sphero

educator guide – DIGITAL EDITION

Includes references to the Australian Curriculum - F-10 Version 9.0 // Design & Technologies and NSW NESA Science and Technology K-6 (2024) Content Descriptions

AUSTRALIAN CURRICULUM
Includes references to the Australian Curriculum
- F-10 Version 9.0 // Design & Technologies

NSW CURRICULUM
Includes references to NSW NESA Science and Technology K-6 (2024)

Please see pages 44 - 107 for further explanation
of how the Content Description is addressed.

blueprint snap™

educator guide

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Table of Contents

Welcome to Snap!

Hello! Welcome to the Blueprint Snap Educator Guide. Within these pages, you'll find a treasure trove of information that will help you get up and running with Snap in your classroom. Here at Sphero, we believe in learning by doing, so let's jump right into the challenge cards.

Snap Challenge Cards

The Snap challenge cards are the best way to introduce Snap to students and start building the fluency and confidence they will need to prototype designs with creativity and purpose. They are also an excellent way to familiarise yourself with Snap parts and build principles.

Each of the 15 challenges included in the Blueprint Snap Kit is a short, focused introduction to building with Snap. Each challenge should take about 15 minutes. You can find a digital version of the cards at: sphero.cc/BPsnapcc

Challenge cards 1-12 are divided into three sections:

learn how Snap parts work together.

build a model based on an image on the back of the card.

explore how the model can be improved or changed.

Challenge cards 13-15 are open-ended, giving students an opportunity to flex their creative muscles alongside the engineering design process.

	challenge	key snap parts
1.	Strong	Trusses & Connectors
2.	Stronger	Plates
3.	Move	Hinges & Turntables
4.	More Moving	Gears, Pulleys, Shaft Collars & Capped Shafts
5.	Spin or Lock?	Lock & Baring Plates
6.	Spinning	Hand Cranks
7.	Spin Faster	Gears
8.	Rolling	Pulleys & Tires
9.	Sliding	Linear Motion Brackets
10.	Drawbridge	Ropes & Rope Anchors
11.	Winching	Spools
12.	Clamping Cardboard	Cardboard Clamps
13.	Grounds for Play	Your Choice (open-ended)
14.	Animal Structures	Your Choice (open-ended)
15.	Driving Around	Your Choice (open-ended)

Implementation Recommendations

Challenge cards can be used in a variety of ways in the classroom. Consider the following implementation models:

Whole Group

Project the challenge cards one at a time for **all students** to see. Preview the challenge together, then give students time to **build** their models and follow the **explore** prompts. Make sure to save time at the end of each card to **review** what students have learned and **share** their models.

Small Group

Distribute challenge cards to **small groups** of students and let them work through a set of cards at their own pace. Near the end of your allotted time, bring the groups back together and have students **share** what they've learned, their designs, and generate ideas for future explorations.

Stations

Set up learning stations with challenge cards. Put a different card at each station and give students about 15 minutes to complete each card before rotating to a new station. Since all stations are working on different cards, you can float and support as needed or remain at one station that you feel is more challenging. As with the other models, be sure to save time at the end for reflection and sharing.

Planning & Facilitation Tips

Before

- Take time to complete the challenge cards **on your own**. This will not only help you anticipate challenges your students may face, but it's also the best way to learn how Snap works (it's also fun!).
- Review the information about each challenge in this guide. This guide offers tips, deeper explanations, examples, and more to make facilitation even easier.
- Choose your implementation method. If possible, plan for two students per Snap Kit.
- Decide if and how you want students to **record their learning** (there are tips on how to use engineering notebooks and reflection videos in the FAQ section of this guide).

During

- Encourage **open-ended exploration** and refrain from giving solutions.
- Celebrate effort and risk-taking. Emphasise that students can make mistakes and that it's okay! The real objective of these challenges is **building fluency** with Snap parts and an iterative approach to design.
- Periodically pause the class to let students who have had breakthroughs or unique designs **share** their discoveries with others.
- As students work on the **explore** section, allow them to follow their own lines of inquiry. Encouraging students to come up with their own creative questions and solutions is a great way to develop curiosity and critical thinking skills.

After

- Bring students together to **review** and **summarise** what they have learned.
- Capture questions or ideas that students want to investigate further. Consider making time in the future for them to build on those ideas.
- Once you have finished these challenges, head on over to Sphero Central to discover more lessons: edu.sphero.com/blueprint-snap

Challenge #1: Strong

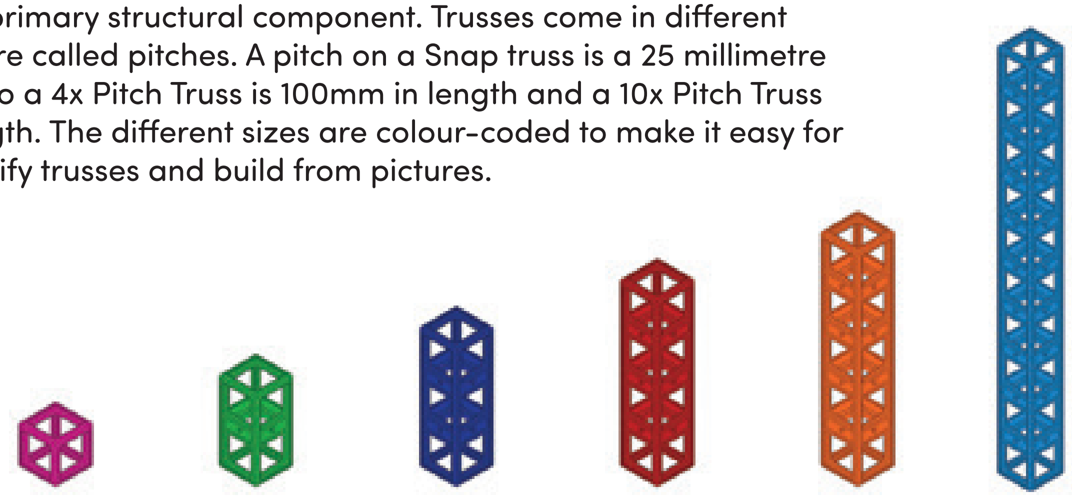
Students learn how to use Connectors and trusses to build a simple bridge.

For references to the ACARA and NSW Curriculum refer to pages 44 to 47.

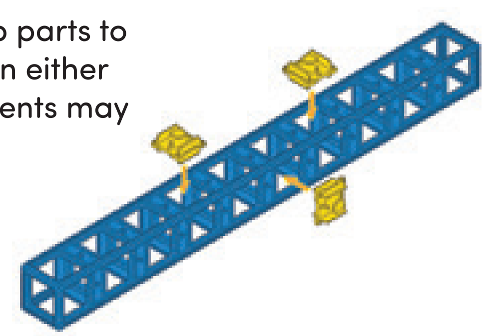
learn

This challenge introduces the two most commonly used parts in the Snap Kit:

- Trusses are the primary structural component. Trusses come in different lengths, which are called pitches. A pitch on a Snap truss is a 25 millimetre (mm) segment, so a 4x Pitch Truss is 100mm in length and a 10x Pitch Truss is 250mm in length. The different sizes are colour-coded to make it easy for students to identify trusses and build from pictures.

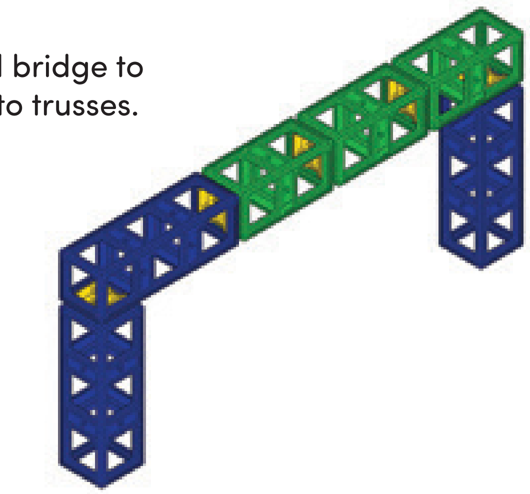


- Connectors are used to attach trusses and other Snap parts to one another. Connectors can be inserted into a truss in either orientation. The orientation shouldn't matter, but students may want to investigate whether they think it does!



build

Students build a very simple, unsupported bridge to give them practice attaching Connectors to trusses.



explore

This bridge is not very sturdy. Add or replace Snap parts to make it stronger.

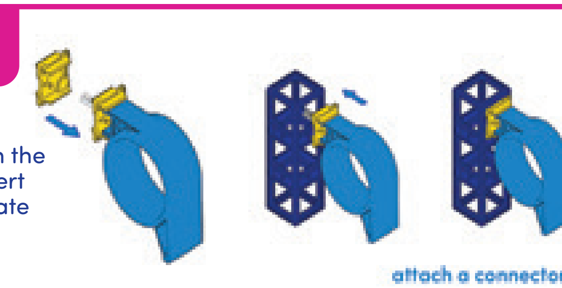
- Students may notice that the top beam could be built with a 5x Pitch Truss and 4x Pitch Truss instead of a 3x Pitch Truss and three 2x Pitch Trusses. The fewer joints, or connections, between trusses, the stronger the bridge will be.
- Students may recommend adding parts to reinforce the joints. Additional trusses and Connectors on the top, bottom, or sides of the bridge will strengthen the joints. Students may also use plates, which are formally introduced in Challenge #2.
- Students may also add trusses to the base of the bridge so it is less likely to tip over.

Try placing a small object on the bridge to see how strong it is. What could make it stronger?

- Encourage students to put the weighted trusses on top of the bridge. They could also place classroom objects like books or pencil boxes on top of the bridge to test.

engineering tip

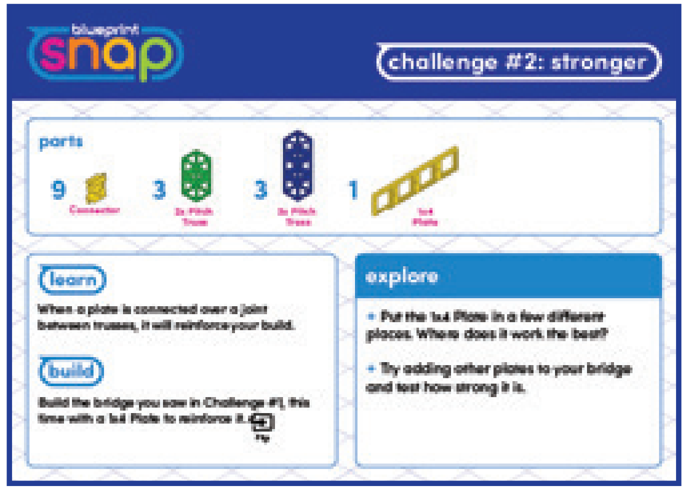
This challenge will also give students lots of practice assembling and disassembling with the Ring Tool. Reinforce some of the ways to insert Connectors, remove Connectors, and separate trusses from the Best Build Practices card.



Challenge #2: Stronger

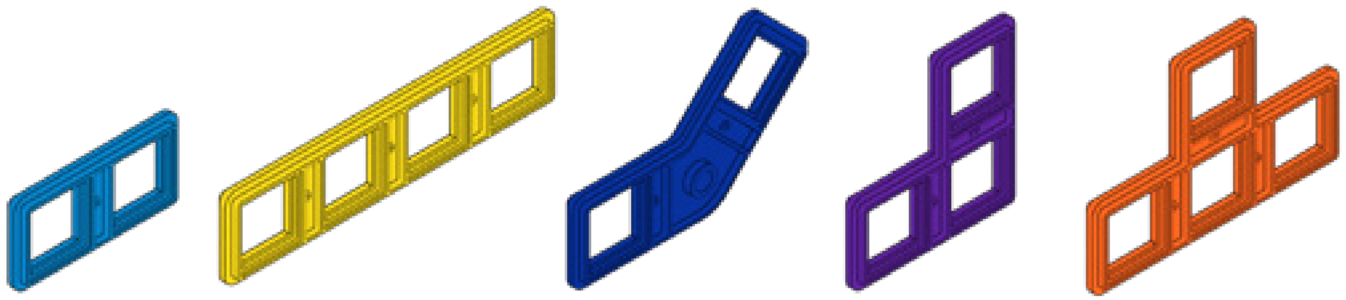
Students learn how to use a plate to reinforce, or strengthen, the bridge they built in Challenge #1.

For references to the ACARA and NSW Curriculum refer to pages 48 to 51.



learn

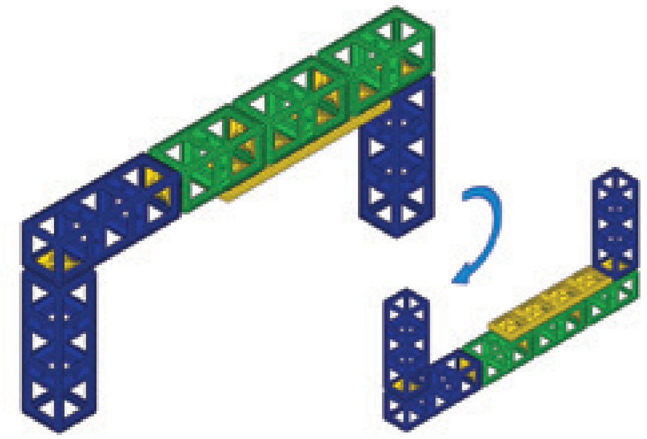
Snap plates can be attached to trusses on either side of a joint to reinforce the connection. Plates come in a variety of sizes and shapes:



Some plates, like the 1x4 Plate, have spots for more than two Connectors. The more Connectors you use to attach a plate, the stronger the connection. Besides using plates for reinforcing joints, they can also be used creatively in builds. Ask your students to think about how they could use a plate to create a flat base for their bridge.

build

Students will support the bridge from Challenge #1 with a 1x4 Plate.



explore

Put the 1x4 Plate in a few different places. Where does it work the best?

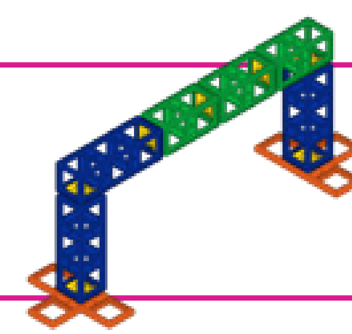
- Students can attach the 1x4 Plate in many different spots, including four different spots on the underside of the bridge. They could also attach the plate to the sides or top of the bridge. Generally speaking, the plate will work best when it covers two joints rather than one.
- Ask students to support their findings with evidence. How much weight could be supported with the plate in different locations?

