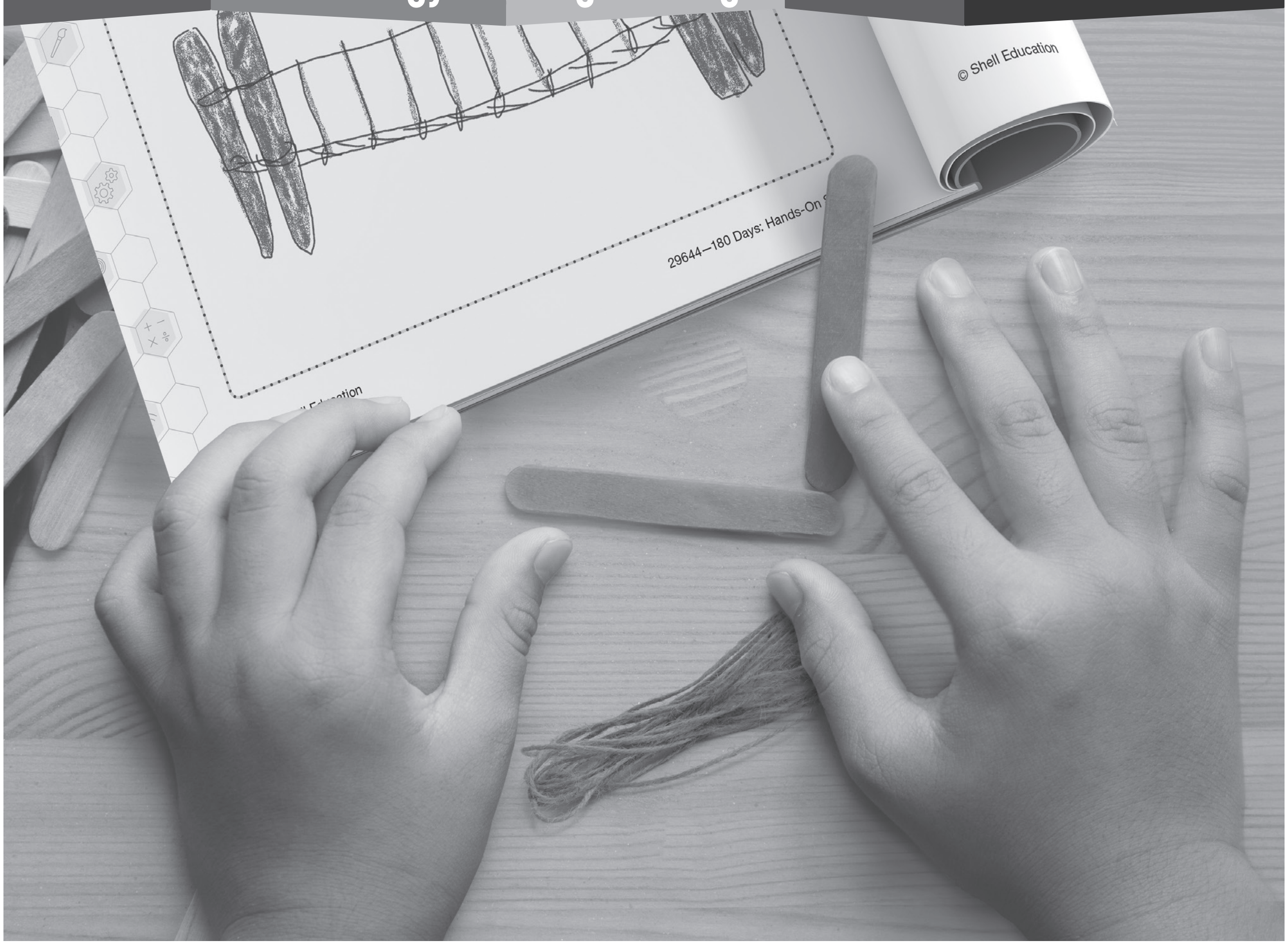

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NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

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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. Rodger 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

