sphero blueprint™

educator guide

build CLASS PACK™

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Welcome

Sphero's mission is to inspire the creators of tomorrow. The creators of tomorrow are collaborative and communicative changemakers, working together as parts of efficient teams. The creators of tomorrow are problem solvers, helping humanity navigate the world's toughest challenges. The creators of tomorrow are engineers, designing new products and solutions to improve our world and our lives.

Our students, the creators of tomorrow, need a classroom tool to make engineering education come to life. Enter Sphero Blueprint.

IN EACH BLUEPRINT BUILD KIT:

- over 330 Blueprint parts
- quick start guide
- 5 engineering challenge cards
- storage bin

IN EACH BLUEPRINT BUILD CLASS PACK:

- 5 Blueprint Build Kits
- educator guide
- additional storage bin with bonus Blueprint parts

What's in This Guide

Blueprint Build Kits make engaging with mechanical and structural engineering hands-on, fun, and accessible to all. This guide will walk you through Blueprint's features and best practices for your classroom. Here's what you can look forward to:

Curriculum - While Blueprint can be integrated into a variety of STEM projects, you'll also be able to access curriculum specifically designed for Blueprint. This curriculum covers engineering basics and offers opportunities for students to create and build on their own.

STEM Classroom Strategies - Hands-on learning can create unique challenges in the classroom. This guide includes student group ideas, suggested preparation for lessons, assessment opportunities, and more.

Challenge Cards - Start using Blueprint right away in your classroom with fast, fun, and engaging challenges that can help students with the engineering design process and introduce them to Blueprint.

The Importance of Teaching Engineering with Blueprint

Solving problems is the foundation of engineering education. Blueprint allows students to quickly build, test, and learn engineering concepts in the classroom.

21ST CENTURY SKILLS

Blueprint is the perfect platform to help students develop the mindset and skills that are necessary to compete in a global, technology-rich 21st-century economy such as:

- problem solving
- iterative design
- analytical thinking
- collaboration
- communication

PROJECT-BASED LEARNING

Teaching and learning with Blueprint values quality over quantity, encouraging students to engage deeply with science and engineering concepts instead of simply memorizing vocabulary and facts. Project-Based Learning (PBL) can lead to:

- increased student engagement
- enhanced retention of content
- development of college and career skills

ENGINEERING FOR ALL

We need to prepare students for the future and the future needs engineers. At the same time, the engineering challenges of the future are complex. Diverse teams with diverse sets of backgrounds, perspectives, and skills are essential to finding the most innovative solutions. Yet, to our detriment, there are many groups of people who continue to be underrepresented in engineering occupations.

Blueprint can help make engineering engaging and accessible to all, attracting more students to engineering Career Technical Education (CTE) pathways and encouraging them to stick with it through graduation.

RELEVANT LEARNING

Blueprint encourages students to take a fresh look at the world around them through an engineering lens. Blueprint curriculum brings engineering to life by taking engineering fundamentals and tying them to each of the following:

- **Engineering careers:** Get a hands-on understanding of mechanical, civil, and electrical engineering fields.
- **Historical engineering successes:** Revisit and learn from the feats of past engineers.
- **Engineering Grand Challenges:** Apply your learning toward the biggest challenges facing our species and our planet in the coming century.

Standards Alignment

Using Blueprint alongside the engineering design process provides for rich and meaningful standards-based learnng in STEM and Engineering classes and beyond.

Next Generation Science Standards (NGSS)

The Sphero Blueprint Engineering Design Process outlined later in this guide adheres closely to the eight Science and Engineering Practices (SEP) identified in the Next Generation Science Standards (NGSS). The SEPs are essential for helping our students "investigate the world and design and build systems."

SCIENCE AND ENGINEERING PRACTICES

- **Practice 1:** Asking Questions and Defining Problems
- **Practice 2:** Developing and Using Models
- **Practice 3:** Planning and Carrying out Investigations
- **Practice 4:** Analyzing and Interpreting Data
- **Practice 5:** Using Mathematics and Computational Thinking
- **Practice 6:** Constructing Explanations and Designing Solutions
- **Practice 7:** Engaging in Argument from Evidence
- **Practice 8:** Obtaining, Evaluating, and Communicating Information

LEARN MORE ABOUT THE NGSS SCIENCE AND ENGINEERING PRACTICES.

sphero.cc/730ee5

Additionally, working through engineering problems with Blueprint aligns with NGSS Disciplinary Core Ideas (DCI) for Engineering Design.

MIDDLE SCHOOL ENGINEERING DESIGN

sphero.cc/6c1505

HIGH SCHOOL ENGINEERING DESIGN

sphero.cc/11ab20

Standards for Technological and Engineering Literacy (STEL)

The International Technology and Engineering Educators Association (ITEEA) recognized that STEM education efforts frequently promote science and math instruction over technology and engineering, and developed their own set of standards. The Standards for Technological and Engineering Literacy (STEL) focus less on discrete facts and more on knowing, thinking, and doing. With Blueprint, students will actively engage with the following STEL core standards:

- **01** Nature and Characteristics of Technology and Engineering
- **02** Core Concepts of Technology and Engineering
- **03** Integration of Knowledge, Technologies, and Practices
- **04** Impacts of Technology
- **05** Influence of Society on Technological Development
- **06** History of Technology
- **07** Design in Technology and Engineering Education
- **08** Applying, Maintaining, and Assessing Technological Products and Systems

LEARN MORE ABOUT STEL

sphero.cc/8b448f

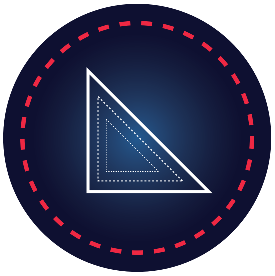
Cross-Curricular Standards

While working through open-ended engineering design problems with Blueprint, students will utilize and develop skills across disciplines. Consider the examples in the following subject areas:

LANGUAGE ARTS

reading and writing about engineering problems and their solutions

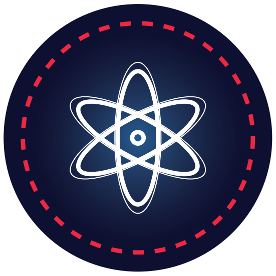
FOR EXAMPLE: *students conduct research to better understand a problem and relevant background information, then use their written and oral communication skills to explain and share their solutions with others.*



MATH

applying grade-appropriate math to better design, define, and describe their engineering solutions

FOR EXAMPLE: *students use ratios to calculate the mechanical advantage of a simple machine to describe the change in the magnitude of force required to complete the movement.*



SCIENCE

integrate concepts from across the science disciplines from physical to environmental sciences

FOR EXAMPLE: *in designing simple machines, students deconstruct how energy changes form in mechanical systems through hands-on exploration.*

Blueprint Resources

The Blueprint resources page provides ready-to-go lessons and unit plans to get started with using Blueprint Build Kits in the classroom.

BLUEPRINT RESOURCE WEBPAGE

sphero.cc/BPresources

On this webpage, you will find the following:

- unit overviews
- teacher instructional guides
- teacher instructional slides
- build instructions for Blueprint lessons
- student handouts

Unit and Lesson Structure

Blueprint units and lessons are designed to be flexible so you can use them in the way that best fits your classroom and the needs of your students. Depending on how much time you have and what concepts you need to teach, you can either follow our suggested sequences or pick and choose which lessons will work best for you.

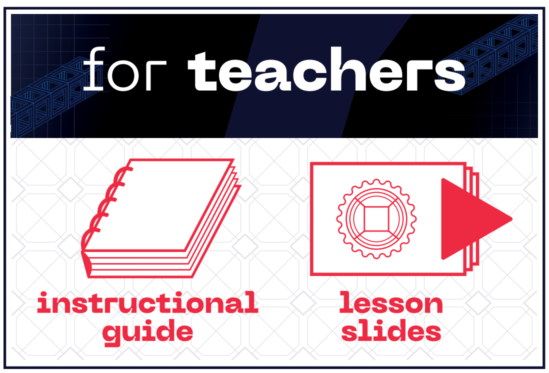
Each Blueprint unit consists of three types of lessons. These can be used in any order you want.

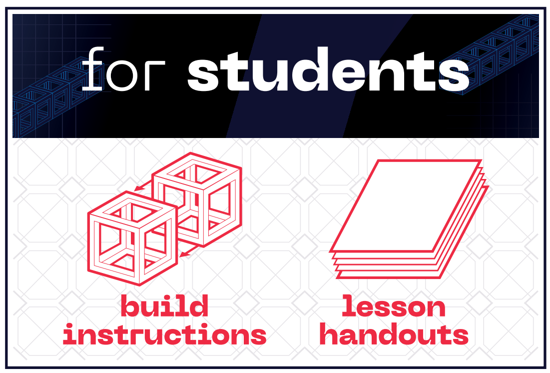
01 level 1 FOUNDATION	02 level 2 EXPLORATION	03 level 3 CREATION
• designed for one class period • introduction to an engineering concept • quick builds with instructions	• designed for one to two class periods • in-depth exploration of engineering concepts • open-ended builds with some support to get started • content connections to historical engineering, emerging tech, and career connections	• designed for up to one week of class time • connections between multiple engineering concepts to serve as an end-of-unit project • open-ended builds using the engineering design process

Each lesson is separated into easy-to-follow sections that may include:

- LAUNCH - Engaging students with an attention grabber
- CONSTRUCT - Building from build instructions
- INTERACT - Gathering information from builds
- CONNECT - Connecting concepts with careers, historical contexts, or emerging tech
- INVENT - Building through the engineering design process
- SHARE - Presenting final solutions
- THINK - Reflecting on learning
- EXPAND - Extending learning with ideas for additional activities

Each lesson for Blueprint will come with a variety of resources to help you successfully execute it in your classroom:





If you want to use the entire unit, it is recommended that you start with a Level 1 Foundation lessons and then complete the Level 2 Exploration lessons for related topics. Once all Foundation and Exploration lessons have been completed in a unit, you can move to the Level 3 Creation lesson. However all lessons are written so that they can stand alone so you can use them in your classroom as you wish, you know best!