Try adding other plates to your bridge and test how strong it is.

- Students may start adding multiple plates over the same joint to further reinforce the bridge's strength.
- The 2x2 90° Plates can be used to reinforce the corners of the bridge. The 2x3 Tee Plates can also be used on the corners, though part of the plate will extend past the edge of the bridge. The 2x2 45° Plates do not have much purpose in this build and are most use-ful when trying to build with angles that are not perpendicular.
- Students may start adding multiple plates over the same joint to further reinforce the bridge's strength.

engineering tip

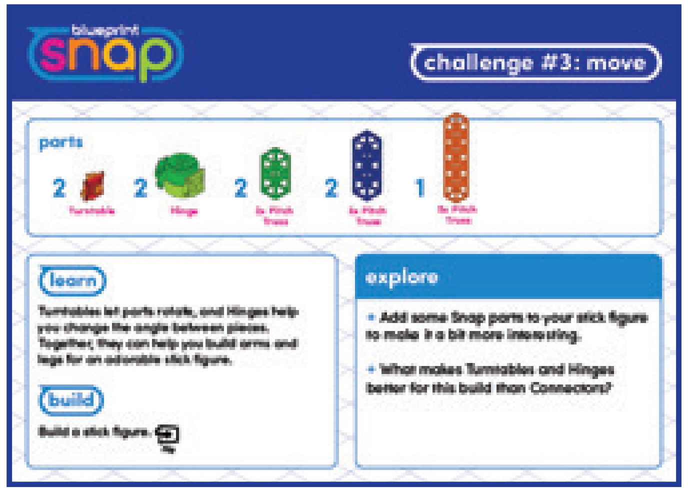
Plates can be used creatively in builds, as well as for reinforcing joints. Ask your students how they could use a plate to add a base to their bridge.



Challenge #3: Move

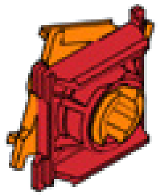
Students learn how to use Turntables and Hinges to make joints that twist and bend.

For references to the ACARA and NSW Curriculum refer to pages 52 to 55.

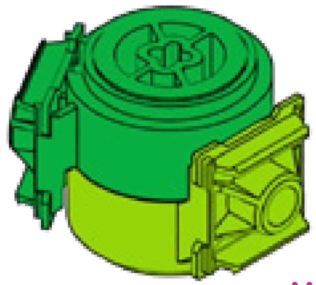


learn

Turntables connect two trusses or other Snap parts and allow them to rotate or twist, while Hinges connect two trusses or other Snap parts and allow them to bend.



Turntable



Hinge

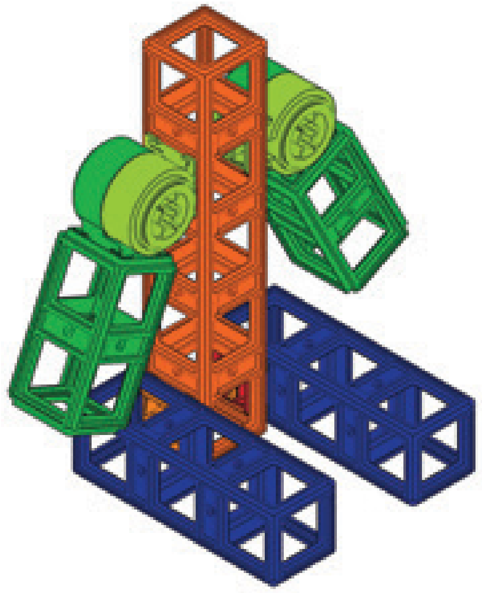
Look closely, and you'll see that both Turntables and Hinges are made up of two separate parts, hence their two colours. A shaft can be inserted through the centre of each.

- One side of the hole locks onto the shaft. When you turn the shaft, the part turns with it.
- The other side of the hole lets the shaft spin freely inside it. Look closely and you'll see that the shaft will lock to one side of the joint and spin freely through the other side.

This allows you to drive motion through a Turntable or Hinge with a shaft. If you find that the wrong side of the joint is spinning in your build, simply flip the Turntable or Hinge around.

build

Students build a stick figure.



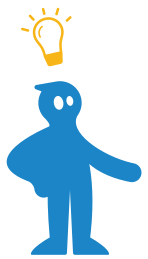
explore

Add some Snap parts to your stick figure to make it a bit more interesting.

- Encourage students to get creative here. They may want to swap out trusses to make their stick figure bigger or smaller. Others may want to make other body parts. For example, the 45mm Pulley will make a great head. They also may want to add objects, like a tool, a hat, or something to carry.
- Students may also want to add more joints to their stick figure. Prompt them to think about the human body and see if they can use more Turntables and Hinges to make their stick figure more realistic.

What makes Turntables and Hinges better for this build than Connectors?

- If possible, discuss this question with students. Connectors are great when you want to lock Snap parts together. However, many builds, like this stick figure, require joints to twist or bend. Hinges and Turntables are just one way to add movement to Snap builds.



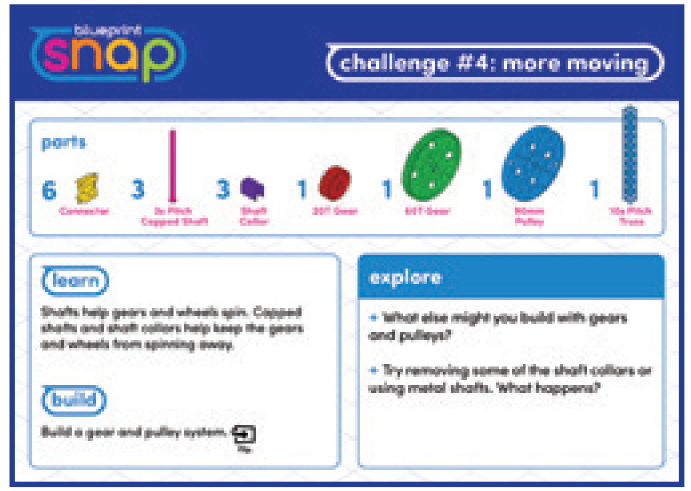
engineering tip

If your students struggle with the names of parts, encourage them to come up with their own names related to a part's purpose or function. For example, at Sphero we often call Turntables "twisties" and Hinges "bendies." As students work through these challenge cards, they will develop formal and informal vocabulary to accurately talk through engineering design challenges with Snap.

Challenge #4: More Moving

Students learn how to use Snap shafts, which act as axles for gears and pulleys, allowing them to spin.

For references to the ACARA and NSW Curriculum refer to pages 56 to 59.

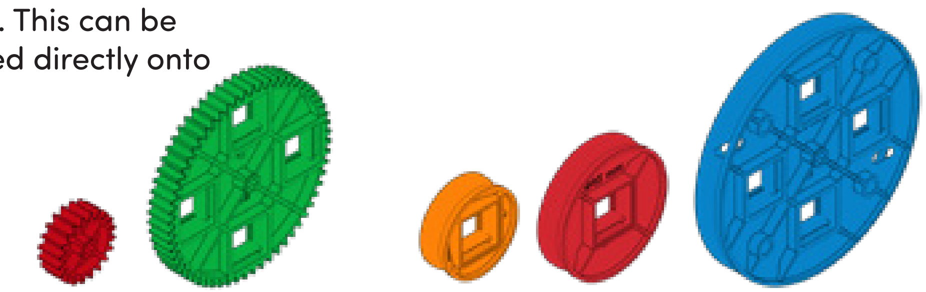


learn

Capped shafts have two ends: one end with a "cap" that acts as a permanent stopper, and another end that slides through Connectors and other Snap parts. Capped shafts come in multiple sizes. Similar to trusses, they are measured in 25mm lengths or pitches. The 2x Pitch Capped Shaft is 50mm and the 4x Pitch Capped Shaft is 100mm.

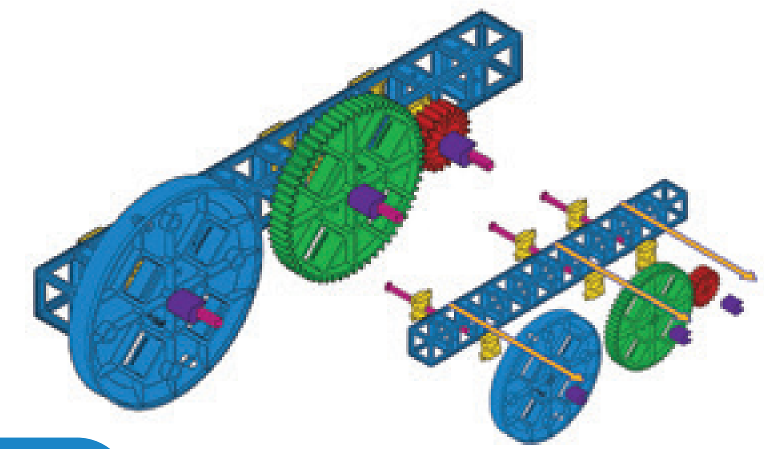
Gears and pulleys slide onto shafts, which allow them to spin. The smaller 30mm and 45mm pulleys need a Turntable, Bearing Plate, or Lock Plate attached to them to hold a shaft.

The uncapped side of the capped shaft must be secured with a Shaft Collar. This can be slid on from the end or snapped directly onto the shaft from the side.



build

Students build a mechanism that will allow them to explore capped shafts, gears, and pulleys.



explore

What else might you build with gears and pulleys?

- Students may suggest some of the following mechanisms with pulleys:
  - a car, bicycle, or other rolling vehicle using the pulleys as wheels
  - a well that uses a rope and a pulley to raise a bucket of water
  - a crane for lifting objects at a construction site

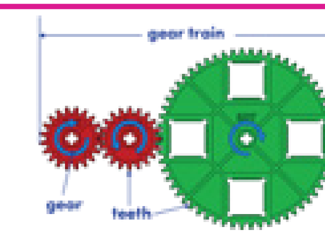
- Students may suggest some of the following mechanisms with gears:
  - a merry-go-round that turns with gears
  - a fan that spins trusses very quickly

Try removing some of the shaft collars or using metal shafts. What happens?

- Students will notice a second type of shaft in their Snap Kits: metal shafts. Prompt students to think about the difference. Metal shafts come in longer sizes (5x, 6x, and 10x pitches) and do not have a capped end. This means they are stronger, but they also need to be secured on both ends with a Shaft Collar.

engineering tip

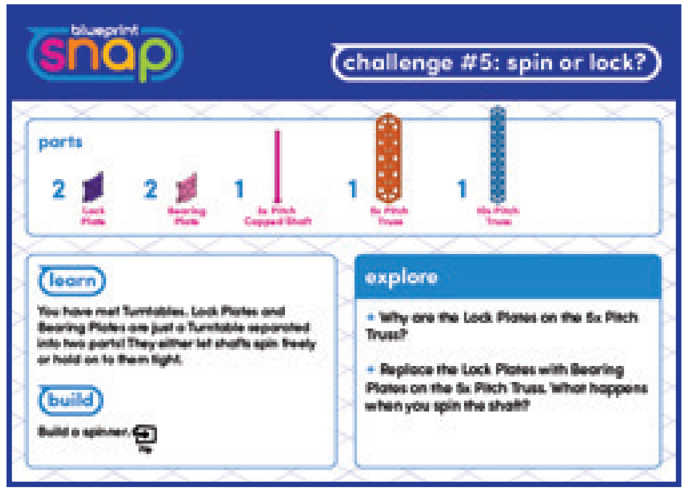
Introduce students to vocabulary that will allow them to talk about gears. Gears have teeth—or cogs—that mesh with other gears. In this build, the 20T Gear is meshed with the 60T Gear to form a series of gears called a gear train. When one gear is rotated, the other gear will rotate as well.



Challenge #5: Spin or Lock?

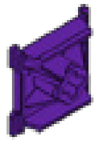
Students learn the difference between Lock Plates and Bearing Plates by building a simple spinner.

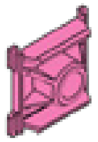
For references to the ACARA and NSW Curriculum refer to pages 60 to 63.



learn

Lock and Bearing Plates are used with shafts to help make builds with spinning parts. A Lock Plate will hold a shaft in place, not allowing it to rotate. Think about the wheel on a car that you want to be locked to the spinning axle. A Bearing Plate will allow a shaft to spin freely. Think about the axle on a car that you want to spin freely while staying attached to the body of the car.

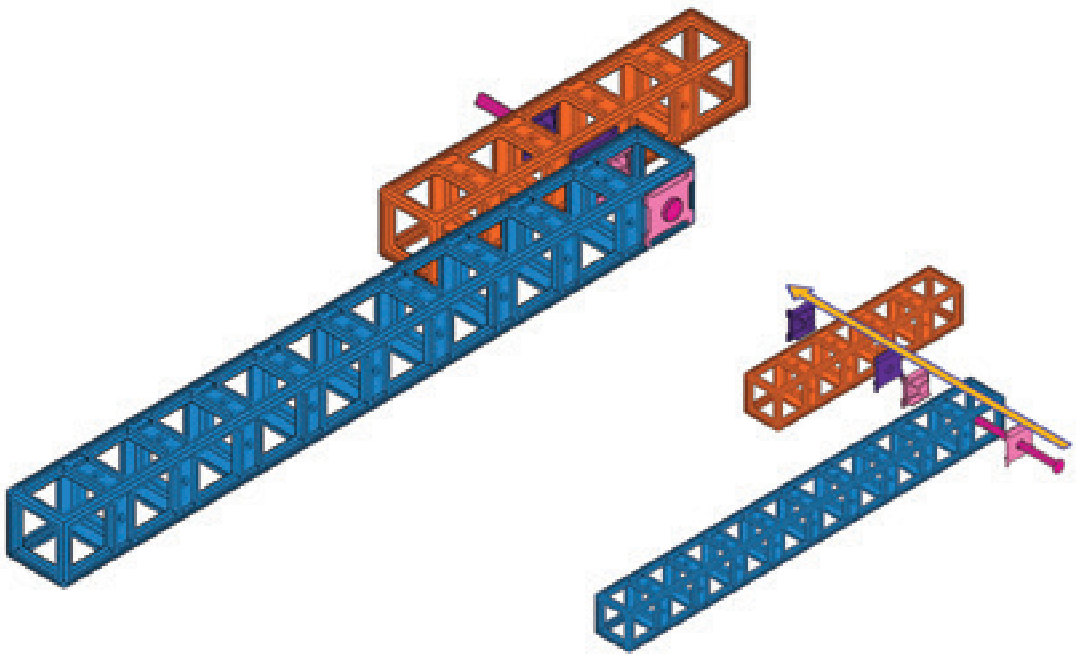

Lock Plate


Bearing Plate

Remember the Turntable from Challenge #2? A Turntable is just a Lock Plate and a Bearing Plate fixed together. Turntables are handy because you don't need to use a shaft to connect the part. You'll always need to use a shaft with a Lock Plate and Bearing Plate.

build

Students build a simple spinning mechanism.