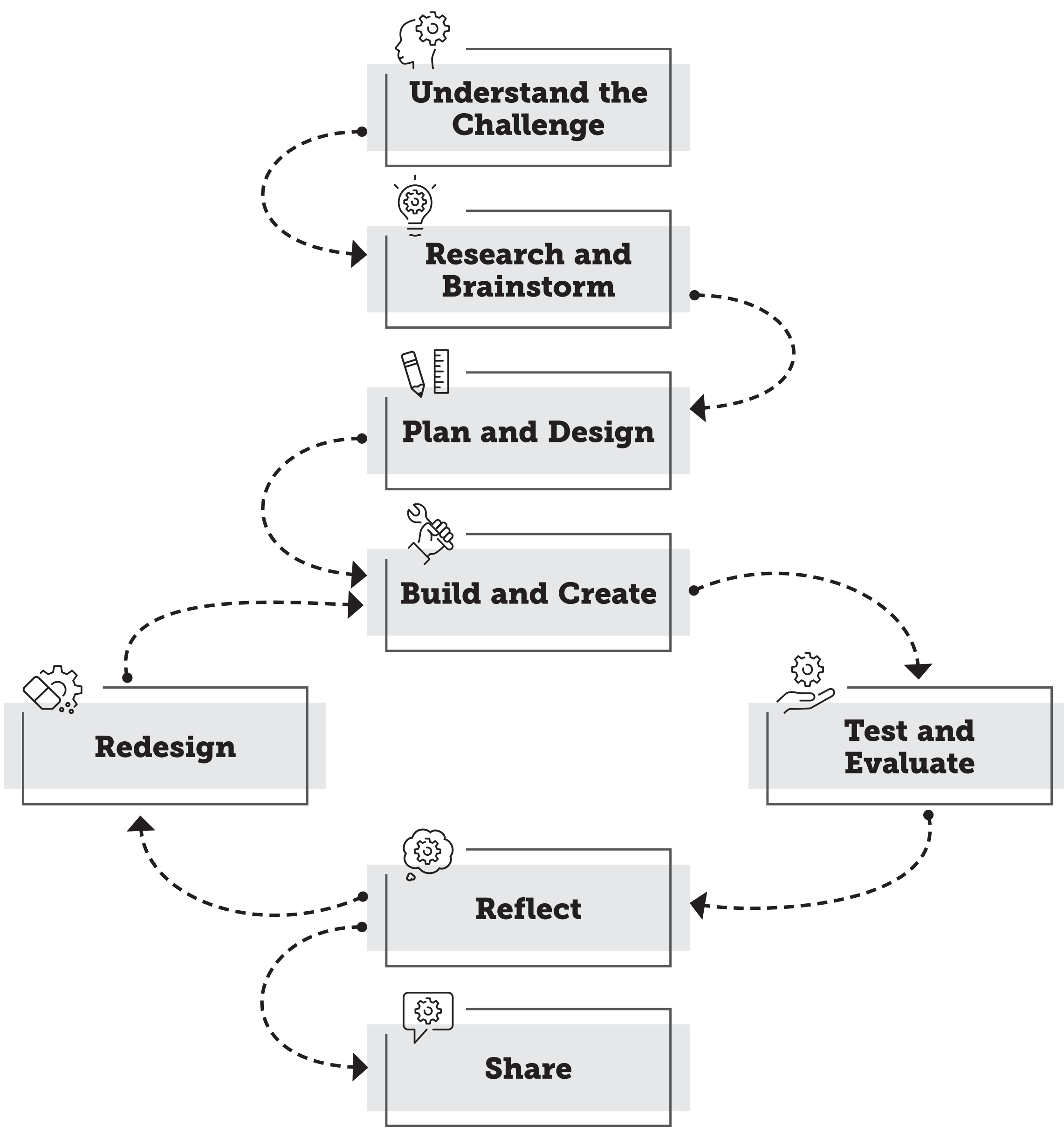
This is the application of mathematics to real-world problems. Often, this includes data analysis—such as collecting data, graphing it, analyzing the data, and then communicating that analysis. It may also include taking mathematical measurements in the pursuit of an answer. The idea is not to learn 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

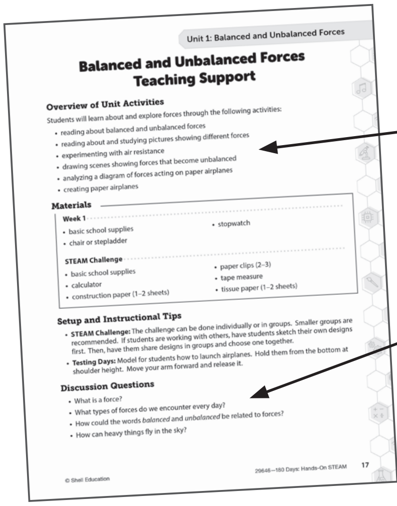
This option shows how each unit can be completed in fewer than 15 days. This option requires approximately 45–60 minutes a day.