The real engagement comes when you use Blueprint in your classroom for new lessons and projects that you create. Have fun and let your students see their ideas come to life.

WHY DO WE USE THE METRIC SYSTEM FOR BLUEPRINT?

The metric system provides a universal standard of measurement that is used in science, technology, engineering, and math around the world. Blueprint pieces were designed with friendly metric measurements to make calculations straight forward, like for mechanical advantage.

Unit Plan: Simple Machines

Level: Middle and High School Introduction to Engineering Courses

Time Required: 2 weeks to 1 month

Simple machines, such as inclined planes, pulleys, gears, and linkages—form the foundation of a mechanical engineer's toolkit. Each simple machine creates mechanical advantage by changing the direction and/or magnitude of force and makes it easier to do work. In this unit, students explore all of the simple machines through hands-on exploration and application, investigating how to use mechanical advantage to our advantage in machines seen every day in the world around us.

BY THE END OF THE UNIT, STUDENTS WILL BE ABLE TO:

- identify and explain the function of each simple machine
- build working models of each simple machine
- calculate the ideal mechanical advantage (IMA) in their mechanical systems
- combine multiple simple machines into a compound machine to complete a task

GET UNIT RESOURCES

sphero.cc/BPsimplemachines

Unit Plan: Carnival Builds

Level: Middle and High School Introduction to Engineering Courses

Time Required: 2 weeks to 1 month

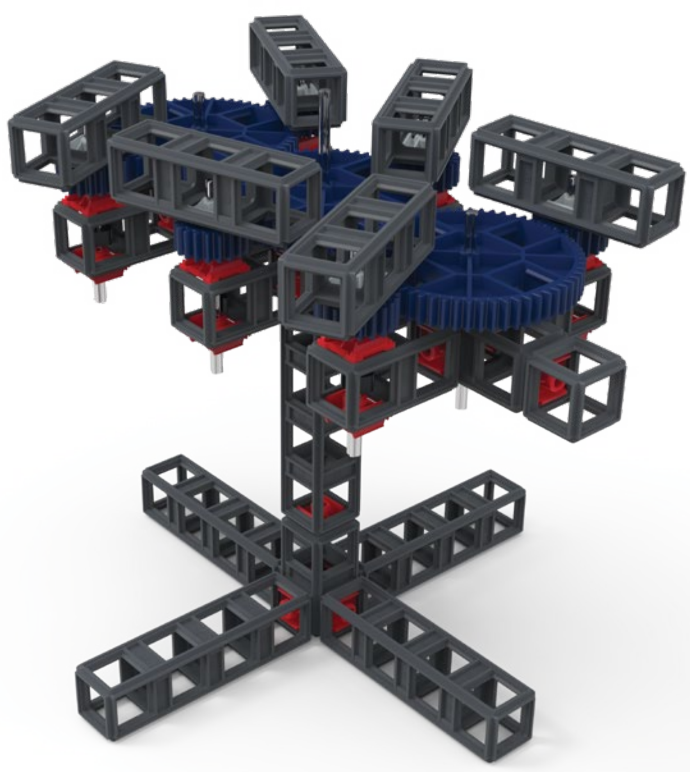
Transform your classroom into a carnival using Blueprint. Carnival rides and games are fun, interactive, and also feature a variety of mechanical concepts. In this unit, students will explore what drives their favorite parts of a carnival while continuing to build and experiment with simple and compound machine concepts.

BY THE END OF THE UNIT, STUDENTS WILL BE ABLE TO:

- identify and explain how different simple and compound machines are used in carnival rides and games
- build models of mechanical systems from different carnival elements
- investigate how different simple machines enable carnival rides and games to function safely and correctly
- calculate ideal mechanical advantage (IMA) in simple and compound machines

GET UNIT RESOURCES

sphero.cc/BPcarnivalbuilds



Managing Students' Learning with Blueprint

Grouping Students

Each Blueprint Build Kit contains enough parts to create large machines and structures from build instructions or students' imaginations. The ideal group size is two to three students. Students working independently will miss the collaborative aspects of the engineering design process. Students working in groups larger than three will have fewer opportunities for hands-on building.

Assigning roles can help students focus their efforts and be part of an effective team. If you do not already have group roles in your engineering classroom, consider the following ideas:

Team Lead: The Team Lead is a project manager, responsible for ensuring that the group stays on task and on schedule. The Team Lead does not boss others around; instead, they are an actively involved group member that leads their group through the engineering process.

Technician: The Technician is the builder, responsible for prototyping, testing, and refining structures and machines. Teams with four students may decide to have more than one Technician to split up the building responsibilities.

Recorder: The Recorder is the documentarian and reporter, responsible for capturing the group's research, engineering process, prototypes, and final designs. The Recorder also leads communication efforts to share their process, findings, and results with a larger audience.

While students will naturally gravitate toward roles that they are most comfortable with, consider rotating roles to give students practice with each role so that they can experience the engineering design process from different perspectives.

At the end of each lesson or project, ask students to reflect on their role.

- *What did they do well in the role?*
- *What about the role was difficult?*
- *What could they improve on the next time?*

Providing structured opportunities for students to analyze their performance within a role will help students create and follow through with their goals.

Planning a Successful Lesson

As previously mentioned, Blueprint lessons can be used in a suggested sequence or can exist as stand-alone lessons. Consider the following steps to prep for each lesson:

01 **Review**: Read through each lesson completely, including educator tips. Specifically look for: math, physics, or other concepts that students may need to review before starting the lesson. Identify parts of the lesson that you may need to eliminate, or the EXTEND portions of lessons that you may want to complete based on the abilities of your students.

02 **Build**: Building with instructions or creating your own solution to design challenges will help you anticipate challenges your students may have. If possible, have a sample build set up on the day of the lesson to give students a tangible example of something they might create.

03 **Plan for student management**: Decide how you will group students. See the section on grouping students for suggestions. Anticipate that some groups will move faster than others. If possible, prepare for which groups may need extra support and be ready to offer more support to them throughout the lesson.

Building and Extending Confidence with Blueprint

Students approach engineering lessons differently. Some students may be hesitant to jump in, while other students are ready to start creating before you even finish talking.

01 For students with low confidence in engineering and working with Blueprint, make sure you start small. Help develop confidence in building with Blueprint by starting with challenge cards and Level 1 lessons. Remember to continuously emphasize that there are a lot of ways to build things and trying and failing only gets you closer to success. Monitoring groups to ensure everyone is interacting and building with Blueprint is important for these students.

02 Allow students with experience and confidence to create and build with Blueprint to take it to the next level. Encourage them to improve and refine their designs. Review the EXTEND sections of lessons and use them to deepen learning for higher-confidence students. You can also have students do peer reviews of designs; have them help each other come up with ideas and improvements.

Engineering Design Process

Bringing Blueprint into your classroom challenges students to think like engineers. They'll practice and refine a systematic process that works for them when tackling open-ended problems. The iterative process values asking questions, defining constraints, and conducting research before learning from failure to create innovative and tested solutions.

The Sphero Blueprint Engineering Design Process, based on the engineering design process from teachengineering.org at the University of Colorado Boulder, is a model with a low floor and high ceiling which can be used to tackle age-appropriate problems all the way from the middle school STEM classroom through engineering careers.

ASK QUESTIONS
Start by asking questions to define the problem and its constraints.

RESEARCH THE PROBLEM
Learn from the experiences and expertise of others.

IMAGINE POSSIBLE SOLUTIONS
Brainstorm as many solutions as possible.

PLAN A SOLUTION
Determine which idea best meets the design requirements and constraints.

BUILD A PROTOTYPE
Create and test your solution.

TEST AND ITERATE
Evaluate, improve, and refine until your solution effectively and elegantly solves the problem.

COMMUNICATE THE RESULTS
Share your solution with others clearly and thoroughly.

Engineering Notebooks

Many engineering teachers choose to have students keep an engineering notebook during the school year. Learning how to structure and continuously document your work is a skill that every engineer needs. Engineering notebooks are often used in the workplace to document projects in case of personnel changes and to serve as documentation for patent purposes.

The Blueprint system is designed to make it easy to iterate and test designs quickly in the classroom, so students can advance through the engineering design process. This creates a great opportunity to practice documentation with an engineering notebook.

However, keeping an engineering notebook might not be right for every classroom. If you decide that engineering notebooks are right for your classroom use the Engineering Design Process steps as a guide to help students organize their thoughts. There are many public resources on this topic as well, if you want to explore further in your classroom.