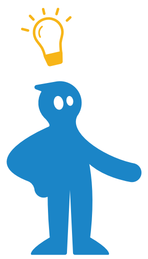
explore

Why are the Lock Plates on the 5x Pitch Truss?

- Ask students to hold the 10x Pitch Truss in one hand and spin the shaft. Students will discover that the Lock Plates on the 5x Pitch Truss hold it to the shaft, causing it to spin as they turn the shaft.
- If they hold the 5x Pitch Truss, they will not be able to spin the shaft.

Replace the Lock Plates with Bearing Plates on the 5x Pitch Truss. What happens when you spin the shaft?

- Students will observe that the shaft spins, but the 5x Pitch Truss does not.
- If they spin the 5x Pitch Truss, they'll notice it spins freely.



engineering tip

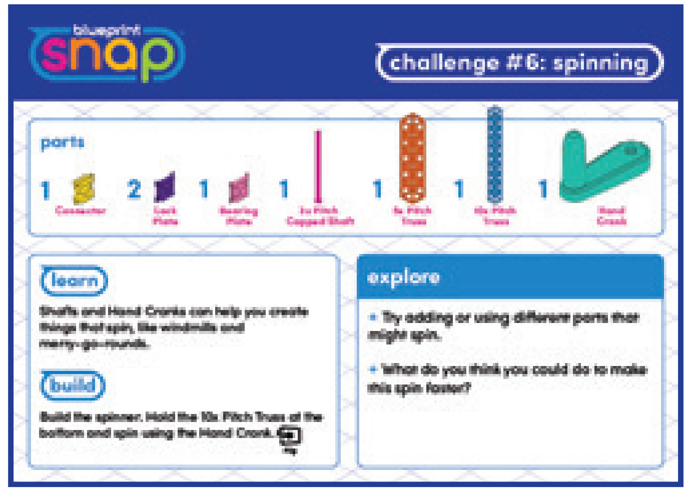
A core job for an engineer is managing friction, a force that slows things down when surfaces rub together. Prompt students to swap out the Lock and Bearing Plates between the trusses with a Turntable and investigate the difference in friction. Which spins better? Which has less friction?

The Turntable has a lot of plastic rubbing together, which slows the spinning down. The trusses spin much more smoothly with less friction with Bearing and Lock Plates. Sometimes, engineers want friction; other times, they don't. Engineers need to select the right parts to get the desired amount of friction for the task at hand.

Challenge #6: Spinning

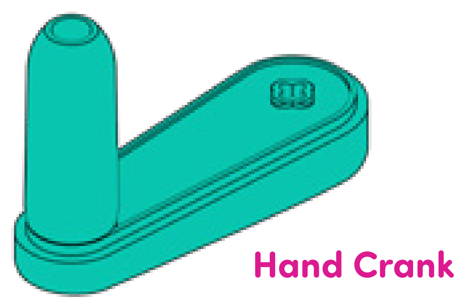
Students learn how the Hand Crank helps you add motion to builds.

For references to the ACARA and NSW Curriculum refer to pages 64 to 67.



learn

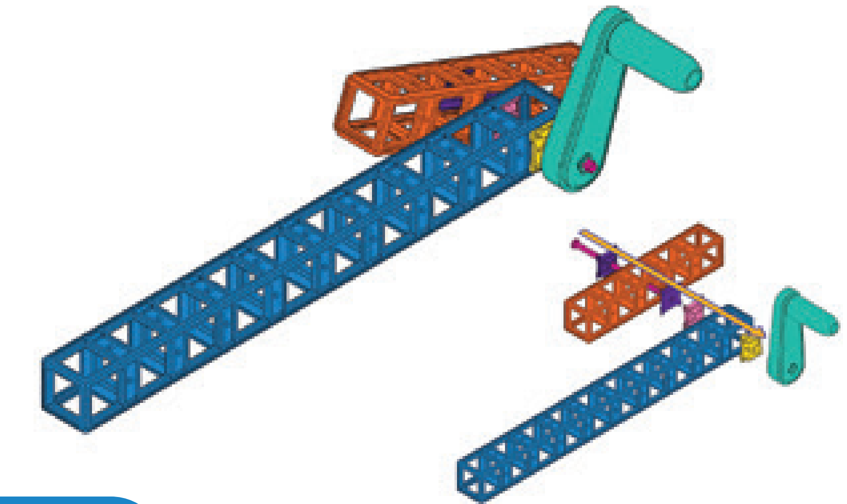
The Hand Crank fits onto shafts and provides a convenient way to power Snap mechanisms by hand.



While not in the build picture, you can secure the Hand Crank by attaching a Shaft Collar to the end of the 3x Pitch Shaft. Both the Hand Crank and Shaft Collar are 0.5x pitch (12.5mm) in width, making just enough space on the end of the 3x Pitch Capped Shaft.

build

Students modify the spinner from Challenge #5 by adding a Hand Crank.



explore

Try adding or using different parts that might spin.

- Students may notice that some parts, such as the 20T Gear, 60T Gear, and 90mm Pulley, are fixed with locking shaft inserts. Remember that other parts, such as the 30mm Pulley and 45mm Pulley, need to be fitted with a Lock Plate to hold onto the shaft.
- Use this exploration as a starting point for a mini engineering design challenge. Ask students to brainstorm Snap parts that might be fun to spin, prototype their ideas, then test and improve their builds. Make sure to provide time for sharing. Students could invent anything from a hand mixer to a hypnotising machine.

What do you think you could do to make this spin faster?

- The obvious student suggestion here is to turn the Hand Crank faster. Prompt them to think about how to use additional Snap parts to make the spinner spin faster while turning the Hand Crank at the same speed. This previews the learning in Challenge #7.

engineering tip

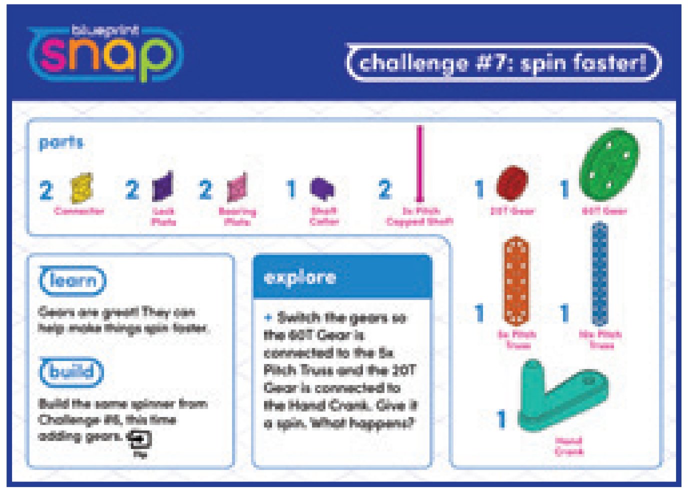
Use the Hand Crank to introduce or reinforce the concept of inputs and outputs in mechanical systems.

- **Input:** The effort used to power a machine. Here, the input is the force a student uses to turn the Hand Crank.
- **Output:** The action or result that the machine produces. Here, the output is the motion of the spinning truss.

Challenge #7: Spin Faster

Students learn how to make their spinner spin faster with gears.

For references to the ACARA and NSW Curriculum refer to pages 68 to 71.

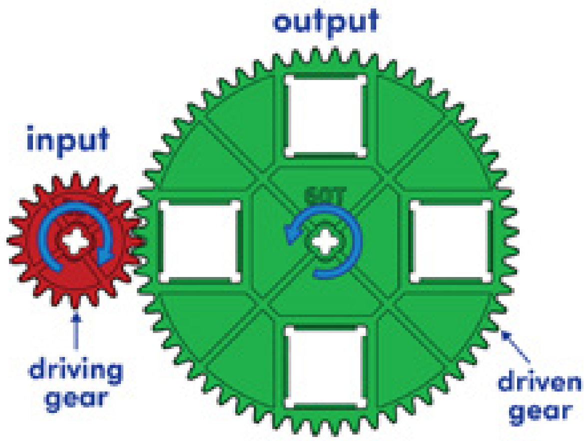


learn

This challenge card does not introduce new parts. Instead, students learn to use a gear train to speed up their spinner.

Different gears in a gear train serve different purposes:

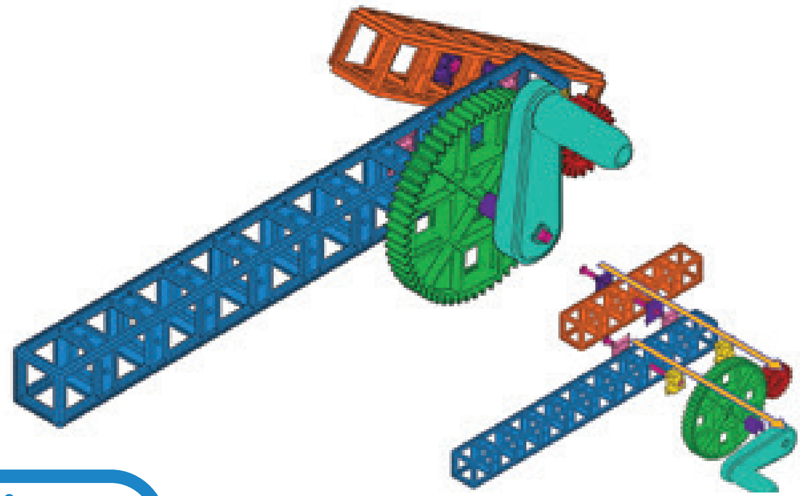
- The gear with the Hand Crank is the input, or driving gear. Force is applied to the driving gear.
- The gear attached to the 5x Pitch Truss is the output, or driven gear. Its movement represents the machine's final work or output.



The driving gear has 60 teeth and the driven gear has 20 teeth. For every rotation of the driving gear, the driven gear spins three revolutions. This gear train is geared to increase the speed of the output.

build

Students modify the spinner from Challenge #6 by adding a gear train.

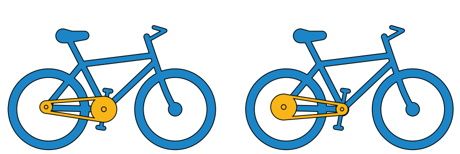


explore

Switch the gears so the 60T Gear is connected to the 5x Pitch Truss and the 20T Gear is connected to the Hand Crank. Give it a spin. What happens?

- Students will discover that when they switch the gears, the spinner will rotate much more slowly.
- Prompt them to consider why. The driving gear now has 20 teeth and the driven gear has 60 teeth. This means that the Hand Crank needs to be rotated three times to make the spinner complete one revolution.
- This gear train increases the output's torque, or turning power. It is slower to spin, but it is hard to stop!

engineering tip



Using gear trains to your advantage, either to gear a mechanism for speed or for torque, is one of the most important concepts in mechanical engineering. Make it relatable to students by discussing gearing on bicycles.

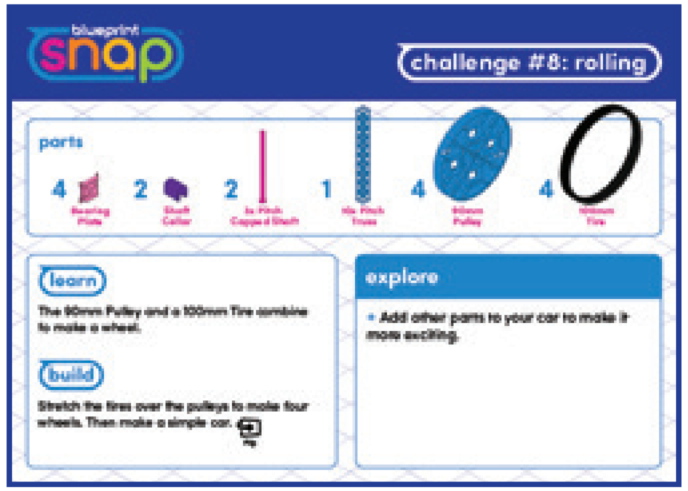
When do you want a large gear on the front crank and a small gear on the back crank? *When you want to go fast!*

When do you want a small gear on the front crank and a large gear on the back crank? *When you want to go up a steep hill!*

Challenge #8: Rolling

Students learn how to turn a pulley into a wheel for vehicles and other creative builds.