	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.


Unit 1: Balanced and Unbalanced Forces

Balanced and Unbalanced Forces Teaching Support

Overview of Unit Activities

Students will learn about and explore forces through the following activities:

- reading about balanced and unbalanced forces
- reading about and studying pictures showing different forces
- experimenting with air resistance
- drawing scenes showing forces that become unbalanced
- analyzing a diagram of forces acting on paper airplanes
- creating paper airplanes

Materials

Week 1
- basic school supplies
- chair or stepladder
- stopwatch

STEAM Challenge
- basic school supplies
- calculator
- construction paper (1–2 sheets)
- paper clips (2–3)
- tape measure
- tissue paper (1–2 sheets)

Setup and Instructional Tips

- **STEAM Challenge:** The challenge can be done individually or in groups. Smaller groups are recommended. If students are working with others, have students sketch their own designs first. Then, have them share designs in groups and choose one together.
- **Testing Days:** Model for students how to launch airplanes. Hold them from the bottom at shoulder height. Move your arm forward and release it.

Discussion Questions

- What is a force?
- What types of forces do we encounter every day?
- How could the words *balanced* and *unbalanced* be related to forces?
- How can heavy things fly in the sky?

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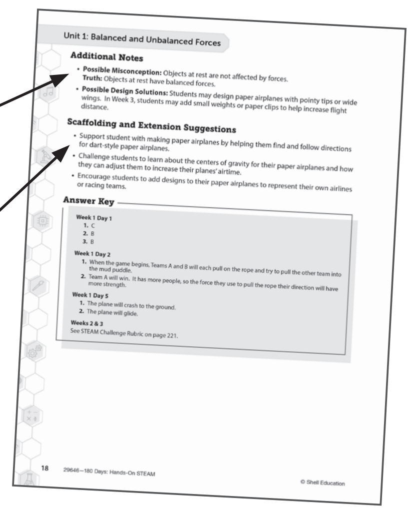
A clear overview of unit activities, weekly materials, safety notes, and setup tips help teachers plan and prepare efficiently and with ease.

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


Unit 1: Balanced and Unbalanced Forces

Additional Notes

- **Possible Misconception:** Objects at rest are not affected by forces.
  Truth: Objects at rest have balanced forces.
- **Possible Design Solutions:** Students may design paper airplanes with pointy tips or wide wings. In Week 3, students may add small weights or paper clips to help increase flight distance.

Scaffolding and Extension Suggestions

- Support student with making paper airplanes by helping them find and follow directions for dart-style paper airplanes.
- Challenge students to learn about the centers of gravity for their paper airplanes and how they can adjust them to increase their planes' airtime.
- Encourage students to add designs to their paper airplanes to represent their own airlines or racing teams.

Answer Key

Week 1 Day 1
1. C
2. B
3. B

Week 1 Day 2
1. When the game begins, Teams A and B will each pull on the rope and try to pull the other team into the mud puddle.
2. Team A will win. It has more people, so the force they use to pull the rope their direction will have more strength.

Week 1 Day 5
1. The plane will crash to the ground.
2. The plane will glide.

Weeks 2 & 3
See STEAM Challenge Rubric on page 221.

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

Differentiation options offer ways to support and extend student learning.