Blueprint Engineering Challenge Rubric

Rubrics can help you assess student work with Blueprint, including the quality of their final product as well as their use of the engineering design process. The Blueprint Engineering Challenge Rubric can be used with the Engineering Challenge Activities in this educator guide. It can also be used with the Blueprint curriculum and any other classroom design challenges you create. Modify and adapt the rubric to suit the objectives of an activity and to meet the needs of your students.

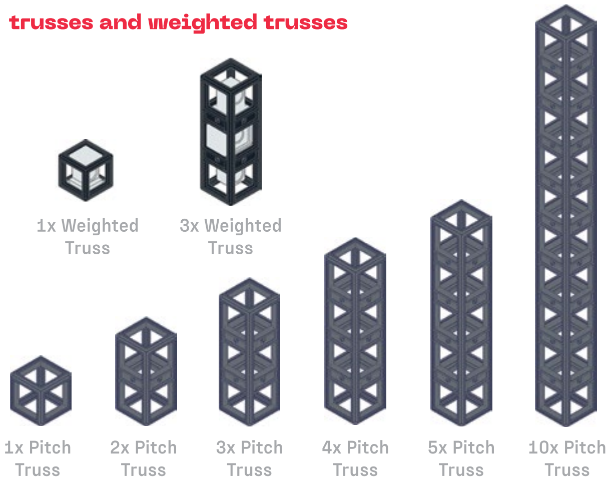
BLUEPRINT RUBRIC

sphero.cc/BPrubric

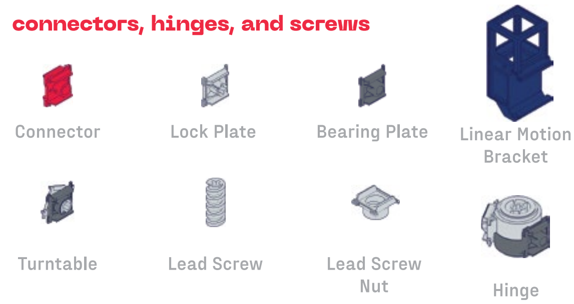
Getting Started

Blueprint Build Kit Inventory and Part Identification

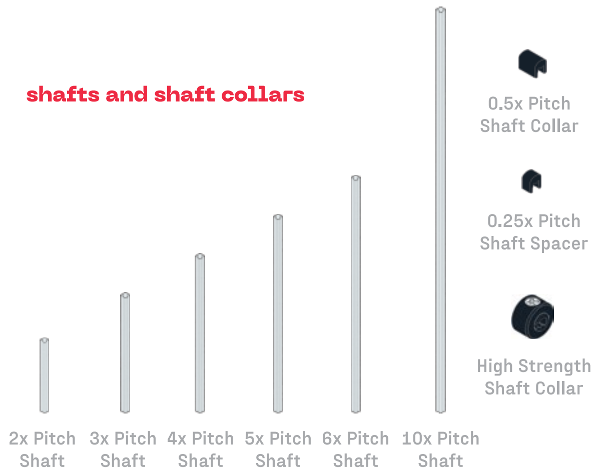
trusses and weighted trusses



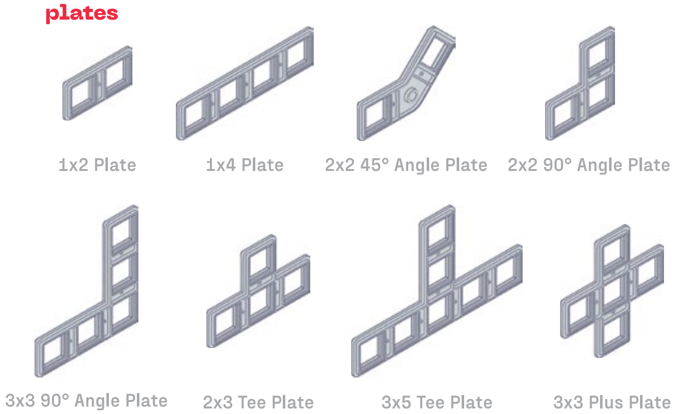
connectors, hinges, and screws



shafts and shaft collars



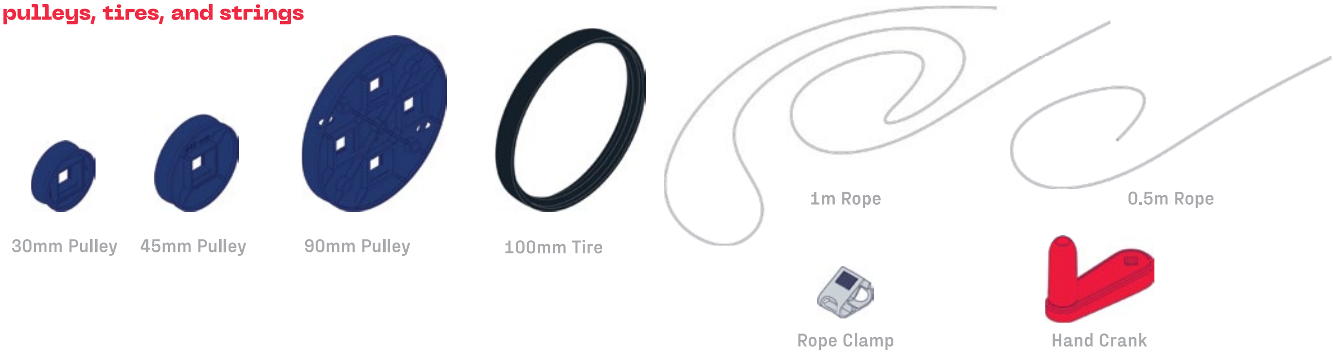
plates



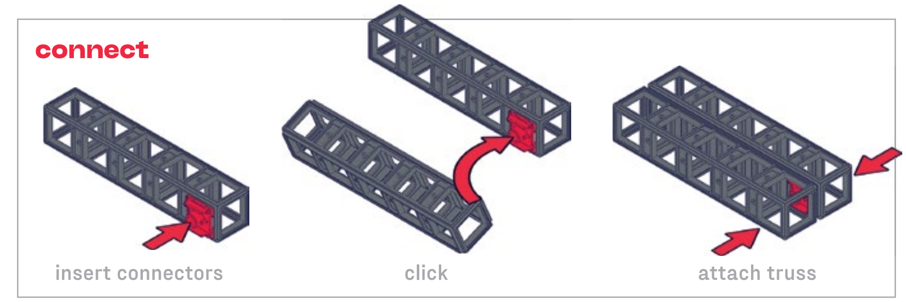
gears

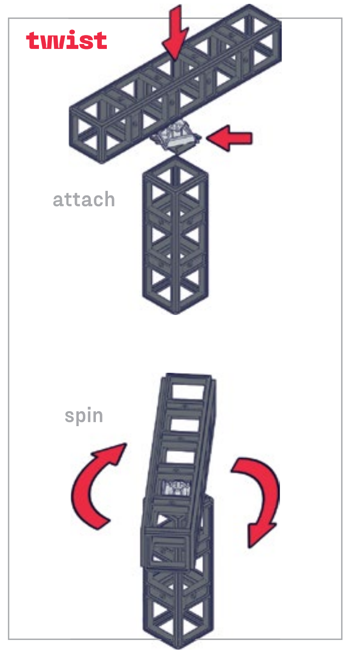
removal tool

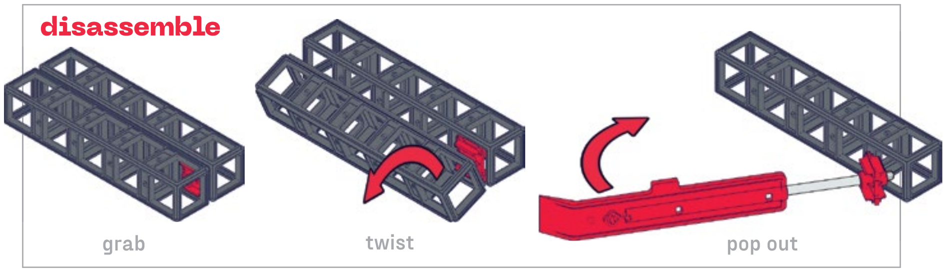
pulleys, tires, and strings

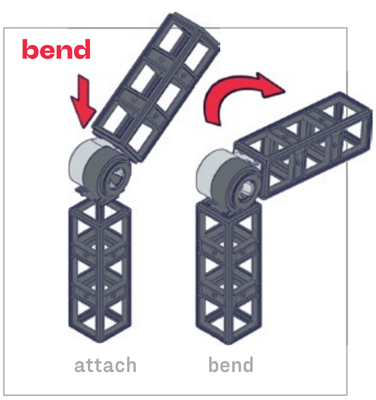


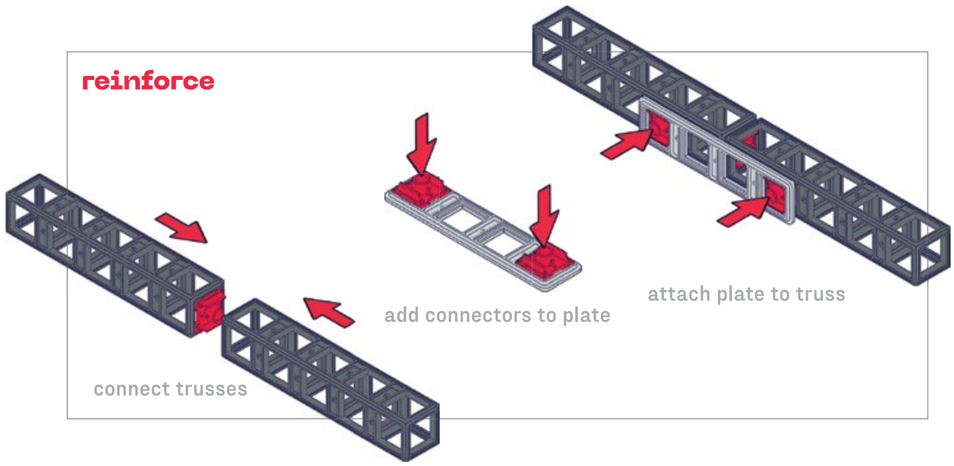
Key Building Practices

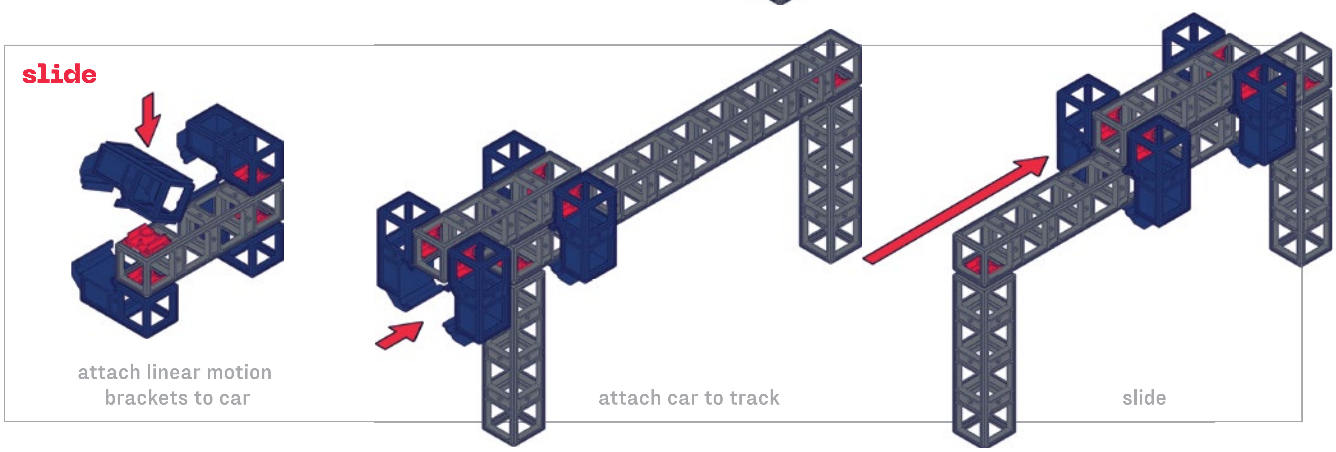






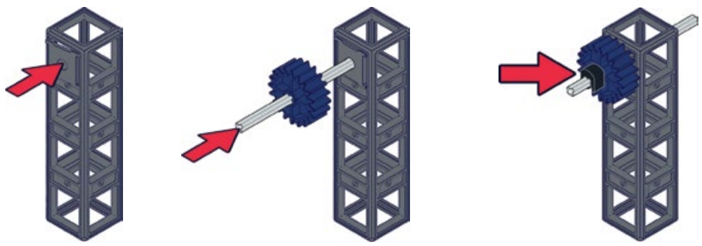






Key Building Practices Continued

gear

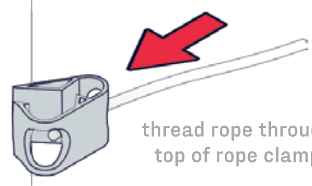


attach bearing plate to truss

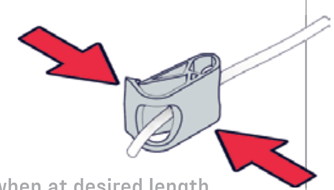
insert shaft into bearing and through center of gear

place a shaft collar on shaft

rope clamp

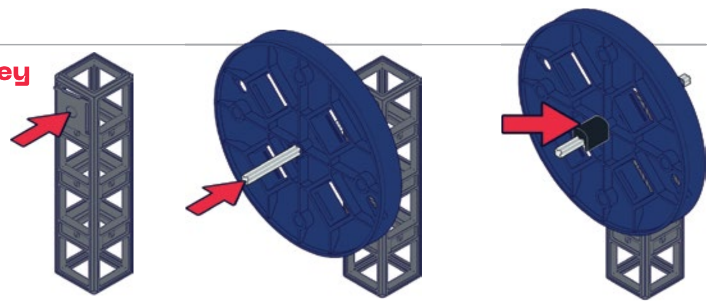


thread rope through top of rope clamp



when at desired length, close clamp

pulley

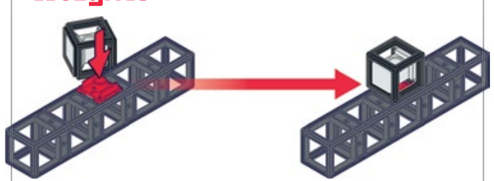


attach bearing plate to truss

insert shaft into bearing and through center of pulley

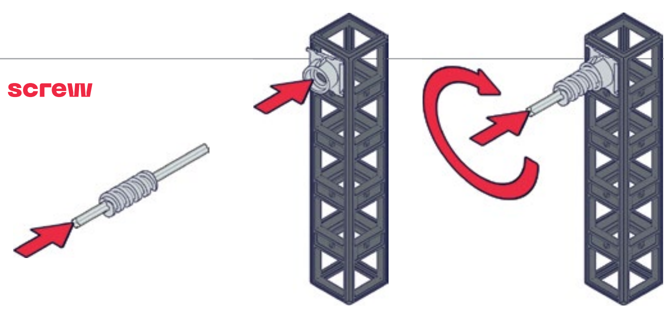
place a shaft collar on shaft

weights



Snap directly to trusses

screw

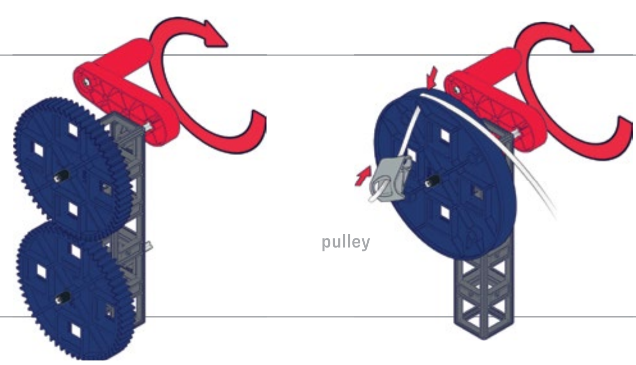


insert shaft through one or more lead screws. use dots on lead screws to align threads.

snap screw nut into truss

twist lead screw to insert into screw nut

create motion



Storage and Organization

Each Blueprint Build Kit is designed to keep all the parts organized so they are easy to inventory and always ready for the next project.

When teaching lessons with Blueprint, make sure to reserve 5-10 minutes at the end of the session to disassemble, clean up, and store each kit. Establish a location in your classroom, lab, or learning space to store builds in progress.

Student kits are stackable, meaning you can easily and neatly store kits on a countertop or in a corner of your classroom.

Care and Maintenance