For references to the ACARA and NSW Curriculum refer to pages 72 to 75.


challenge #8: rolling

parts

4 Bearing Plate · 2 Shaft Collar · 2 Capped Shaft · 1 Truss · 4 Pulley · 4 Tire

learn

The 90mm Pulley and a 100mm Tire combine to make a wheel.

build

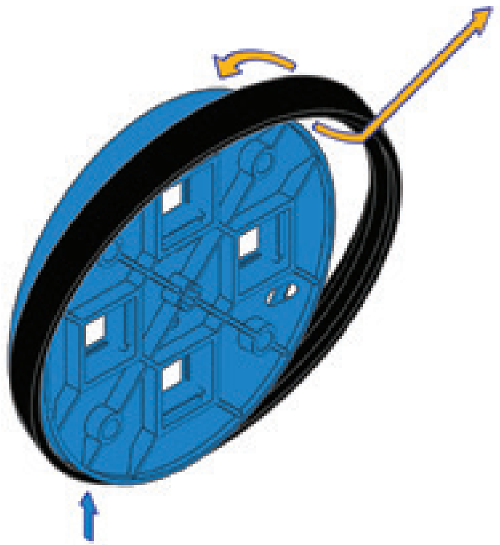
Stretch the tires over the pulleys to make four wheels. Then make a simple car.

explore

- Add other parts to your car to make it more exciting.

learn

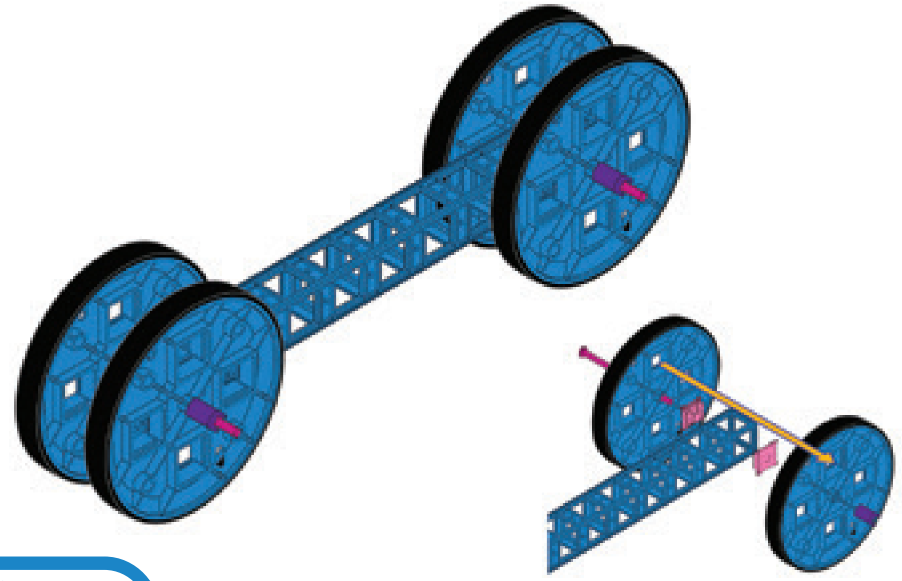
Only one new Snap part is introduced in this challenge card: the 100mm Tire. The tire is stretched over the 90mm pulley to make a wheel. The bump inside the tire fits into a groove on the pulley to make a wheel with a diameter of 100mm. The tires are meant to be durable, but remind students not to stretch them.



This challenge card reinforces the difference between Bearing Plates and Lock Plates. What would happen if the Lock Plates were used instead?

build

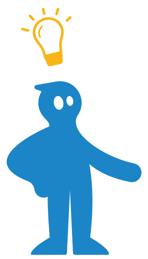
Students build a simple car.



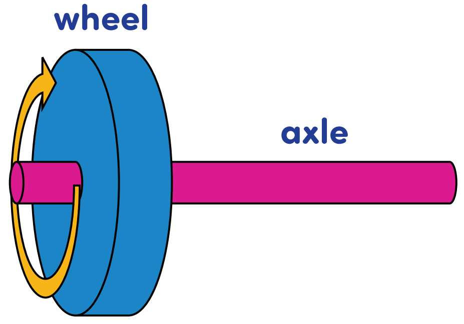
explore

Add other parts to your car to make it more exciting.

- This is a purposefully open-ended prompt. Building cars and other vehicles is fun, and the build in this challenge is pretty basic. Students can try some of the following:
  - add trusses to make the car wider or longer
  - add features like a driver's seat, doors, or a trunk
  - add gears to be able to turn the wheels with the Hand Crank
- As time allows, turn this prompt into a design challenge and ask students to brainstorm ideas for their car, prototype their ideas, then test and improve their builds.
- Look ahead to Challenge #11. It asks students to attach a winch to the front of their car.



engineering tip



The wheel and axle is a simple machine that allows objects to roll instead of being dragged. This reduces friction and makes the objects easier to move.

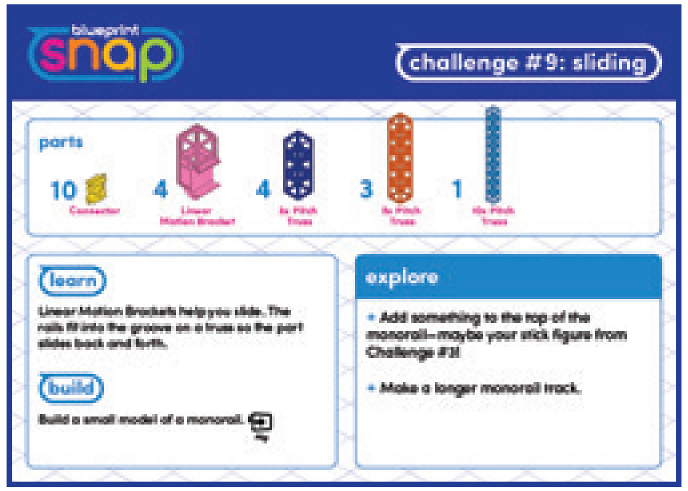
Discuss other common examples of wheels and axles in the real world:

- Steering wheel: The driver holds the wheel, which spins the steering column or axle and turns the car.
- Doorknob: The knob is the wheel and the small shaft that opens the latch is the axle.
- Pizza cutter: The cutting blade is the wheel and the pin that holds it in place is the axle that the blade spins around.

Challenge #9: Sliding

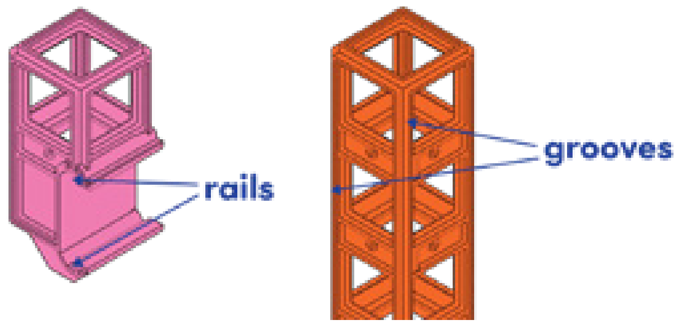
Students will learn how to use Linear Motion Brackets to add sliding motion to their builds.

For references to the ACARA and NSW Curriculum refer to pages 76 to 83.

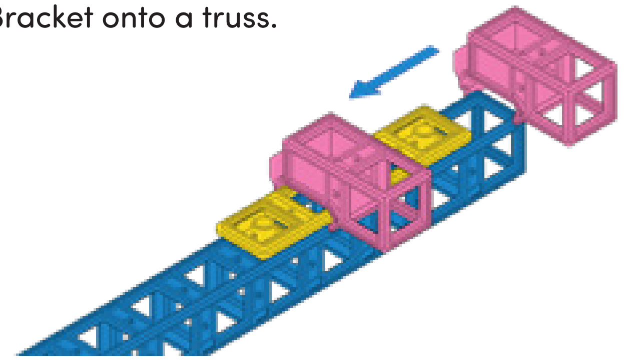


learn

The rails on the Linear Motion Brackets fit into the grooves on a truss and slide back and forth with minimal friction. This motion is similar to drawers in a dresser or a train on a track.



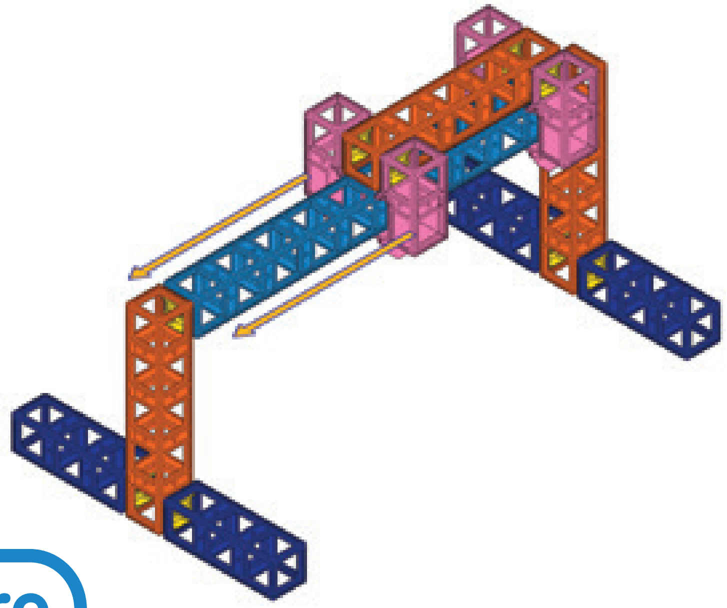
Linear Motion Brackets are often used in pairs, one on each side of the object. In this challenge card, students will place the monorail on the 10x Pitch Truss and then add the Linear Motion Brackets to secure the monorail to the track. They can also use plates to lock the Linear Motion Bracket onto a truss.



Note that the name, Linear Motion Bracket, is a mouthful. At Sphero, we often call them "slides."

build

Students build a monorail that slides back and forth on a 10x Pitch Truss.



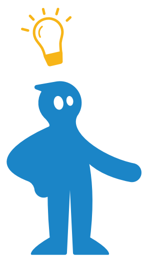
explore

Add something to the top of the monorail—maybe your stick figure from Challenge #3!

- Besides their stick figure, students may want to build onto the car to make it look more like a monorail.
- As students add on, prompt them to think about stability. How can they ensure their monorail maintains balance and slides smoothly on the track?

Make a longer monorail track.

- With six 10x Pitch Trusses in each Snap Kit, students can build a track that is 60 pitches in length. Incorporate measuring by asking students to calculate the length of their tracks. Remember, each pitch on a Snap truss is 25mm.



engineering tip

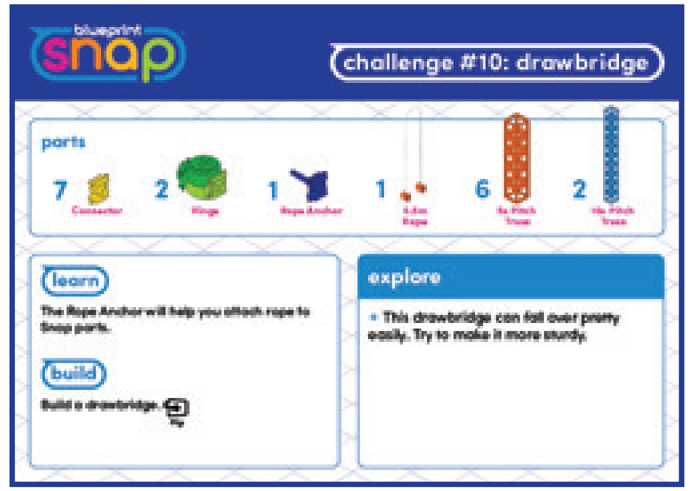
In this build, the track is just as important as the monorail that slides. The main job of the truss track is to be straight, stable, and smooth. Structural engineers spend a lot of time making sure tracks for things like elevators or high-speed trains are smooth and supported.

Students will discover that longer tracks require more structural support to prevent them from breaking. Encourage them to reinforce their tracks with plates and add extra truss supports.

Challenge #10: Drawbridge

Students learn how to secure rope to their builds with Rope Anchors.

For references to the ACARA and NSW Curriculum refer to pages 84 to 91.

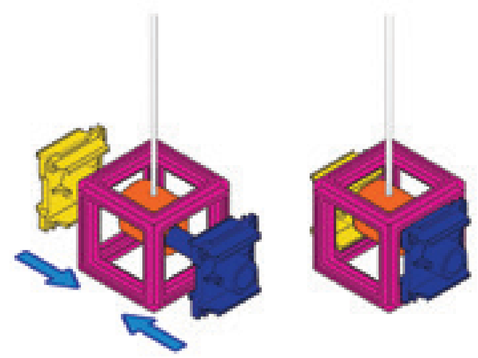


learn

The 0.5m and 1m Ropes in the Snap Kit are identifiable by the colour of the ends: the 0.5m Rope has orange ends, and the 1m Rope has blue ends. These ends allow the rope to be easily connected to trusses with a special connector called a Rope Anchor.

To use a Rope Anchor:

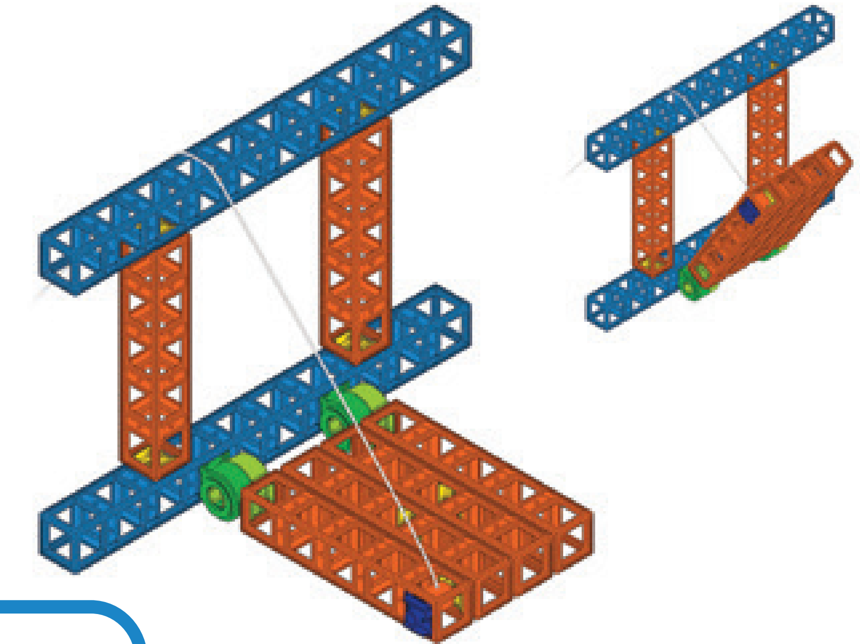
- drop the rope end inside a truss
- insert the Rope Anchor into the rope end
- click the Rope Anchor into the truss
- secure the other side with a Connector



Keep in mind that Rope Anchors can secure ropes to other Snap parts. For example, imagine attaching a rope to a Linear Motion Bracket in Challenge #9 and using the rope to move the monorail.

build

Students build a drawbridge that can be raised and lowered with a rope.



explore

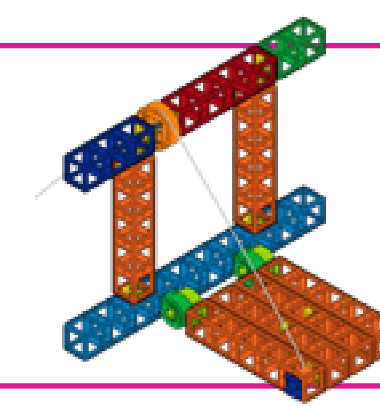
This drawbridge can fall over pretty easily. Try to make it more sturdy.