Materials

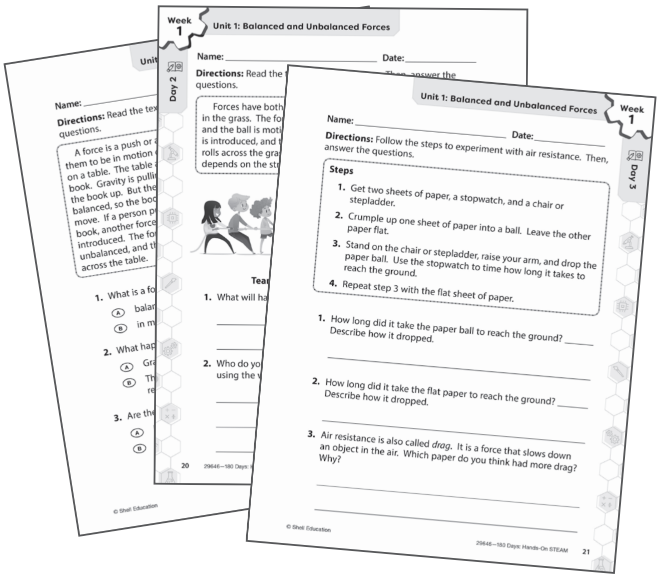
Due to the nature of engineering, the materials listed are often flexible. They may be substituted or added to, depending on what you have available. More material options require greater consideration by students and encourage more creative and critical thinking. Fewer material options can help narrow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

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


Unit 1: Balanced and Unbalanced Forces
Week 1
Day 3
Name: ________________ Date: ________
Directions: Follow the steps to experiment with air resistance. Then, answer the questions.
Steps
1. Get two sheets of paper, a stopwatch, and a chair or stepladder.
2. Crumple up one sheet of paper into a ball. Leave the other paper flat.
3. Stand on the chair or stepladder, raise your arm, and drop the paper ball. Use the stopwatch to time how long it takes to reach the ground.
4. Repeat step 3 with the flat sheet of paper.
1. How long did it take the paper ball to reach the ground? ______ Describe how it dropped.
2. How long did it take the flat paper to reach the ground? ______ Describe how it dropped.
3. Air resistance is also called *drag*. It is a force that slows down an object in the air. Which paper do you think had more drag? Why?
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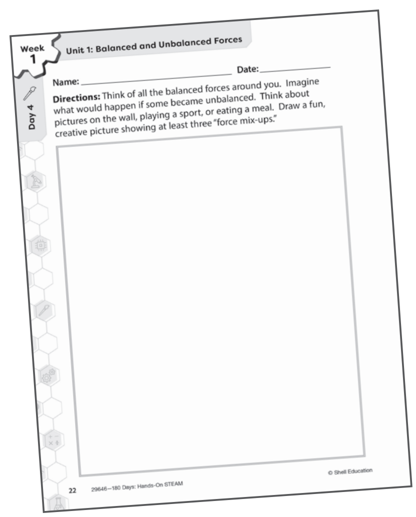
Activities in **Week 1** help build background science content knowledge relevant to the STEAM Challenge.


Week 1
Unit 1: Balanced and Unbalanced Forces
Day 4
Name: ________________ Date: ________
Directions: Think of all the balanced forces around you. Imagine what would happen if some became unbalanced. Think about pictures on the wall, playing a sport, or eating a meal. Draw a fun, creative picture showing at least three "force mix-ups."
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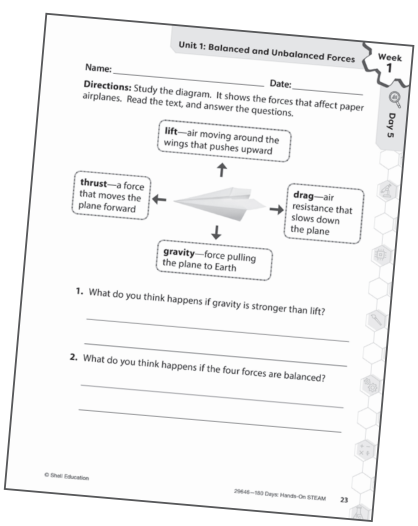
Creative activities encourage students to connect science and art.


Unit 1: Balanced and Unbalanced Forces
Week 1
Day 5
Name: ________________ Date: ________
Directions: Study the diagram. It shows the forces that affect paper airplanes. Read the text, and answer the questions.