Blueprint parts are strong and durable. However, you can protect parts from accidental loss and ensure they last by establishing the following routines with students:

- Check the floor around your workspace for parts so that they aren't stepped on or smashed by a chair leg.
- When possible, keep small parts like the Connectors, Lock and Bearing Plates, Hinges, and Turntables in a pocket in the kit tray.
- Always clean up and close kits at the end of a session.

If you find a cracked connector or truss, set it aside so it isn't used in a future build.

Inevitably, kit materials will become mixed amongst different kits. Periodically, use the digital kit contents sheet to inventory the parts with students and make sure every student kit is complete at the beginning or end of a semester.

DIGITAL KIT CONTENTS SHEET

sphero.cc/BPbuildkitcontents

Engineering Challenge Activities

Use the following five challenges to introduce your students to building with Blueprint and the engineering design process. Each challenge is designed to give students hands-on experience with Blueprint parts and provide an opportunity for students to work as a team to address open-ended challenges. These challenges are also opportunities to develop engineering design standards as outlined in NGSS and STEL.

Each challenge consists of three parts:

- **Challenge Cards** - Instructions to get students started with the challenge (included with each Blueprint Build Kit)
- **Teaching Guides** - Instructional steps to help you facilitate each challenge with students (included in this Educator Guide)
- **Student Handouts** - Optional resources to help students document and think through the challenge (linked from the Teaching Guides)

The challenges are flexible and can be used in a variety of classrooms with a variety of time constraints.

- **If you have a 45-60 minute class period,** use the Challenge Cards included in the Blueprint Build Kits and focus on quick builds to familiarize students with the Blueprint materials.
- **If you have two or more class periods,** deepen the activity by integrating the engineering design process into the challenge. Use the suggestions in the teaching guides and distribute the optional student handouts to help focus and organize student work.

Consider three possible usage scenarios:

AS AN INTRODUCTION:

Launch your engineering class with one or more of the design challenges. Encourage students to get to know their Blueprint kit as well as work through the engineering design process.

AS A TEAMBUILDING BREAK:

Do your students need a day for fun—outside the normal routine? Try using a challenge before a long weekend or holiday break for an engaging way to help develop class relationships and engineering skills.