- If students have completed the other challenge cards, they will understand the importance of considering stability.
- Some students may attach trusses or weighted trusses to the base, like in Challenge #9. Some might get creative and build a castle to hold the bridge frame. This might be the most sturdy of them all.
- The picture only includes two Hinges. Increasing the number of Hinges to four will connect the bridge to the frame more securely.
- For students who need an extra challenge, prompt them to build a latch that will hold the bridge upright.

engineering tip

When the rope in the drawbridge is dragged over the corner of a truss, friction makes it harder to lift the bridge. A pulley is a simple machine designed to solve this exact problem.

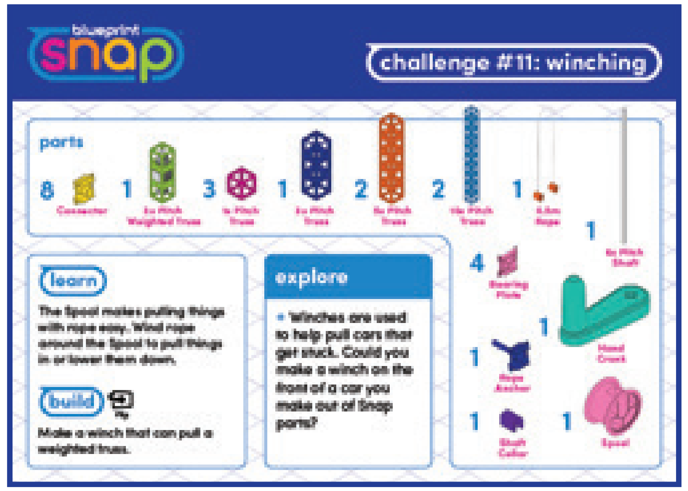
The pulley in this adapted drawbridge allows the rope to change direction smoothly. As the pulley spins, it replaces high-friction dragging with low-friction rolling. Give it a try!



Challenge #11: Winching

Students learn how to use a Spool to wind rope.

For references to the ACARA and NSW Curriculum refer to pages 92 to 99.

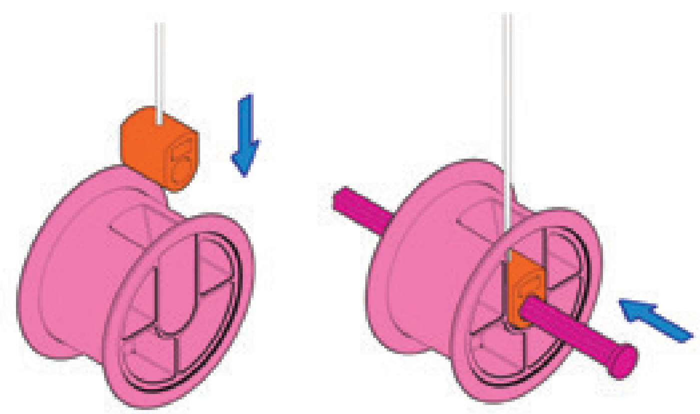


learn

The Spool allows you to wind and unwind the rope. In this challenge, students use the Spool to raise and lower the load or 3x Pitch Weighted Truss. Spools have many uses; you can find them in fishing poles, sewing machines, and 3D printer filament.

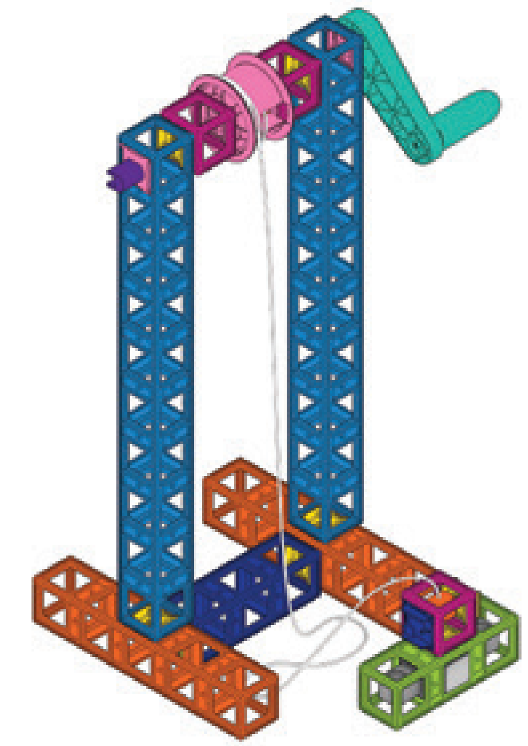
To attach a rope to the Spool:

- drop the end of a rope into the centre of the Spool
- insert a shaft through the rope end and Spool to secure the rope



build

Students build a winch that raises and lowers a 3x Pitch Weighted Truss.



explore

Winches help pull cars that get stuck. Could you make a winch for the front of a car out of Snap parts?

- Students can use the car they built in Challenge #8 as a starting point, but they will need to make modifications to be able to fit their winch. To attach it to the front of the car, they will need to make the wheelbase wider. Another option is to build up and attach the Spool above the wheel.
- If the winch pulls something heavy, the car will roll forward. Ask students to design a solution to prevent the car from rolling.

engineering tip

In engineering, there are two main types of motion or ways things can move.

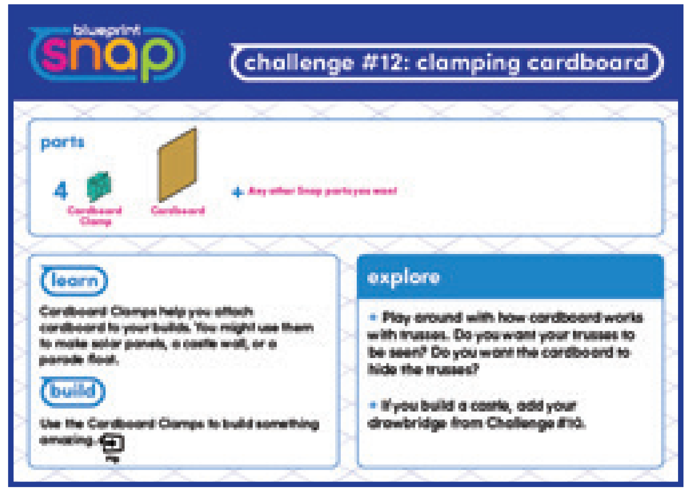
- Rotational motion is movement in a circle around a central point. Think spinning and Hand Cranks.
- Linear motion is movement in a straight line. Think sliding and Linear Motion Brackets.

The winch build combines both. The Spool showcases rotational motion to wind the rope, and the load showcases linear motion as it rises into the air.

Challenge #12: Clamping Cardboard

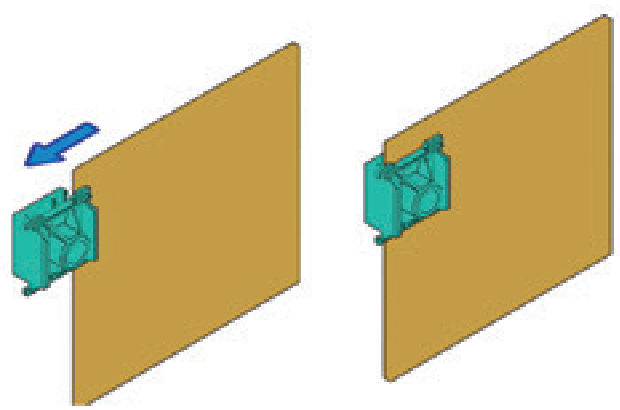
Students learn how to attach cardboard to the Cardboard Clamps to add creativity to their builds.

For references to the ACARA and NSW Curriculum refer to pages 100 to 107.



learn

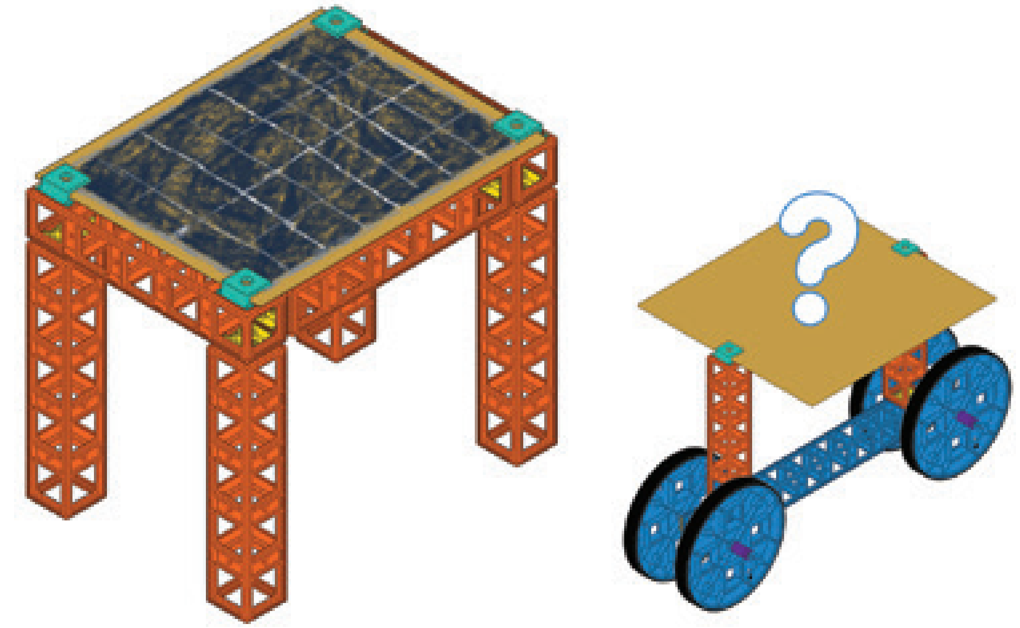
Cardboard Clamps snap into trusses like Connectors and have a flexible slot that securely grips pieces of cardboard. The clamp can hold cardboard of varying thicknesses and other craft materials like pipe cleaners or popsicle sticks.



Cardboard is a common classroom engineering tool, but building strong structures can be challenging. With Snap, students can build the frame with trusses and add the fun details with cardboard.

build

Students build something to showcase their creativity with Cardboard Clamps and craft materials.



explore

Play around with how cardboard works with trusses. Do you want your trusses to be seen? Do you want the cardboard to hide the trusses?

- Students will need practice cutting cardboard to fit their builds. If they use rect-angular pieces of cardboard, the edges of the trusses may be seen. To avoid this, they can cut notches in the cardboard to fit the Cardboard Clamps.

If you build a castle, add your drawbridge from Challenge #10.

- Revisit all the builds from the challenge cards and discuss how Cardboard Clamps could be used. For example, students might want to add a face to the stick figure in Challenge #3 or frame out the car in Challenge #8.

engineering tip

An inclined plane, or ramp, is a simple machine that helps move objects to a different height with less effort. Ask students to prototype different cardboard ramps with Snap and explore how a car rolls up and down.

- Ramps with steeper slopes will make the car roll faster on the way down, but will be harder to push back up.
- Ramps with less steep slopes will make the car roll more slowly on the way down, but will be easier to push back up.

You can also explore the same principles with a Sphero robot, like BOLT+. What is the steepest inclined plane that students can program the robot to roll up before it slips and loses traction?

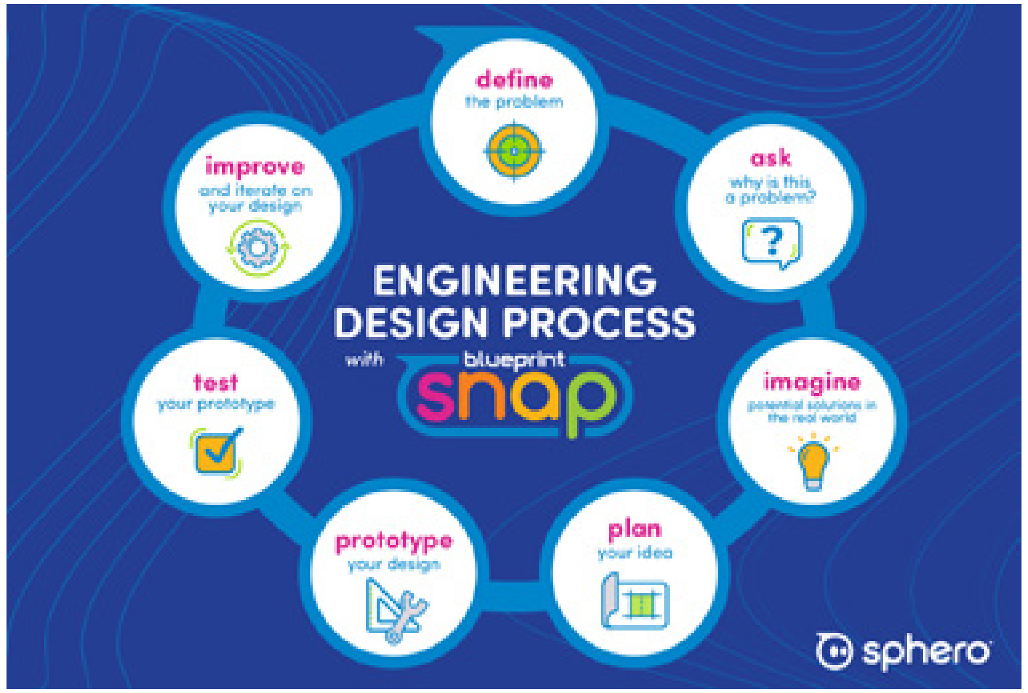
challenges #13-15

Challenges 13-15 are open-ended and do not require a prescribed set of parts or a predetermined final build. Here are a few ideas that might be useful when completing these challenges:

- Encourage students to sketch their ideas before building. This initial planning stage helps them visualize the final structure, consider constraints, and think through the assembly process, mirroring how engineers create blueprints before construction.
- Encourage students to share designs that did not work as expected and discuss how they improved them. This highlights that iteration and problem solving are necessary parts of the engineering design process and a step towards a better solution. This helps students build persistence and authentically models the work of engineers.
- Combine individual builds to promote collaborative learning. If the whole class is working on the same challenge, groups can bring their designs together in a shared space to create, for example, one big park. Consider a "gallery walk" for students to present their work, observe different solutions, and learn from their peers.
- Formally introduce the engineering design process to add structure and deepen the learning. Guiding students through the distinct stages of this process provides a valuable framework for their work and reinforces critical thinking and problem-solving skills.

engineering design process

Each lesson is structured around the Engineering Design Process, and Snap is the tool that brings it to life. Because the components easily click together and pull apart, students are empowered to quickly test ideas and troubleshoot when things don't work. This iterative cycle of building, testing, and refining helps students embrace failure not as an endpoint, but as a crucial part of developing innovative solutions. This process allows them to productively struggle with real-world problems and discover that the best answer is usually not the first answer.