1. What do you think happens if gravity is stronger than lift?
2. What do you think happens if the four forces are balanced?
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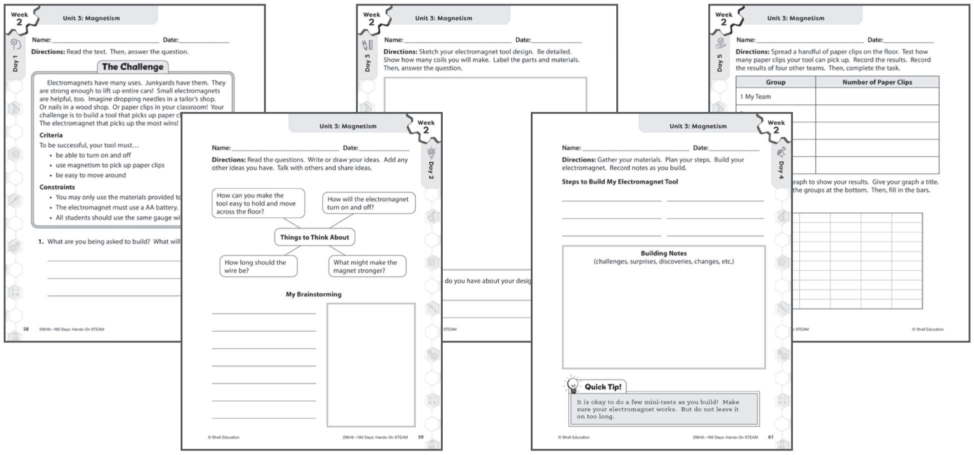
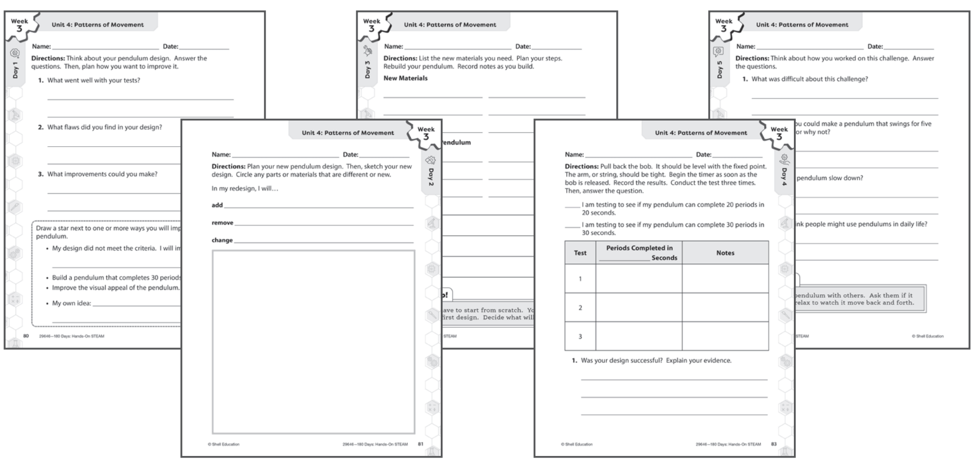
Graphs, charts, and maps guide students to make important mathematics and real-world connections.

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.)*

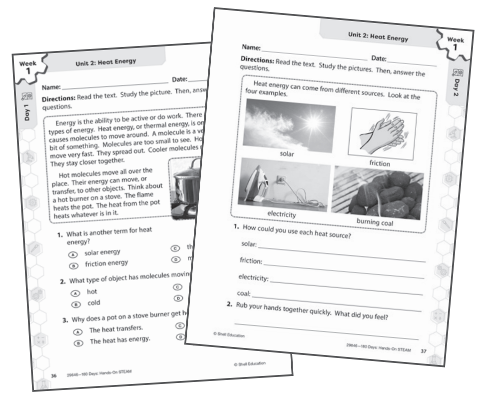
Assessment Options

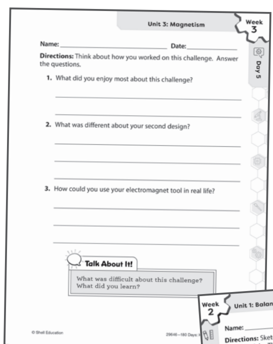
Assessments guide instructional decisions and improve student learning. This resource offers balanced assessment opportunities. The assessments require students to think critically, respond to text-dependent questions, and utilize science and engineering practices.

Progress Monitoring

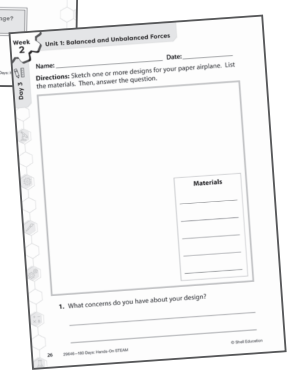
There are key points throughout each unit when valuable formative evaluations can be made. These evaluations can be based on group, paired, and/or individual discussions and activities.