AS A MENTORSHIP:

Allow your engineering students to introduce Blueprint to younger students by guiding them through a design challenge. Have your students introduce engineering terminology and the design process.

Each challenge can be used either as informal classroom learning or a more formal graded assignment. The Blueprint Engineering Challenge Rubric can be used to assess student work and can be expanded if there are other items you would like to add.

challenge #1

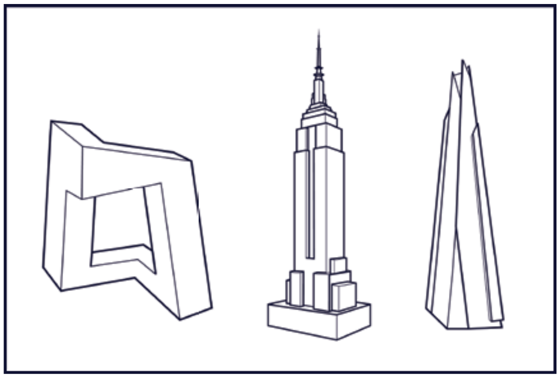
iconic skyscrapers

Overview: Nowadays, a regular tall building doesn't seem sensational enough for a skyscraper. So, architects and civil engineers try to take their creativity to the next level to build the most spectacular building possible. In this challenge, students will use Blueprint to build a model of iconic skyscrapers. In the process, they will learn about building with Blueprint and practice working as part of a team.

LEARNING OBJECTIVES

By the end of this session, students will be able to:

- build a model structure with Blueprint
- follow engineering design steps to build and refine a model
- share their process and results with their classmates

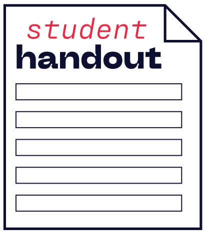


MATERIALS

- Blueprint Build Kits
- Iconic Skyscraper Challenge Card

ICONIC SKYSCRAPER STUDENT HANDOUT (OPTIONAL)

sphero.cc/bpc1sh



PREPARATION

01 Decide how much time you will dedicate to the challenge, anywhere from one day to one week.

02 Preview the challenge and experiment with Blueprint ahead of time to anticipate student challenges.

03 Review the Iconic Skyscraper Student Handout. Then decide whether students will use it to document the process and their thinking throughout the challenge.

04 Consider whether there are other buildings from units of study or in your community, city, or country that you'd like students to construct.

05 Divide students into groups of 2-4. Ensure each group has access to a Blueprint kit and a clear work surface. Structures with a base larger than 60 cm × 60 cm (24" × 24") will be more challenging to transport and store between classes.

Challenge Steps

launch

Introduce the challenge and review the three suggested skyscrapers with students to capture their interest.

Use the Iconic Skyscrapers Student Handout to walk through the challenge with students.

Share the time constraints with students. For a 45-minute class period, consider suggesting:

- select, research, and plan: 10 minutes
- build and iterate: 25 minutes
- communicate: 10 minutes

If you are extending the challenge into a multi-day activity, share time guidelines with students to help them manage their time.

support

As students work, circulate and support them with the challenge.

If you see students overwhelmed with building a large structure,
then prompt students to start by building a two-to three-story building they may have seen in their community.

If you see students struggling to get started,
then suggest that they start by building the base of the building.

If you see students with toppling structures,
then show students how to build sturdy bases and use plates to reinforce truss connections. Weights can also be added to bases to make student models more stable.

extend

To increase the rigor of the design challenge, ask students to try some or all of the following:

- build their model to scale
- include at least one movable part on their skyscraper model
- document their process, including their research, planning, and design solutions in an engineering notebook

share

Reserve 5-10 minutes at the end of your session for students to share their models. Remind students to communicate:

- how their model represents their chosen structure
- how their group overcame obstacles
- what they learned about building with Blueprint

assess

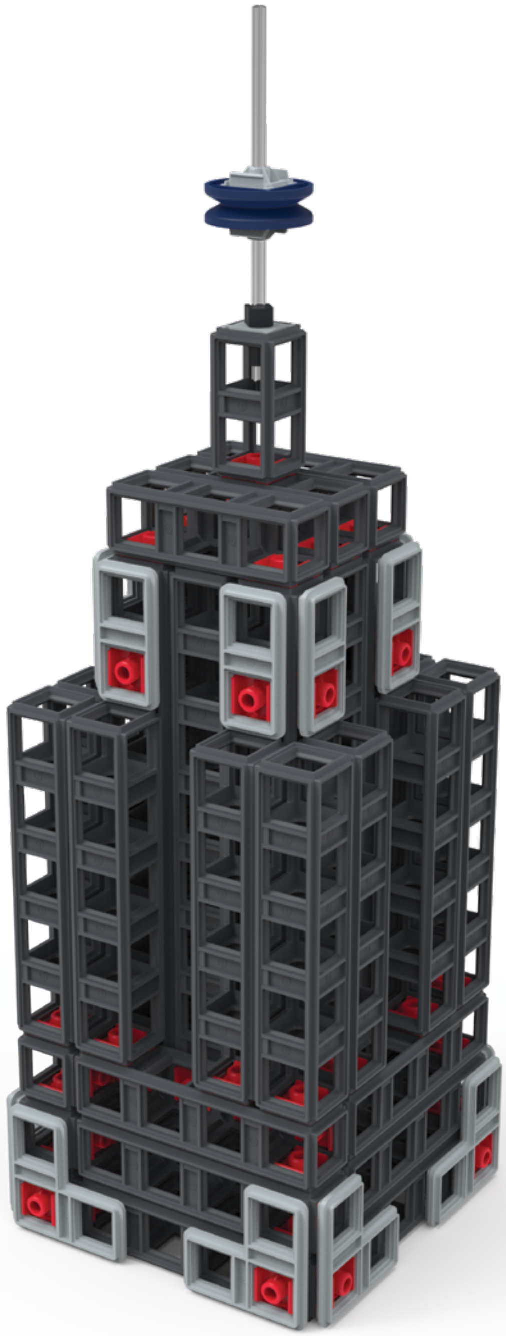
Consider the following questions as you observe students throughout the session:

- How did students work together as part of a team? Did they listen to each other and share responsibilities? Did certain students assume leadership roles?
- Did students use their time wisely for research, planning, and then building and iterating?
- What were students' primary struggles while building with Sphero Blueprint?
- Were students able to share their model clearly and concisely?

Then, consider what support students will need in future design challenges.

Optionally, use the Sphero Blueprint Engineering Challenge Rubric to assess student performance during the challenge.

Build Example



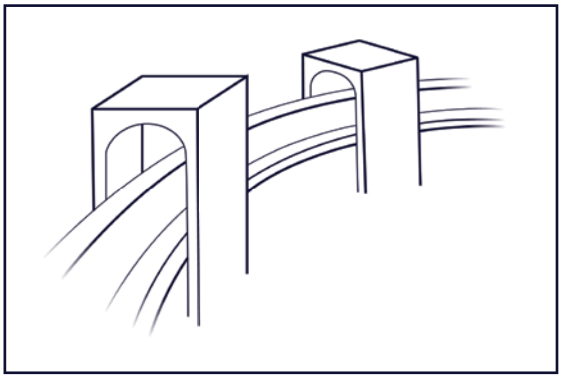
bridging the gap

Overview: Get ready to bridge the gap between design and construction! Students will put their design skills to the test and construct a Blueprint bridge that can support the weight of four textbooks (up to 10kg).

LEARNING OBJECTIVES

By the end of this session, students will be able to:

- build a structure with Blueprint to hold weight and use the least amount of parts
- follow engineering design steps to build and refine the structure
- share their process and results with their classmates



MATERIALS

- Blueprint Build Kits
- Bridging the Gap Challenge Card

BRIDGING THE GAP STUDENT STUDENT HANDOUT (OPTIONAL)

sphero.cc/bpc2sh

student handout

PREPARATION

01 Decide how much time you will dedicate to the challenge, anywhere from 1-3 days.

02 Preview the challenge and experiment with Blueprint ahead of time to anticipate student challenges.

03 Review the Bridging the Gap Student Handout. Decide whether students will use it to document the process and their thinking throughout the challenge.

04 Select objects to test the strength of the Blueprint bridges. Textbooks are a great option, and around four (approximately 10 kg) would be an ideal weight.

05 Divide students into groups of 2-4. Ensure each group has access to a Blueprint kit and a space that will be large enough to accommodate structures that are about 60 cm × 15 cm (24” × 6”).

Challenge Steps

launch

Introduce the challenge to students. Students will use Blueprint to construct a bridge to hold up to four textbooks (approximately 10 kilograms) and get the highest score. The bridge must:

- only contain connectors, trusses, and plates
- be at least 5 pitches above the ground
- include a span that is at least 12 pitches long and 2 pitches wide with no support underneath

Your score will be determined using the following guidelines:

- every team starts with 100 points
- every Blueprint part used deducts points from your score
- Connectors (-1 points)
- each truss pitch (-2 points)
- each plate pitch (-3 points)

Show students the textbooks or other weights you have chosen to use, and let them interact with them before building.

Blueprint parts are very strong. However, do not let students put excessive weight, like a student's body weight, on top of their bridges. Blueprint parts could break and students could hurt themselves.

Review the engineering design process. If you are using the Bridging the Gap Student Handout, talk through the steps and reinforce that these are all important engineering practices.