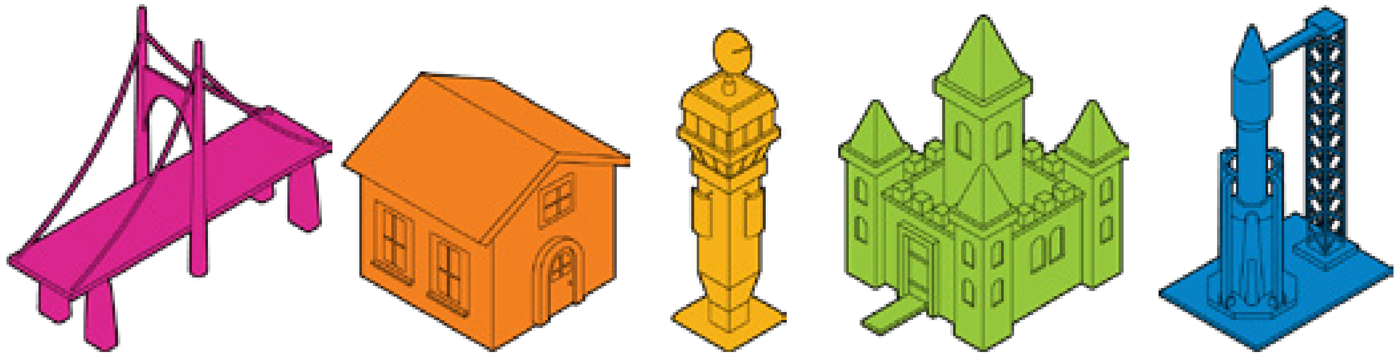


next steps

The challenge cards are great for introducing Snap, but what's next? Head over to Sphero Central to find more Snap lessons:

edu.sphero.com/blueprint-snap

the **Strong Structures** collection is a great place to start!



lesson 1: a bad bridge | lesson 2: welcome home | lesson 3: toppling towers | lesson 4: castle defense | lesson 5: ready, set, launch!

For references to the ACARA and NSW Curriculum refer to this link:
https://docs.google.com/spreadsheets/d/1GtjGHXqJpgBg39RgefFWkWxI_XE-TzNQCxpmPKStMJ0U/edit?gid=1876958769#gid=1876958769

Student Outcomes

Next Generation Science Standards (NGSS)

Blueprint Snap aligns closely to the NGSS 3-5 Engineering Design standards and their Science and Engineering Practices (SEPs).

science and engineering practices:

- Asking Questions and Defining Problems
- Planning and Carrying out Investigations
- Constructing Explanations and Designing Solutions

performance expectations:

- **3-5-ETS1-1**: Define a simple design problem reflecting a need or a want that includes specific criteria for success and constraints on materials, time, or cost
- **3-5-ETS1-2**: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- **3-5-ETS1-3**: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Standards for Technology and Engineering Literacy (STEL)

The International Technology and Engineering Educators Association (ITEEA) established STEL with a focus on transferable skills that set students up for success in STEM fields. Blueprint Snap offers opportunities for students to engage with and work towards mastery of the following STEL standards:

- 7H: Illustrate that there are multiple approaches to design
- 7I: Apply the technology and engineering design process
- 7J: Evaluate designs based on criteria, constraints, and standards
- 7K: Interpret how good design improves the human condition
- 7L: Apply universal principles and elements of design
- 7M: Evaluate the strengths and weaknesses of existing design solutions, including their own solution
- 7N: Practice successful design skills
- 7O: Apply tools, techniques, and materials in a safe manner as part of the design process

Career and Technical Education (CTE)

CTE offers practical training and education for students, setting them up for success when they enter the workforce. While CTE programs typically begin after elementary school, Snap lays the foundation for those programs by offering creative opportunities to develop necessary skills for any profession. Advance CTE has outlined Career Ready Practices that are essential for students from Pre-K onward. Blueprint Snap provides activities specifically designed to help students develop and strengthen these critical skills in the classroom.

CTE career ready practices:*

- Communicate clearly, effectively, and with reason
- Think critically to make sense of problems & persevere in solving them
- Manage time & space effectively
- Demonstrate a creative & innovative mindset
- Apply appropriate academic & technical skills

*More on Career Ready Practices from Advance CTE can be found at careertech.org

FAQs (frequently asked questions)

How do I take care of Snap parts?

Snap parts are durable, but we know classrooms can put even the strongest materials to the test. With that in mind, we recommend the following best practices to help keep your Snap Kit in tip-top shape:

- Create designated workspaces to avoid dropping parts, especially large builds. Lab tables, desks joined together, or even building on the floor, work well in some classroom environments.
- Remind students about the best build practices while taking apart builds. Using the Ring Tool will help prevent damage.
- Routinely check the floor around workspaces so parts are not stepped on or lost.
- When possible, keep small parts like Connectors in the Snap bin or tray until they're needed.
- Always put away parts and secure bins at the end of a lesson.
- If your Snap parts are dirty, use a wipe or towel with an alcohol-based cleaner to make them sparkle again.

How many students does a Blueprint Snap kit support?

We recommend two students per kit.

How can my students document their learning?

The student handouts that come with each lesson are a great place to start. If you'd like to take things further, consider having students keep an engineering notebook during the school year to document their thinking, models, and mistakes. Consider having students record reflection videos as an alternative or complement to pen and paper responses.

If you're unsure how to structure the notebooks or reflection videos, the engineering design process is a great framework to encourage consistent and clear documentation. Below are some prompts for each stage in the engineering design process that can help students get started.

define the problem

- What are you trying to build or create?
- What does your design need to do?
- What makes a design successful?

ask why is this a problem?

- What makes this challenge tricky?
- Why does the problem need a solution?
- What might go wrong with your design?

imagine potential solutions in the real world

- What is a wild idea that might solve your problem?
- Can you sketch three different possible solutions?
- Are there solutions to this problem already out there? What can you learn from them?

plan your idea

- Which solution are you going with?
- Which parts will you need?
- Draw a picture of your design.

prototype your design

- What does your finished prototype look like?
- What was the hardest part to build?
- How is your prototype different from your plan?

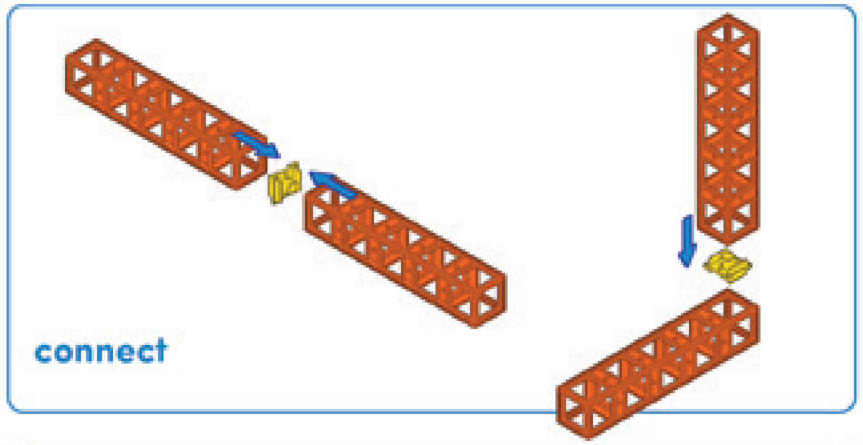
test your prototype

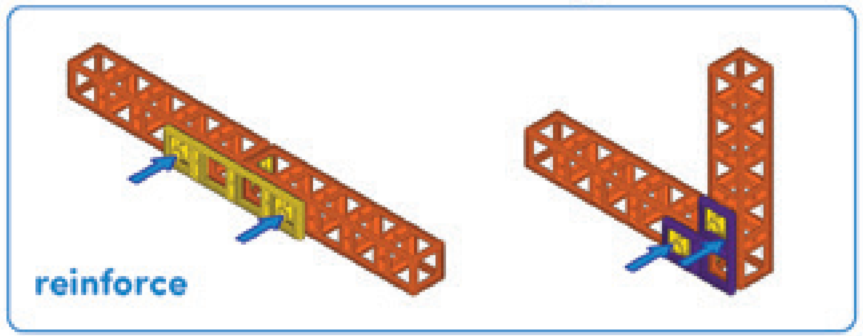
- How will you test your design to see if it works?
- What happened when you tested it?
- Did anything break or fail during your testing?

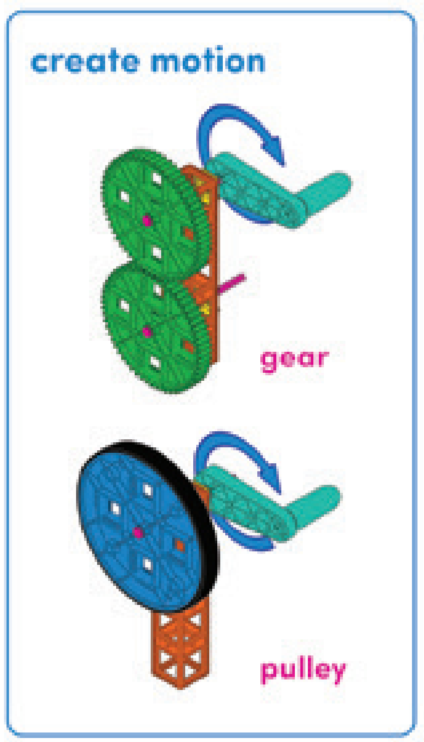
improve and iterate on your design

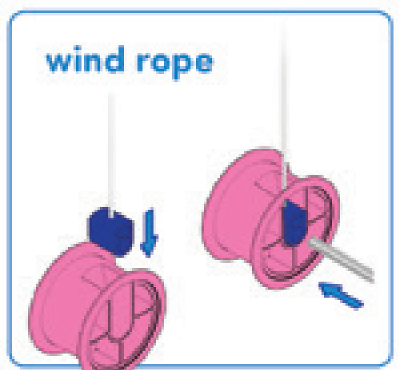
- What is one thing you would change to make it better?
- What did you learn from your testing?
- Draw a picture of your design.