- **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.

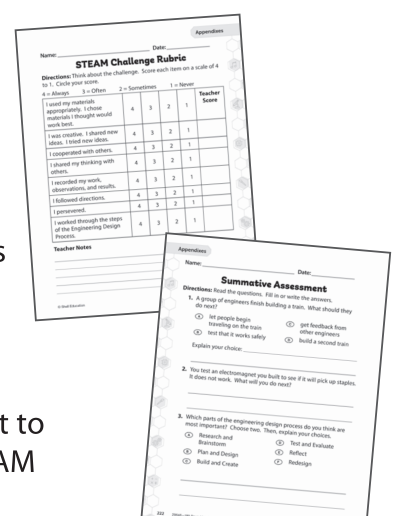




- **Talk About It!** graphics on student activity sheets offer opportunities to monitor student progress.



- **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 all the following NGSS Scientific and Engineering Practices and Engineering Performance Expectations for 3–5.

Scientific and Engineering Practices	Engineering Performance Expectations
Asking Questions and Defining Problems	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
Developing and Using Models	
Planning and Carrying Out Investigations	
Analyzing and Interpreting Data	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.
Constructing Explanations and Designing Solutions	
Engaging in Argument from Evidence	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.
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
Balanced and Unbalanced Forces	PS2.A: Forces and Motion PS2.B: Types of Interactions	Cause and Effect; Patterns
Heat Energy	PS3.B: Conservation of Energy and Energy Transfer	Energy and Matter
Magnetism	PS2.B: Types of Interactions	Cause and Effect
Patterns of Movement	PS2.A: Forces and Motion	Patterns
Adaptations	LS4.C: Adaptation	Cause and Effect
Animal Groups	LS2.D: Social Interactions and Group Behavior	Scale, Proportion, and Quantity
Changing Habitats	LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS4.D: Biodiversity and Humans	Systems and System Models
Life Cycle of Plants	LS1.B: Growth and Development of Organisms LS1.A: Structure and Function	Systems and System Models; Patterns
Fossils	LS4.A: Evidence of Common Ancestry and Diversity	Scale, Proportion, and Quantity
Pollution Problems	ESS3.C: Human Impacts on Earth Systems	Systems and System Models
Severe Weather Hazards	ESS3.B: Natural Hazards ESS2.D: Weather and Climate	Cause and Effect; Patterns
Measuring the Weather	ESS2.D: Weather and Climate	Patterns

Balanced and Unbalanced Forces Teaching Support

Overview of Unit Activities

Students will learn about and explore forces through the following activities:

- reading about balanced and unbalanced forces
- reading about and studying pictures showing different forces
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- drawing scenes showing forces that become unbalanced
- analyzing a diagram of forces acting on paper airplanes
- creating paper airplanes

Materials Per Group

Week 1

- basic school supplies
- chair or stepladder
- stopwatch

STEAM Challenge

- basic school supplies
- calculator
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- paper clips (2–3)
- tape measure
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Scaffolding and Extension Suggestions

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Answer Key

Week 1 Day 1

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2. B
3. B

Week 1 Day 2

1. When the game begins, Teams A and B will each pull on the rope and try to pull the other team into the mud puddle.
2. Team A will win. It has more people, so the force they use to pull the rope their direction will have more strength.

Week 1 Day 5

1. The plane will crash to the ground.
2. The plane will glide.

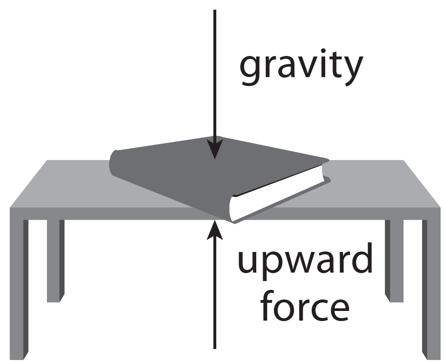
Weeks 2 & 3

See STEAM Challenge Rubric on page 221.

Name: ______________________ Date: ____________

Directions: Read the text, and study the diagram. Then, answer the questions.