Share the time constraints with students. For a 45-minute class period, consider suggesting:

- select, research, and plan: 10 minutes
- build and iterate: 25-30 minutes
- compete: 5-10 minutes

If you are extending the challenge into a multi-day activity, share time guidelines with students to help them manage their time.

support

As students work, circulate and support them with the challenge.

If you see students that are overwhelmed by building a large structure,
then prompt students to start by making a structure that only spans half the distance first.

If you see students with weak connections between trusses,
then show students how to reinforce connections with plates.

If you see students struggling to get started,
then suggest that they start by building the base on each side, then figure out how to connect them.

extend

Depending on your students' level and available class time, consider some of the following ideas to increase the rigor of the design challenge:

- Increase the height and span length requirements to make the bridge design more challenging.
- Require students to document design flaws they encounter and their solutions.

share

Reserve five minutes for students to test their bridges. Distribute your textbooks or other weights and have students test their bridge strength all at once. If you want students to test them one by one in the front of the class, plan for more time. Do not place more than approximately 10 kilograms on top of the Blueprint bridges.

assess

Consider using the Sphero Blueprint Engineering Design Challenge Rubric to assess each group's process and product for this challenge. Additionally, you may want to ask students the following questions to encourage them to reflect on what they learned about building with Blueprint and constructing bridges:

- *What were common weak spots in your bridge designs? How did you reinforce these weak spots?*
- *If you were to build a new bridge tomorrow, what would you do differently?*
- *How did your team work well together? What could you do better the next time?*

Build Example

challenge #3

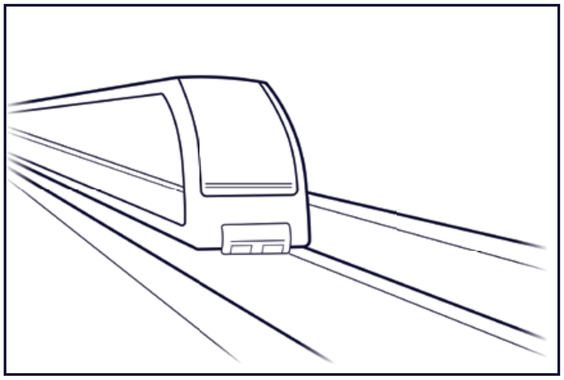
blueprint monorail

Overview: Monorails, or single-track railways, are not just in people's imaginations, they are used in cities worldwide to transport people and freight. In this challenge, students will use Blueprint Linear Motion Brackets and weighted trusses to design and build a monorail car that will transport passengers from one end of a track to the other.

LEARNING OBJECTIVES

By the end of this session, students will be able to:

- construct a powered monorail car to meet design constraints and criteria
- follow the engineering design process to build and refine their car
- share their process and results with their classmates

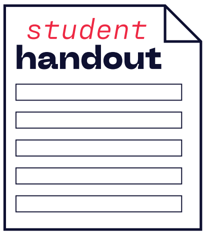


MATERIALS

- Blueprint Build Kits
- rubber bands (optional)
- Blueprint Monorail Challenge Card

BLUEPRINT MONORAIL STUDENT HANDOUT (OPTIONAL)

sphero.cc/bpc3sh



PREPARATION

01 Decide how much time you will dedicate to the challenge, anywhere from 1-3 days.

02 Preview the challenge and experiment with Blueprint ahead of time to anticipate student challenges. Decide whether you want students to try the extended challenge and power their monorail car with a rubber band or other means.

03 Review the Blueprint Monorail Student Handout. Decide whether students will use it to document the process and their thinking throughout the challenge.

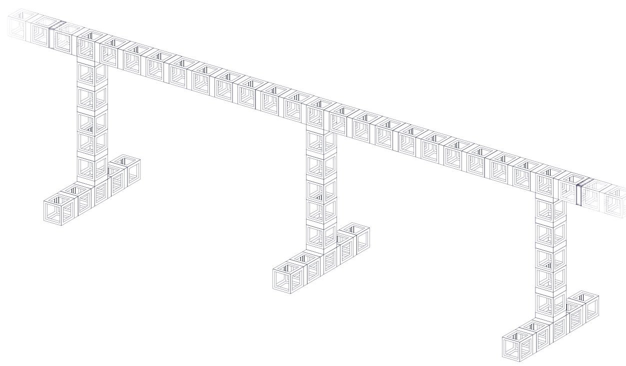
04 Build an example of the 60 pitch monorail track shown and the 5 pitch monorail car base to show students.

05 Divide students into groups of 2-4. Ensure each group has access to a Blueprint kit and plan for spacing to accommodate monorail tracks 60 pitches in length (1.5 meters or approx. 5 feet).

Challenge Steps

launch

If possible, show students examples of monorails to familiarize them with what they will be constructing.



Show the example of the monorail track. Then give students five minutes to construct their own.

- Attach four 10x Pitch Trusses end to end with Connectors.
- Reinforce the connections between the trusses with 1x2 Plates
- Elevate the track off the surface with T-shaped supports built from two 5x Pitch Trusses every 10 pitches along the track.

Explain the challenge. Students will design and construct a monorail car. The car must:

- use Linear Motion Brackets to connect to a 40 pitch track
- hold at least 10 passengers, each represented by a pitch on a weighted truss
- include a space for the conductor (another 1x Pitch Weighted Truss) separated by 1 pitch in all directions, including diagonals from passengers

If you are asking students to try the extended challenge, share and discuss the self-powered car constraint: use a rubber band, or other power source to glide from one end of the track to the other end of the track without falling off the end.

As needed, discuss the constraints to ensure students have a clear understanding of the task.

p	p	p	p	p	
p	p	p	p	p	c
p	p	p	p	p	

NOT OK ⊗
Passengers too close to conductor

p	p	p	p	p		
p						c
p	p	p	p	p		

NOT OK ⊗
Not 15 passengers

p	p	p	p	p		
p	p	p	p	p		c
p	p	p	p	p		

OK ✓

Review the engineering design process. If you are using the Blueprint Monorail Student Handout, talk through the steps and how students can use them to organize and document their design process.

Share the time constraints with students. For a 45-minute class period, consider suggesting:

- plan: 10 minutes
- build and iterate: 25 minutes
- compete: 10 minutes

If you are extending the challenge into a multi-day activity, share time guidelines with students to help them manage their time.

support

As students work, circulate and support them with the challenge.

If you see students struggling to attach their car to the track,
then show students how to attach a 5x Pitch Truss with 4 Linear Motion Brackets to the track. They can use this as the base for their monorail car base.

If you see students students with unbalanced weights on their monorail cars,
then ask students to compare how cars glide with even vs. uneven weight distribution.

If you see students students struggling to power their monorail cars,
then show them examples of how to power the car with a rubber band or with a balloon to start their brainstorming. Refer to the build examples at the end of the activity for ideas.

extend

Depending on the level of your students and your available class time, consider some of the following ideas to increase the rigor of the design challenge:

- Many monorail systems have two tracks to accommodate two cars traveling in opposite directions. Challenge students to add a second track for a second monorail car.
- Increase the length of the track from 40 to 80 pitches. Students will need to adjust their power source to accommodate the longer track.
- Ask students to decrease and increase the number of passengers and investigate how weights affect the glide of their monorail car. Can they graph the relationship between car weight and glide distance?

share and compete

Reserve 10 minutes for students to share their monorail cars and test their performance against their peers.

Ask students to bring their tracks and their monorail cars to a central location.