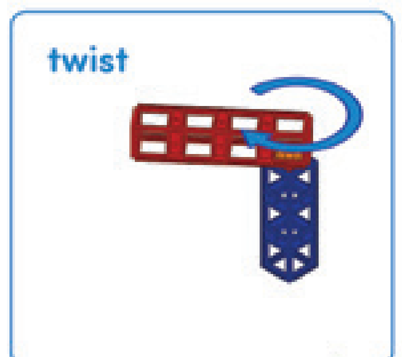
Key Building Practices

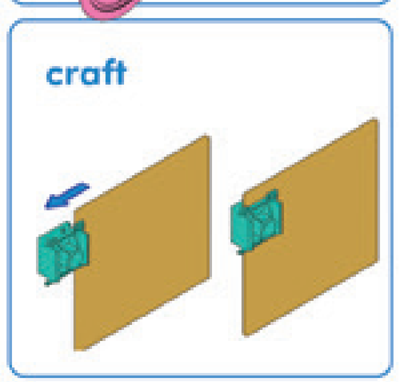


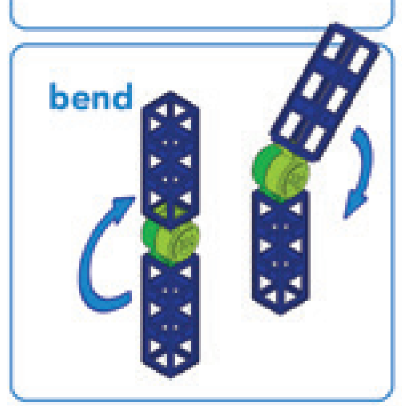


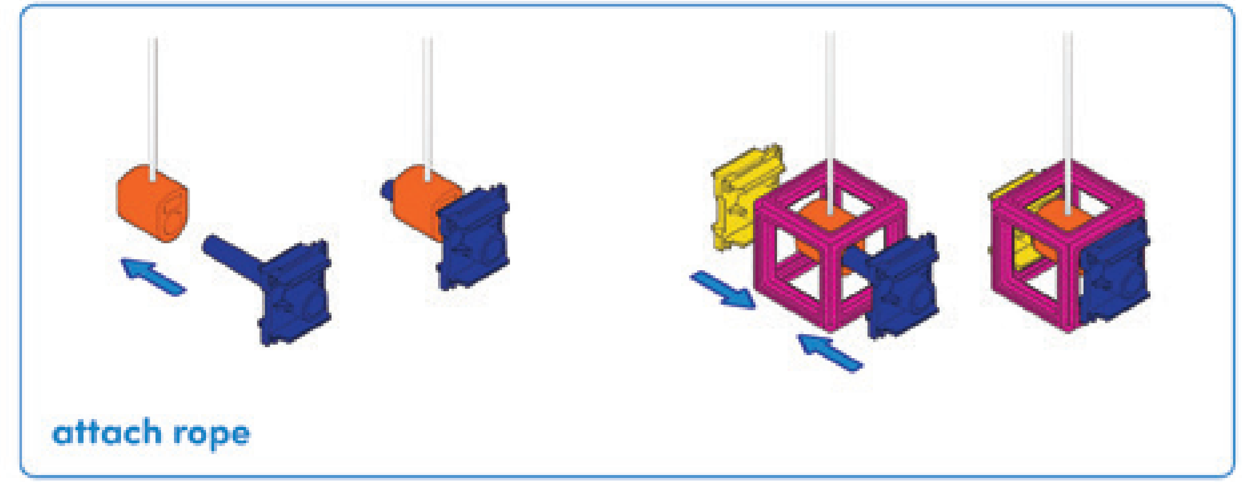


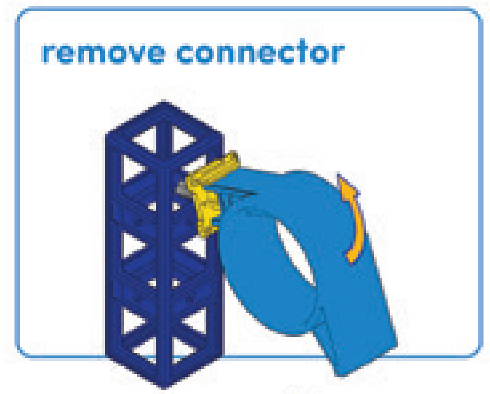


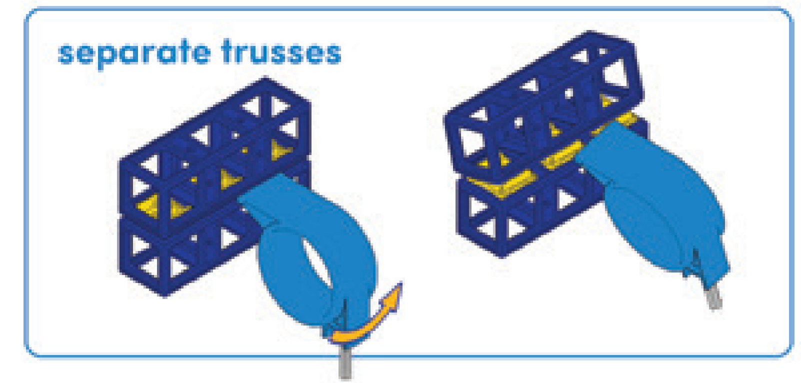


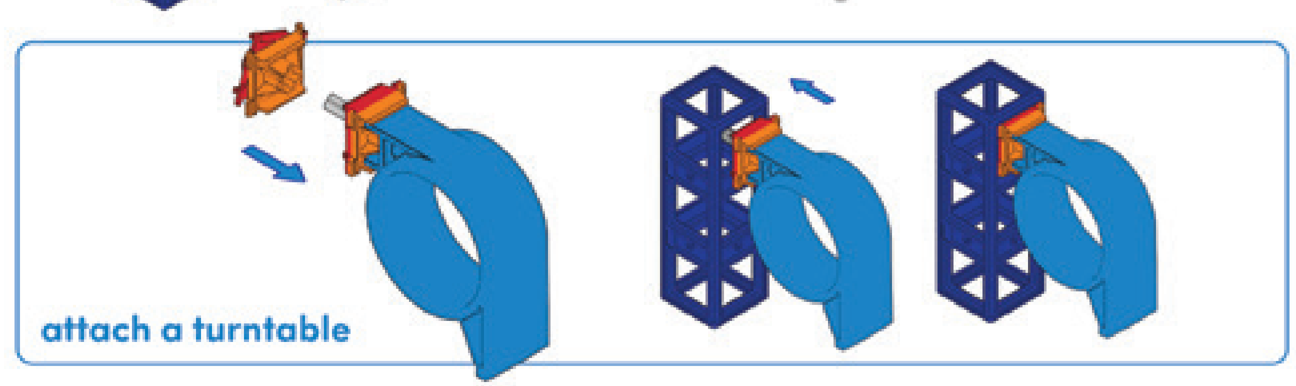




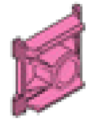
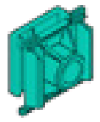
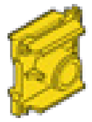
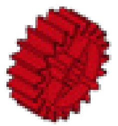
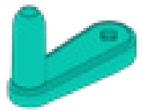
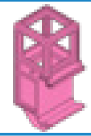
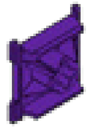
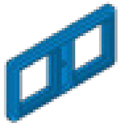
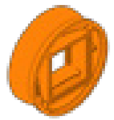


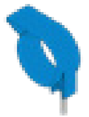
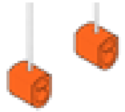
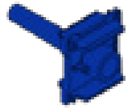
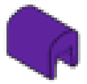
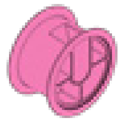
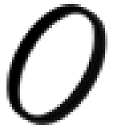
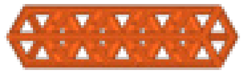
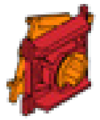






Snap Parts Glossary

	**Bearing Plate**	Bearing Plates click into trusses and other Snap parts. They hold shafts while allowing them to rotate.
	**Capped Shaft**	Plastic-capped shafts fit through Lock Plates, Bearing Plates, and Connectors, allowing things to spin. One side is capped so it won't slide all the way through another Snap part. The other side can be secured with a Shaft Collar. **Varieties**: 2x Pitch Capped Shaft | 3x Pitch Capped Shaft | 4x Pitch Capped Shaft
	**Cardboard Clamp**	Cardboard Clamps snap into trusses and are used to attach cardboard and other craft materials to Snap builds, facilitating the addition of creative elements.
	**Connector**	Connectors click into openings on Snap parts and allow you to connect two parts.
	**Gear**	Snap gears have teeth, or cogs, that mesh with other gears and help make motion. **Varieties**: 20T Gear | 60T Gear
	**Hand Crank**	The Hand Crank allows you to spin a shaft or other Snap part by hand.
	**Hinge**	Hinges click into trusses and other Snap parts to allow connections at angles other than 90° and 180°.
	**Linear Motion Bracket**	Linear Motion Brackets help add sliding motion to Snap builds. The rails fit into the groove on trusses, allowing the part to slide back and forth.
	**Lock Plate**	Lock Plates click into trusses and other Snap parts, stopping them from rotating.
	**Plate**	Plates reinforce connections between trusses and other Snap parts and come in a variety of straight and angled arrangements. They help add strength and stability to builds **Varieties**: 1x2 Plate | 1x4 Plate | 2x2 45° Angle Plate | 2x2 90° Angle Plate | 2x3 Tee Plate
	**Pulley**	Pulleys are wheels with grooved rims that work with ropes to change the direction of force. The large 90mm Pulley can also be converted into a wheel by adding the 100mm Tire. **Varieties**: 30mm Pulley | 45mm Pulley | 90mm Pulley

	**Ring Tool**	The Ring Tool is a multi-purpose tool for inserting Connectors, removing Connectors, and prying trusses apart.
	**Rope**	Rope can be used with the Spool and pulleys to help add movement to your builds. **Varieties**: 0.5m Rope | 1m Rope
	**Rope Anchor**	Rope Anchors secure rope to trusses and other Snap parts by attaching the end of the rope to the anchor.
	Shaft	Metal shafts fit through Lock Plates, Bearing Plates, and Connectors, allowing things to spin. They need to be secured on both sides with Shaft Collars. **Varieties**: 5x Pitch Shaft | 6x Pitch Shaft | 10x Pitch Shaft
	**Shaft Collar**	Shaft Collars attach to shafts and help keep them in place.
	**Spool**	Wind rope around the Spool to pull things in or lower them down. Secure rope to a Spool by sliding the shaft through the end of the rope in the centre of the Spool.
	**Tire**	The Tire wraps around the 90mm Pulley to create a wheel with a diameter of 100mm that can be used in cars, trucks, and other vehicles.
	**Truss**	Trusses are the primary structural part in any Snap build and have openings on all six faces for Connectors, Lock Plates, and Bearing Plates. Each pitch, or unit on a truss, is 25mm long. For example, a 3x Pitch Truss is 75mm in length and a 5x Pitch Truss is 125mm in length. **Varieties**: 1x Pitch Truss | 2x Pitch Truss | 3x Pitch Truss | 4x Pitch Truss | 5x Pitch Truss | 10x
	**Turntable**	Turntables combine the Lock Plate and Bearing Plate. They hold shafts and allow one connection to spin while the other remains stationary.
	**Weighted Truss**	Weighted trusses are similar to regular trusses but have additional mass. Each pitch on a weighted truss weighs 25 grams (g). Therefore, the 1x Pitch Weighted Truss weighs 25g, and the 3x Pitch Weighted Truss weighs 75g. **Varieties**: 1x Pitch Weighted Truss | 3x Pitch Weighted Truss

ACARA and NSW Curriculum Alignment Summary

Challenge 1 - Strong		
Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how structural engineers design bridges to meet community needs for strong, stable structures. They explore factors that impact bridge design, discovering that minimising connection points and adding reinforcement improves structural integrity—key principles that structural engineers consider when designing real-world bridges and buildings.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how downward forces (weight/gravity) affect the bridge structure, causing stress at joints. They explain how the properties of different configurations affect strength—discovering that single long trusses are stronger than multiple connected shorter trusses—and how plates distribute forces across joints to prevent structural failure.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore the design opportunity of creating a stronger bridge by testing different configurations of trusses and connectors. They experiment with various Snap components (different truss lengths, additional connectors, plates, weighted trusses as stabilisers) and conduct fair tests using classroom objects to measure and compare the effectiveness of different reinforcement strategies.
AC9TDE4P02	Generate, communicate and compare designs	Students generate multiple design solutions for strengthening the bridge and communicate their ideas using technical vocabulary (pitch, truss, connector, joint, plate, reinforcement). They document their improvements through annotated sketches, photographs, or engineering notebooks showing before-and-after modifications.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate Snap components based on their structural properties and use the Ring Tool safely to assemble, disassemble, and modify their bridges. They demonstrate proper handling techniques for inserting connectors, removing connectors, and separating trusses without damaging components.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their bridge modifications against design criteria such as strength (ability to hold weight), stability (resistance to tipping), and structural efficiency (achieving strength with minimal parts). They justify their design decisions by providing evidence from load testing and compare different reinforcement approaches to determine which modifications best meet the design goal.
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how structural engineers analyse competing factors in bridge design: the trade-off between using longer single-piece trusses (stronger but potentially more material-intensive) versus connected shorter trusses (more flexible in design but requiring reinforcement at joints). They consider how engineers balance structural integrity, material efficiency, construction complexity, and cost when designing real-world structures, demonstrating understanding that optimal design involves managing multiple competing requirements.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how the structural properties of Blueprint Snap components determine their function in bridge construction—trusses provide rigid framework and transfer loads, connectors create articulation points that become stress concentrators under load, plates redistribute forces across joints by increasing contact area, and the modular pitch system allows for scalable structural designs with predictable strength characteristics.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students investigate the complex engineering challenge of optimising bridge strength through systematic experimentation with component selection (comparing structural efficiency of various truss configurations), reinforcement strategies (testing plate positions and quantities), and base stabilisation methods (using weighted trusses). They document comprehensive findings about which materials and processes produce superior structural outcomes.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated design iterations exploring multiple reinforcement approaches, iterate based on load-testing data, and communicate their engineering solutions using precise technical language (structural terminology like "load distribution," "stress concentration," "joint reinforcement"). They create detailed engineering documentation including force diagrams, comparative analysis charts, annotated diagrams showing stress points, photographs comparing configurations, or digital presentations explaining structural mechanics and their design improvements.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make informed selections of Snap components based on structural engineering principles—choosing truss lengths that minimise joint counts, positioning plates strategically at high-stress locations, and incorporating weighted trusses for enhanced stability. They demonstrate mastery of assembly techniques using the Ring Tool for precise, safe construction and modification of increasingly complex structures.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate comprehensive design criteria encompassing structural performance (load capacity, stability), material efficiency (achieving strength with minimal components—a sustainability consideration), and engineering elegance (simple, effective solutions). They conduct rigorous evaluation through quantitative testing and provide evidence-based justifications for their final design decisions, demonstrating understanding that sustainable design means using resources efficiently whilst meeting performance requirements.

Challenge 1 - Strong		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use an iterative design process to address the need for a stronger bridge structure. They identify the problem (weak bridge), generate solutions (various reinforcement methods), test prototypes, evaluate results, and modify their designs based on testing outcomes—demonstrating the complete design cycle.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how forces and energy affect physical systems by exploring how gravitational force acts on bridge structures under load. They examine how energy is transferred through the structure when weight is applied, observe how applied forces can cause structural failure, and explore ways to coun-teract these forces through reinforcement to prevent collapse.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about what makes bridges stronger (e.g., "Does using a longer single truss make a bridge stronger than connecting multiple shorter trusses?" or "Where should plates be positioned for maximum strength?"). They create fair tests by systematically adding weight to different bridge configu-rations and comparing results to gather evidence about structural performance.
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students use sophisticated design processes involving multiple iterations: creating initial bridge structures, systematically evaluating structural performance through controlled testing, identifying specific failure points, modifying designs with targeted improvements, re-evaluating enhanced structures, and con-tinuing this cycle to achieve optimised solutions demonstrating advanced problem-solving and engineering thinking.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustain-able practices	Students use empirical evidence from structural testing to explain how engineering knowledge of forces, material properties, and structural mechanics enables the design of efficient, sustainable structures. They demonstrate that understanding load paths and stress distribution allows engineers to reinforce only critical locations, minimising material use whilst maximising strength—a key principle in sustainable engineering design that reduces waste and envi-ronmental impact.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about structural engineering, identify multiple variables (truss configuration, joint density, reinforcement placement, base geometry, load distribution), design controlled experiments isolating specific variables, and conduct fair tests using standardised loading procedures to gather quantitative data about structural performance under various configurations.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret load-testing data to support explanations about which structural modifications produce superior strength. They construct evi-dence-based arguments for their design decisions, citing specific test results to explain why particular configurations (e.g., "the 5x pitch truss supported more weight than three connected 2x pitch trusses") demonstrate engineering principles about joint strength and load distribution.