A force is a push or a pull. Forces act on objects and cause them to be in motion or stay at rest. Imagine a book sitting on a table. The table and gravity are both forces acting on the book. Gravity is pulling the book down; the table is pushing the book up. But the forces are balanced, so the book does not move. If a person pushes on the book, another force has been introduced. The forces are now unbalanced, and the book moves across the table.



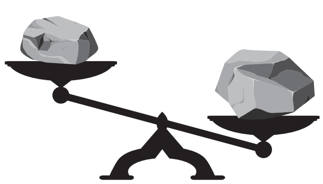
1. What is a force?

- (A) balance or unbalance
- (B) in motion or at rest
- (C) a push or a pull
- (D) action or inaction

2. What happens to an object with balanced forces?

- (A) Gravity pulls it down.
- (B) The object will stay at rest.
- (C) The force will change direction.
- (D) The object will move.

3. Are these forces balanced or unbalanced?

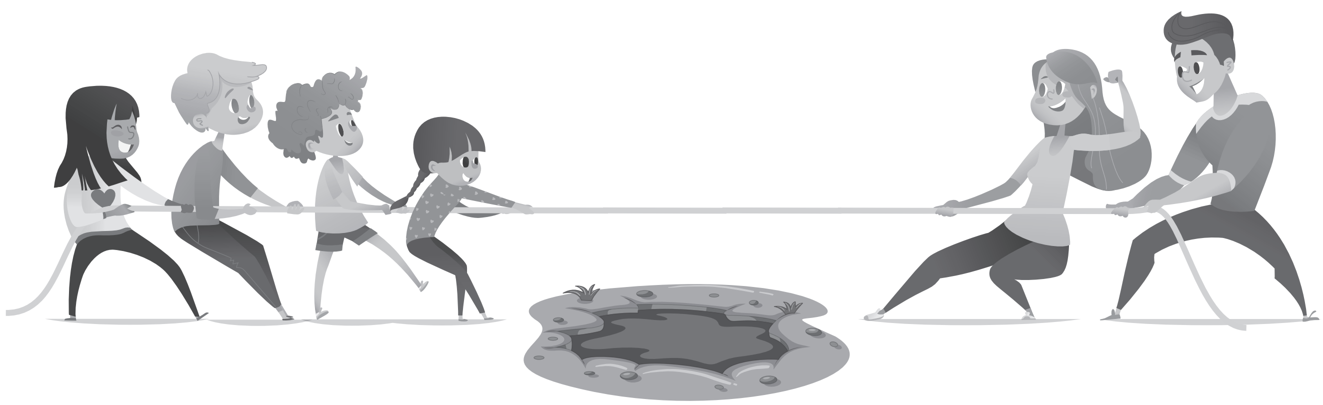


- (A) balanced
- (B) unbalanced

Name: ______________________________ Date: ______________

Directions: Read the text, and study the picture. Then, answer the questions.

Forces have both strength and direction. Imagine a soccer ball in the grass. The forces of the ground and gravity are balanced, and the ball is motionless. If someone kicks the ball, a new force is introduced, and the forces become unbalanced. Now the ball rolls across the grass. How far will it go? Where will it go? That depends on the strength and direction of the kick.



Team A **Team B**

1. What will happen when the tug-of-war game begins?

____

____

2. Who do you think will win the competition? Explain your answer using the words *force*, *strength*, and *direction*.

____

____

____

Name: ______________________________ Date: ______________

Directions: Follow the steps to experiment with air resistance. Then, answer the questions.

Steps

1. Get two sheets of paper, a stopwatch, and a chair or stepladder.
2. Crumple up one sheet of paper into a ball. Leave the other paper flat.
3. Stand on the chair or stepladder, raise your arm, and drop the paper ball. Use the stopwatch to time how long it takes to reach the ground.
4. Repeat step 3 with the flat sheet of paper.

1. How long did it take the paper ball to reach the ground? _______ Describe how it dropped.

   ____

2. How long did it take the flat paper to reach the ground? _______ Describe how it dropped.

   ____

3. Air resistance is also called *drag*. It is a force that slows down an object in the air. Which paper do you think had more drag? Why?

   ____

   ____

Name: ______________________ Date: ______________

Directions: Think of all the balanced forces around you. Imagine what would happen if some became unbalanced. Think about pictures on the wall, playing a sport, or eating a meal. Draw a fun, creative picture showing at least three "force mix-ups."