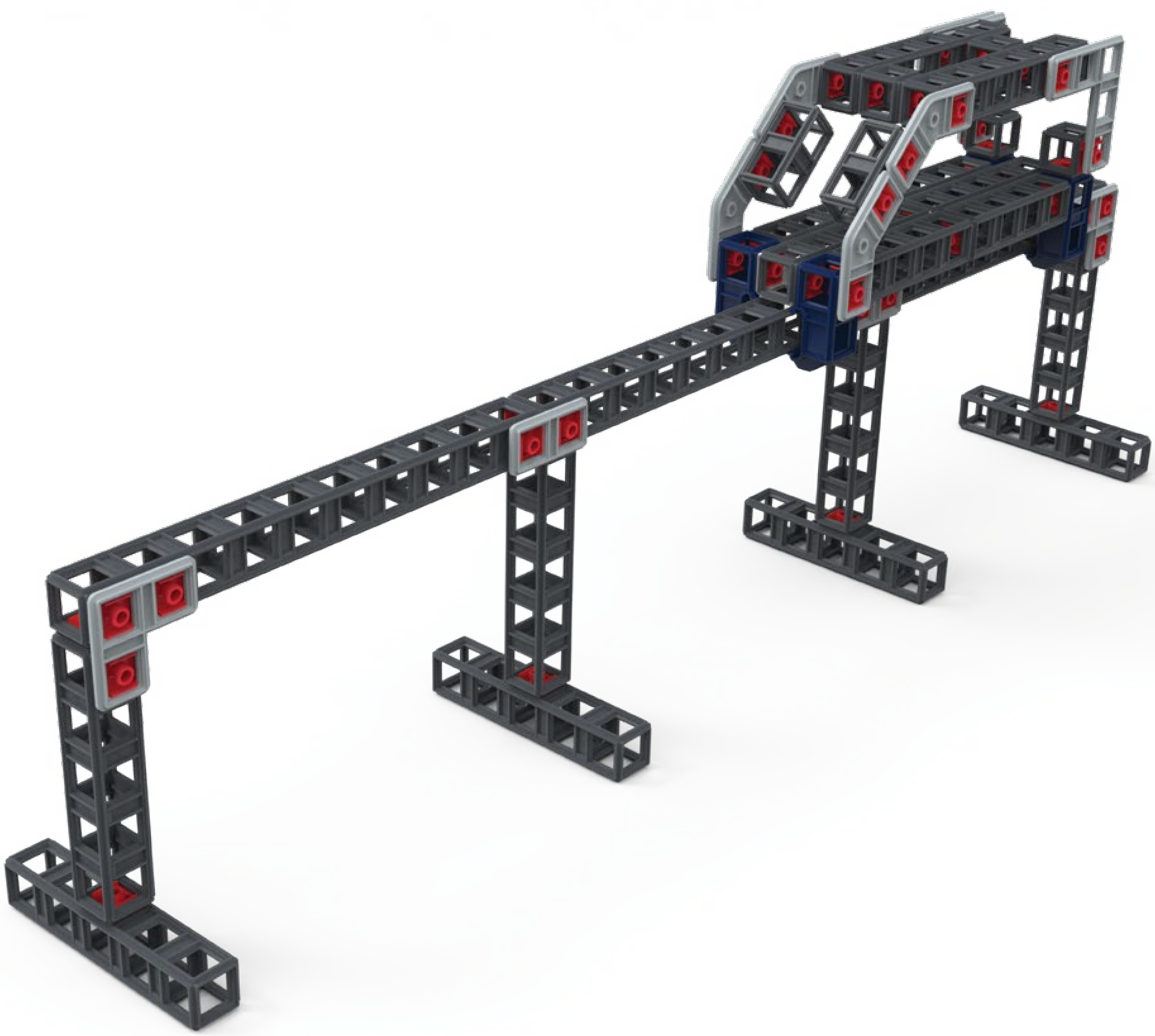
Invite groups to share their monorail car models one-by-one, explaining how they distributed passenger weight and managed available space.

Ask groups to demonstrate how their model is powered. Which car gets as close as possible to the end of the track without falling off the end?

assess

Consider using the Sphero Blueprint Engineering Challenge Rubric to assess each group's process and product for this challenge.

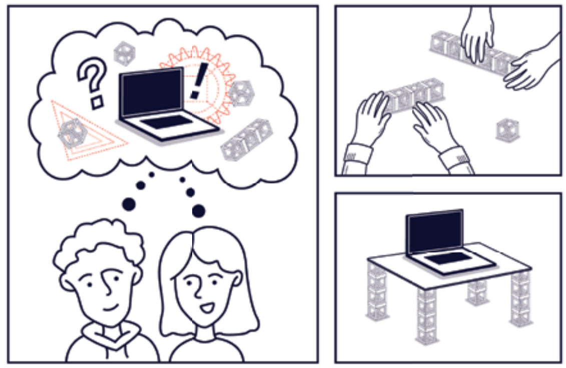
Build Example



challenge #4

construct for the classroom

Overview: You and your students spend a lot of time in your classroom. So why not design something that makes life in your learning space a little easier? In this challenge, students identify a classroom problem or need and then work in teams to prototype and construct a solution using Blueprint. They will then deliver an elevator pitch to "sell" their idea to their classmates.



LEARNING OBJECTIVES

By the end of this session, students will be able to:

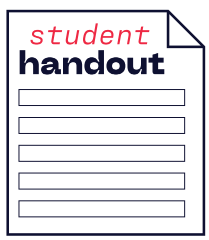
- empathize with their classmates and teachers to identify a classroom problem and define its constraints
- deliver an elevator pitch to share their idea to their classmates

MATERIALS

- Blueprint Build Kits
- Construct for the Classroom Challenge Card

CONSTRUCT FOR THE CLASSROOM STUDENT HANDOUT (OPTIONAL)

sphero.cc/bpc4sh



PREPARATION

01 Decide how much time you will dedicate to the challenge, anywhere from 1-3 days.

02 Preview the challenge and brainstorm your own ideas for classroom improvements (i.e., bookcases, material management, etc.).

03 Review the Construct for the Classroom Student Handout. Decide whether students will use it to document the process and their thinking throughout the challenge.

04 Decide how students will share their inventions. For those with additional time, think about building the presentations into a Shark Tank-style activity, where students hone their message and try to convince their classmates to vote for their invention.

05 Divide students into groups of 2-4. Ensure each group has access to a Blueprint kit and a clear work surface.

Challenge Steps

launch

Introduce the design challenge: Students will use Blueprint to prototype a solution to a classroom problem and improve their learning space.

Together with students, create a list of ways you could improve your classroom. Discuss: *What bothers you the most about your learning space?*

As needed, review example problems and solutions as a class.

classroom problem	engineered solution
lack of space for textbooks and desks	bookcase to stores textbooks vertically
difficulty sharing materials at table	lazy susan turntable
uncomfortable or cramped workspaces	laptop or chromebook stands

If you only have 45 minutes for the challenge, consider providing the classroom problem that students will attempt to solve. Use any of the above ideas or come up with your own.

If you are using the Construct for the Classroom Student Handout, talk through the steps to reinforce the Engineering Design Process.

Share the time constraints with students. For a 45-minute class period, consider suggesting:

- identify and imagine: 10 minutes
- build and iterate: 25 minutes
- deliver pitches: 10 minutes

If you are extending the challenge into a multi-day activity, share time guidelines with students to help them manage their time.

Note: Whatever classroom inventions your students created cannot be permanent as your students will need to use the Blueprint Build Kits for other learning. Use some of the ideas in the Extend section below to make this a longer term design challenge with more permanent construction materials.

support

As students work, circulate and support them with the challenge.

If you see students struggling to come up with a problem,
then provide a problem for students to work on.

If you see students mismanaging the allotted time,
then write stop times for each step on the board and appoint a Team Lead for each group to keep students on track.

If you see students struggling to develop an elevator pitch,
then give students sentence frames to help organize their pitch. **For example:**

- *We noticed [classroom problem]*
- *This is challenging because .... [description of problem]*
- *We designed a .... [engineered solution]*
- *It will improve your life by ... [description of its value]*

share

Dedicate at least five minutes at the end of class for students to quickly share elevator pitches for their solutions. Elevator pitches should clearly state:

- the classroom design problem
- how their invention addresses and solves the problem

If you have more time, allow students to further prepare for their pitches. Build it into a classroom Shark Tank-style activity. Encourage students to make their presentation persuasive, concise, and clear. Poll students at the end of the presentation to identify the top three classroom inventions!

extend

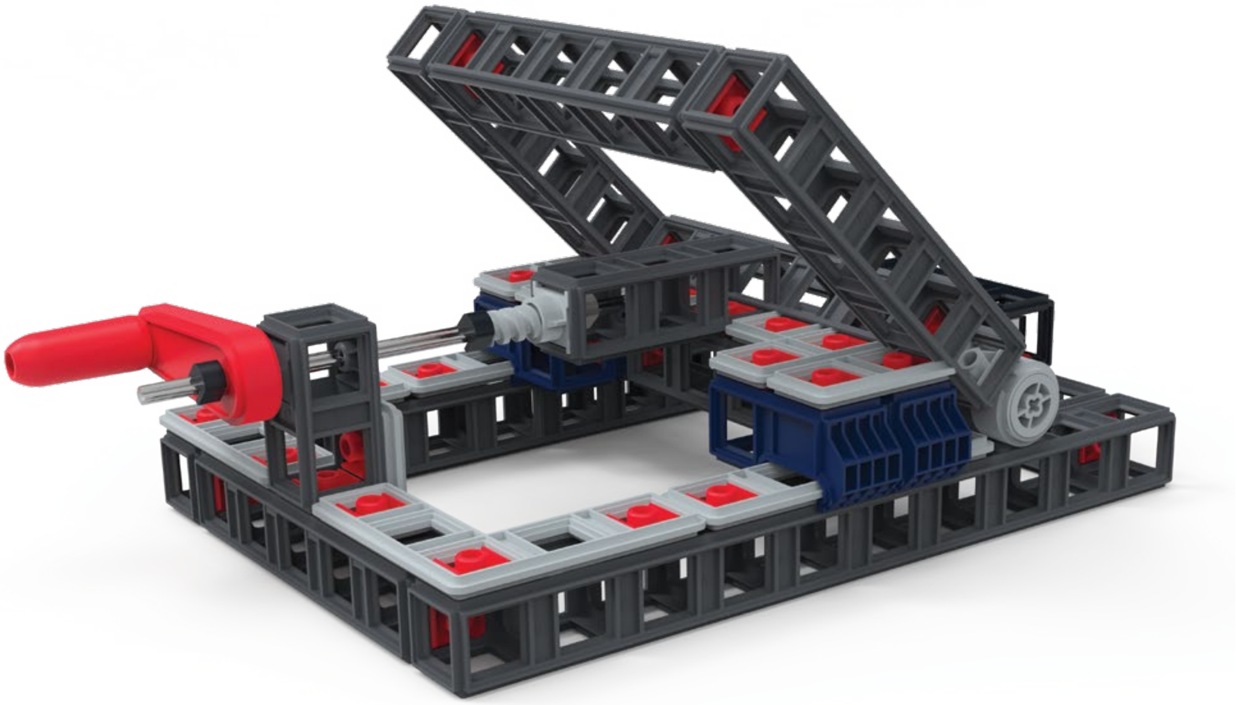
Depending on the level of your students and your available class time, consider some of the following ideas to increase the rigor of the design challenge:

- Use this as a catalyst for a larger empathy-based design challenge. Ask students to interview other teachers for their classroom-specific problems. Then design solutions for problems around the school.
- Turn the prototype into permanent solutions with other available resources. Do you have 3D printers, a laser cutter, or a router and access to CAD? Consider making this a longer term project where students can fully design and build their ideas that can stay in a classroom for years to come.

assess

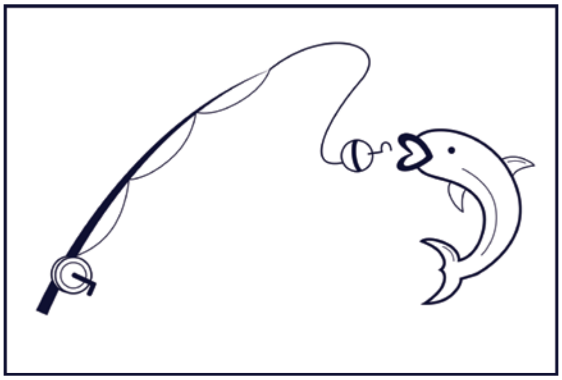
Use the Sphero Blueprint Engineering Challenge Rubric to assess each group's process and product for this challenge. Add on to the rubric to assess elevator pitches for persuasiveness, creativity, and clarity.

Build Example



gone fishing

Overview: To catch a fish, you need patience, determination, and skill. Of course, it would help if you also had a good fishing pole! A fishing pole is a simple machine with a reel that makes it easier for you to pull in that prize-winning fish. In this challenge, students will use Blueprint to design and build a working model of a fishing pole. In the process, they will get to know Blueprint's moveable parts, including cranks, pulleys, and gears.



LEARNING OBJECTIVES

By the end of this session, students will be able to:

- build a working model of a fishing pole with Blueprint
- follow the engineering design process
- explain how the ideas of peers can help improve their models

MATERIALS

- Sphero Blueprint Build Kit
- Gone Fishing Challenge Card

GONE FISHING STUDENT HANDOUT (OPTIONAL)

sphero.cc/bpc5sh

student handout

PREPARATION

01 Decide how much time you will dedicate to the challenge, anywhere from 1-3 days.

02 Preview the challenge and explore the Hand Crank, pulleys, and rope. Students will need to use these to build a successful model.

03 Review the Gone Fishing Student Handout. Decide whether students will use it to document the process and their thinking throughout the challenge.

04 Divide students into groups of 2-4. Ensure each group has access to a Blueprint kit.

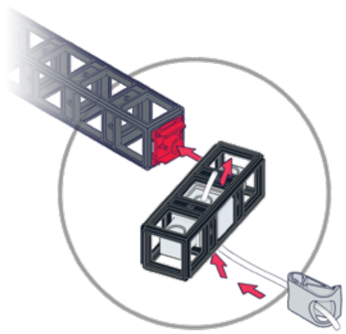
Challenge Steps

launch

Introduce the challenge. Students will design and build a fishing pole with Sphero Blueprint. The fishing pole must meet the following requirements:

- be at least 10 pitches long from the reel to the pole's tip (25 cm)
- use a Hand Crank, pulley, and rope
- be able to reel in a 3x Pitch Weighted Truss "fish" (75 grams)

Explain that the 3x Pitch Weighted Trusses can be attached to the end of the line by either tying a basic knot or threading rope through a Rope Clamp.



rope feeds through the 3x pitch weighted truss

If you are using the Gone Fishing Student Handout, talk through the steps and review the process students will follow to ideate, construct, and share their solutions.

Share the time constraints with students. For a 45-minute class period, consider suggesting:

- explore, ideate, and plan: 10 minutes
- build and iterate: 25 minutes
- share: 10 minutes

If you are extending the challenge into a multi-day activity, share time guidelines with students to help them manage their time.

support

As students work, circulate and support them with the challenge.

If you see students struggling to know where to start,
then show students a picture of a fishing reel and ask students which Blueprint parts could be used to build a reel.

If you see students troubleshooting how to guide the rope,
then show students how to thread string through trusses and the center holes in Connectors and Bearing Plates.

extend

Depending on the level of your students and your available class time, consider some of the following ideas to increase the rigor of the design challenge for students:

- Add gears to fishing poles. Can students add gears to increase torque, making it easier to pull in that heavy fish? Can they add gears to increase speed, making it faster to get that fish out of the water?
- Challenge students to create an automated system for attaching the end of the Rope to a 3x Pitch Weighted Truss, like a hook.
- Ask students to investigate how much weight their fishing pole can pick up. What modifications do they need to make to their design to increase its load capacity?

share

Reserve at least 10 minutes for students to gather in a central area and share their fishing poles. In addition to describing how their model works, ask students to share their biggest challenge when building their model.

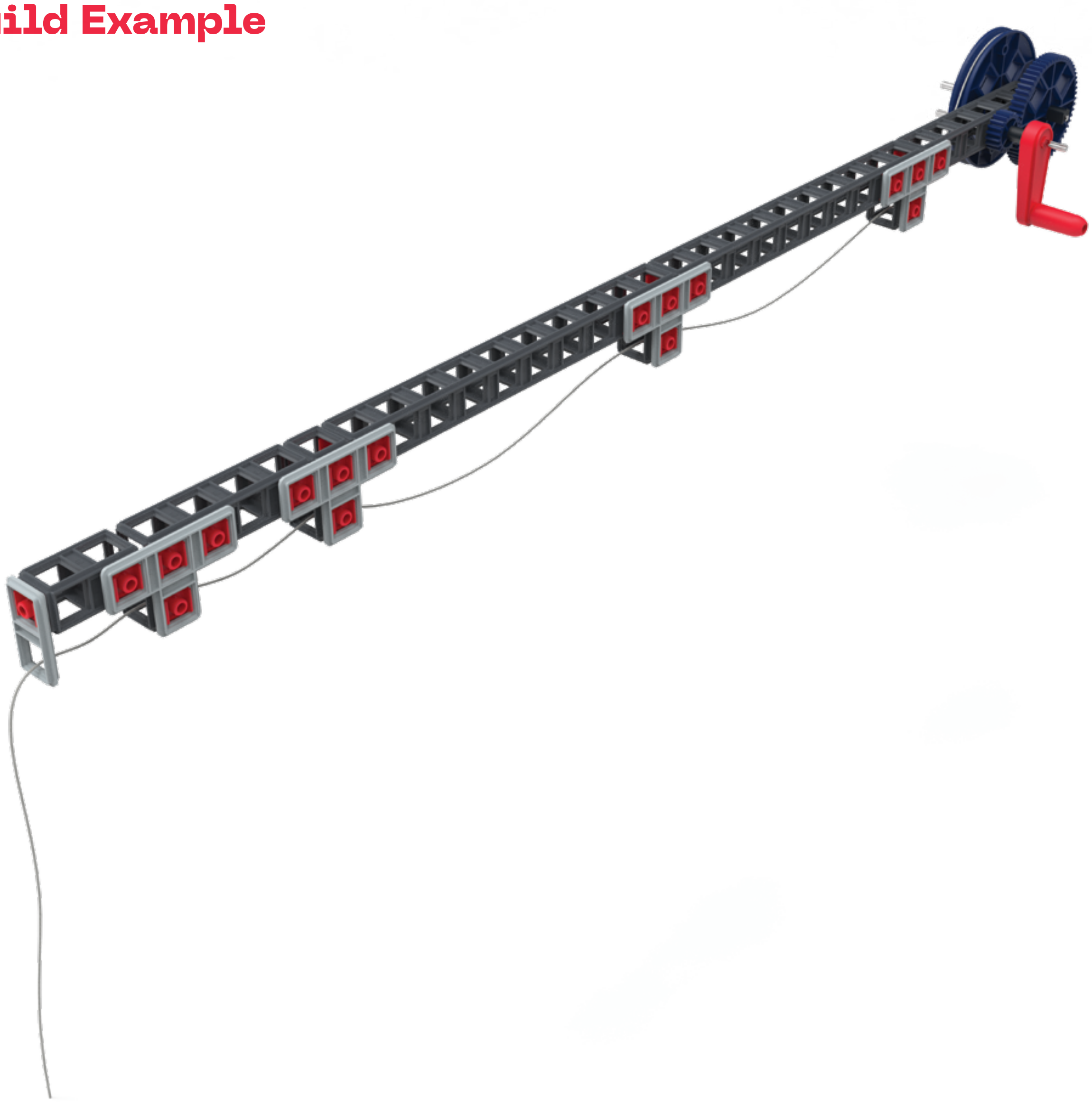
After all groups have shared, go around the class one more time and ask students how they could use the ideas of other groups to improve their fishing poles.

assess

Pay close attention to how students contribute to the class discussion at the end of the session. Learning from their peers is a key engineering practice.

If desired, you can adapt and use the Sphero Blueprint Engineering Challenge Rubric to more formally assess each group's process and final product.

Build Example



All digital Blueprint resources are available on the Blueprint resources webpage. Use this guide in tandem with everything included digitally.

BLUEPRINT RESOURCE WEBPAGE

sphero.cc/BPresources

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