Challenge 2 - Stronger

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how structural engineers use reinforcement techniques to strengthen structures, exploring how the strategic placement of plates can significantly improve bridge stability. They discover that engineers must consider where to apply reinforcements most effectively to maximise strength whilst minimising material use—demonstrating sustainable design thinking in meeting community infrastructure needs.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how plates work as structural reinforcements by distributing forces across joints, preventing point-stress failures. They explain how different plate shapes (1x4 Plate, 2x2 90° Plate, 2x3 Tee Plate, 2x2 45° Plate) have different properties and applications, discovering that plates covering multiple joints provide greater reinforcement than those covering single connection points.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore the design opportunity to strengthen their bridge from Challenge #1 by testing various plate configurations. They experiment with different plate types, positions (underside, sides, top, corners of the bridge), and quantities to determine which combinations most effectively reinforce the structure, conducting comparative tests to measure improvements in load-bearing capacity.
AC9TDE4P02	Generate, communicate and compare designs	Students generate and communicate multiple design solutions for plate placement, using technical terminology (1x4 Plate, 2x2 90° Plate, reinforcement, joint). They document their findings about where plates work best, explaining their reasoning with evidence from testing, and may create annotated diagrams showing optimal plate positions for maximum structural reinforcement.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate plates based on the structural needs of their bridge—choosing 1x4 Plates to span multiple joints, 2x2 90° Plates for corner reinforcement, and 2x3 Tee Plates for complex junction points. They safely attach plates using connectors and the Ring Tool, demonstrating understanding of how multiple connector points increase reinforcement strength.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their reinforcement strategies against design criteria such as structural strength improvement, efficiency of plate placement, and material economy. They test how much weight their bridges can support with plates in different locations, compare results, and determine which approach provides optimal reinforcement—supporting their conclusions with quantitative evidence from load testing.
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how structural engineers balance competing factors when reinforcing structures: adding plates increases strength but also adds weight, material cost, and construction complexity. They analyse trade-offs between maximum reinforcement (multiple plates over every joint) versus strategic reinforcement (plates only at critical stress points), demonstrating understanding that sustainable engineering involves achieving required performance with minimal resource use.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how different plate types have distinct structural properties suited to specific applications: 1x4 Plates provide linear reinforcement across multiple joints; 2x2 90° Plates strengthen perpendicular connections at corners; 2x3 Tee Plates reinforce T-junctions; and 2x2 45° Plates accommodate non-perpendicular angles. They articulate that plate effectiveness depends on the number of connector points securing it and its geometric relationship to the joint being reinforced.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into structural reinforcement, systematically testing all available plate types in various positions and orientations. They explore creative applications beyond simple joint reinforcement, such as using plates as flat bases for bridges or as structural elements that extend beyond the truss framework, documenting which materials and techniques provide optimal strength-to-weight ratios.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate multiple reinforcement schemes, iterate through testing cycles to refine plate placement, and communicate sophisticated design rationales using precise engineering terminology (stress concentration, force distribution, structural redundancy, load path). They may create detailed technical documentation including stress-point diagrams, comparative load-test data tables, or digital presentations explaining the engineering principles behind effective plate reinforcement.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make strategic selections of plate types based on structural analysis of their bridge design, choosing appropriate configurations for specific reinforcement needs. They demonstrate advanced assembly techniques, using multiple connectors per plate for maximum strength, positioning plates for optimal load distribution, and safely modifying complex structures using the Ring Tool with precision and care.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate sophisticated design criteria balancing structural performance (maximum load capacity, failure prevention), material efficiency (minimal plate usage for required strength—sustainability consideration), and engineering effectiveness (strategic reinforcement at critical points). They evaluate solutions through rigorous testing, quantify improvements, and justify their final reinforcement strategies with evidence-based reasoning about performance versus resource investment.

Challenge 2 - Stronger		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use an iterative design process to enhance their bridge from Challenge #1, identifying weak joints as the problem, generating solutions through plate reinforcement, prototyping different configurations, testing load capacity, and refining their designs based on results. They demonstrate understanding that effective reinforcement requires strategic placement rather than simply adding more material.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how forces affect physical systems by exploring how plates redistribute force energy across bridge structures. They examine how concentrated forces at joints can cause failure, and discover that plates spread these forces over larger areas, reducing stress concentrations and preventing structural collapse—demonstrating practical applications of force distribution principles.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose investigative questions about plate effectiveness (e.g., "Does plate placement on the underside work better than on top?" or "How many connectors should be used to attach a plate for maximum strength?"). They create fair tests by placing plates in different positions on identical bridge structures and systematically measuring load capacity to compare reinforcement effectiveness.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students collect data from load tests on bridges with various plate configurations, interpret this data to identify patterns (e.g., plates covering two joints are more effective than those covering one), and describe relationships between plate placement, number of connector points, and overall structural strength.
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, multi-iteration design processes: analysing structural weaknesses from Challenge #1, hypothesising about effective reinforcement locations, creating prototypes with various plate configurations, conducting systematic load testing, evaluating results against performance criteria, modifying designs based on evidence, and repeating this cycle until achieving optimised reinforcement solutions that demonstrate advanced engineering problem-solving.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use empirical evidence from comparative load testing to explain how engineering knowledge of stress distribution and structural mechanics enables sustainable reinforcement strategies. They demonstrate that understanding where forces concentrate allows engineers to reinforce only critical locations rather than over-engineering entire structures, exemplifying sustainable practice through strategic material placement that minimises waste whilst maximising structural performance.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose complex investigative questions about reinforcement effectiveness, identify multiple variables (plate type, placement position, orientation, number of connector points, coverage of single versus multiple joints), design controlled experiments that isolate these variables, and conduct systematic fair tests using standardised loading procedures to gather quantitative data about the relationship between reinforcement strategies and structural performance.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret comprehensive data sets from multiple load tests, analyse patterns showing how different plate configurations affect structural strength, and construct evidence-based arguments for optimal reinforcement strategies. They cite specific quantitative results (e.g., "the bridge with a 1x4 Plate covering two joints supported 40% more weight than one with plates covering single joints") to support engineering explanations about force distribution principles.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create written documentation explaining the engineering concepts behind structural reinforcement, using technical vocabulary (force distribution, stress concentration, joint failure, structural redundancy) and scientific reasoning. They may produce engineering reports, annotated diagrams with explanatory text, or design journals that document their testing methodology, data analysis, and conclusions about effective plate reinforcement strategies.

Challenge 3 - Move

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how designers and engineers create products with moving parts to meet human needs, such as toys, tools, and mechanisms. They explore how Turntables and Hinges allow designers to add realistic movement to models and functional mechanisms, discovering that different types of joints serve different purposes in designed products—rotating joints for twisting motions and hinged joints for bending movements.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how Turntables and Hinges function differently from fixed Connectors, explaining that these joints allow controlled movement in specific directions. They discover that each joint has two sides—one that locks onto a shaft and rotates with it, and another that allows the shaft to spin freely—demonstrating how the properties of these components enable force transmission and movement in mechanical systems.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore the design opportunity to create articulated models by testing Turntables for twisting movements and Hinges for bending movements. They experiment with building moveable joints in their stick figure, discovering which component types work best for different body parts (Turntables for shoulders that rotate, Hinges for elbows and knees that bend).
AC9TDE4P02	Generate, communicate and compare designs	Students generate creative design ideas for enhancing their stick figure with additional joints, accessories, or features. They communicate their designs using technical terms (Turntable, Hinge, joint, rotate, bend) and may sketch or photograph their models, explaining which joints they used for specific movements and why certain components were better suited to particular applications.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate joint types based on desired movement—choosing Turntables when parts need to rotate or twist, and Hinges when parts need to bend at angles. They safely assemble their stick figures using the Ring Tool, learning to orient Turntables and Hinges correctly so movement occurs in the intended direction.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their stick figure designs against criteria such as range of movement, joint stability, and realistic articulation. They assess whether Turntables and Hinges provide more suitable movement for their model than fixed Connectors would, justifying their component choices based on how well the joints enable the intended motions.
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how mechanical engineers and product designers balance competing factors when incorporating joints into designs: Turntables and Hinges provide movement but introduce complexity and potential failure points compared to fixed connections; adding more joints increases articulation but reduces structural stability; and different joint types serve different purposes, requiring designers to select appropriate mechanisms for specific functions whilst maintaining overall product integrity.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explore how mechanical systems transform input forces into rotational or bending motion through joints. They explain that Turntables enable rotational movement around a central axis whilst Hinges enable angular movement in one plane, demonstrating understanding of how different joint mechanisms transform applied forces into specific types of motion in mechanical systems.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain the dual-sided property of Turntables and Hinges: one side locks onto shafts to transmit rotational force, whilst the other side allows free rotation, creating controlled movement in mechanical systems. They articulate that this property enables force transmission through joints when desired, or independent movement when needed, and explain how shaft orientation determines which side locks and which side spins, affecting the overall function of articulated mechanisms.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students investigate the engineering challenge of creating realistic articulated models by comprehensively exploring how Turntables and Hinges enable different types of movement. They experiment with combining multiple joints to create complex motion systems, test how shaft placement affects joint behaviour, and explore creative applications such as articulated tools, mechanical toys, or functional mechanisms that demonstrate understanding of kinematic principles.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated designs for articulated figures or mechanisms with multiple moving parts, iterate through testing cycles to optimise joint placement and movement range, and communicate their mechanical designs using precise engineering terminology (rotation axis, angular movement, kinematic chain, degrees of freedom, joint articulation). They may create technical drawings showing joint locations, movement diagrams with arrows indicating motion directions, or digital animations demonstrating how their mechanisms function.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make informed selections between Turntables and Hinges based on biomechanical analysis of their stick figure or mechanism design—choosing Turntables for ball-and-socket style joints (shoulders, hips) requiring rotational movement, and Hinges for single-axis joints (elbows, knees) requiring bending motion. They demonstrate mastery of joint orientation, ensuring the locking side faces the correct direction for intended force transmission, and safely construct increasingly complex articulated systems.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate design criteria for articulated models including functional performance (range of motion, joint stability, realistic movement), mechanical efficiency (appropriate joint selection for intended motion, minimal unnecessary joints—sustainability consideration), and structural integrity (joints that provide movement whilst maintaining stability). They evaluate their designs by testing joint functionality, assessing whether movements are realistic and controlled, and refining joint selection and placement based on performance evidence.

Challenge 3 - Move		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create an articulated stick figure, identifying the need for moveable joints, selecting appropriate components (Turntables and Hinges), assembling their model, testing joint movements, and enhancing their design with additional features or improved articulation based on how well the joints function.
ST2-DDT-02	Designs and uses algorithms, represents data and uses digital systems for a purpose	Students design a sequential process (algorithm) for building their stick figure: selecting trusses for limbs, choosing appropriate joints for connections, assembling components in logical order, and testing movements. They follow step-by-step construction procedures, demonstrating algorithmic thinking in creating a functional mechanical system.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how physical systems involve movement and energy transfer through mechanical joints. They explore how applying force (energy) to one part of their stick figure causes motion to transfer through Turntables and Hinges, demonstrating that joints can either transmit movement (when locked to a shaft) or allow independent motion (when freely rotating).
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ iterative design processes to create sophisticated articulated mechanisms: planning joint locations based on desired movements, constructing initial prototypes, testing range of motion and joint stability, identifying improvements (adding joints for increased articulation, reorienting joints for correct movement, replacing inappropriate joint types), and refining their designs through multiple iterations to achieve optimal mechanical function.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create sequential algorithms for constructing articulated mechanisms, breaking complex assemblies into ordered steps (select limb trusses, position joints, insert shafts, test movements, add features). They evaluate whether their construction sequence was efficient and modify their approach for improved results, demonstrating algorithmic thinking in planning and executing mechanical assembly procedures.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from testing different joint configurations to explain how engineering knowledge of mechanics and kinematics enables efficient mechanism design. They demonstrate that understanding joint properties allows designers to select appropriate components for specific movements, avoiding over-engineering with excessive joints or using incorrect joint types—representing sustainable design practice through purposeful component selection that achieves required functionality with minimal complexity.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose investigative questions about joint functionality (e.g., "How does shaft orientation affect which side of a Turntable locks?" or "Can Hinges provide the same movement as Turntables for certain joints?"), identify variables (joint type, shaft placement, number of joints, joint orientation), and conduct systematic tests to understand how these variables affect the range and type of movement achievable in articulated mechanisms.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret observations from joint testing to support explanations about mechanical function. They construct evidence-based arguments for joint selection decisions, citing specific examples of how Turntables provided superior rotation for certain applications whilst Hinges proved more suitable for others, demonstrating understanding of the relationship between joint properties and mechanical performance.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create written documentation explaining how Turntables and Hinges function as mechanical joints, using technical vocabulary (rotation, articulation, angular movement, force transmission, locking mechanism) and scientific reasoning. They may produce technical explanations comparing joint types, annotated diagrams labelling joint components and movement directions, or design journals documenting their decision-making process for selecting and positioning joints in their articulated mechanisms.

Challenge 4 - More Moving

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how mechanical engineers use gears, pulleys, and shafts to create machines that transfer motion and force to meet various needs. They explore how these components appear in everyday products like bicycles, clocks, and toys, discovering that engineers select specific mechanisms based on whether they need to transmit rotation, change speed, or alter the direction of movement in their designs.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how capped shafts act as axles that transmit rotational force through gears and pulleys. They explain that gears have teeth that mesh together to transfer motion between shafts, whilst pulleys can rotate freely on shafts or be locked to them. They discover that Shaft Collars secure the un-capped end of shafts, preventing components from sliding off, and that different shaft lengths accommodate different spacing requirements in mechanical systems.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore how gears and pulleys create motion by testing the mechanism provided in the challenge. They experiment with removing shaft collars to observe what happens, comparing capped shafts with metal shafts to understand their different properties and applications. They investigate how gears mesh together and how pulleys can be used with or without additional components like Turntables or Bearing Plates.
AC9TDE4P02	Generate, communicate and compare designs	Students generate creative ideas for mechanisms using gears and pulleys, such as vehicles with wheels, wells with pulley systems, or fans with spinning components. They communicate their design concepts using technical vocabulary (gear, pulley, shaft, axle, mesh, rotate, Shaft Collar) and may sketch or photograph their mechanisms, explaining how components work together to create movement.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate shafts based on their needs—capped shafts for simpler assemblies with one fixed end, or metal shafts for longer spans requiring support on both ends. They safely assemble mechanisms by sliding gears and pulleys onto shafts, positioning Shaft Collars correctly to secure components, and ensuring gears mesh properly. They learn to attach smaller pulleys using Turntables or Bearing Plates to enable rotation.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their mechanisms against criteria such as smooth operation, proper gear meshing, secure shaft connections, and functional movement. They test whether their gears rotate together correctly and whether pulleys spin freely or drive other components as intended, making adjustments based on how well their mechanisms perform.
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing fac-tors including sustainability in the design of products, services and environments	Students explain how mechanical engineers balance competing factors when designing gear and pulley systems: capped shafts are simpler to use (requir-ing securing on only one end) but come in limited lengths and may be less strong; metal shafts are stronger and available in longer lengths but require Shaft Collars on both ends, adding complexity. Engineers must consider assembly difficulty, strength requirements, spatial constraints, and material efficiency when selecting components for mechanical systems.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain how rotational energy is transmitted and transformed through mechanical systems. They describe how input rotation applied to one gear is transferred through meshed teeth to drive another gear, and how this principle enables machines to convert one type of motion into another or to change the speed and force of rotation—foundational concepts for understanding how motors drive mechanical systems.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain the distinct properties of capped versus metal shafts: capped shafts have a permanent end cap that prevents components from sliding off one side, making them suitable for cantilever-style assemblies but limiting length options; metal shafts lack fixed ends, requiring Shaft Collars on both sides but providing greater strength, longer spans (5x, 6x, 10x pitch), and flexibility for complex assemblies. They articulate how gears with teeth create positive engagement for force transmission, whilst pulleys with smooth surfaces enable different mechanical functions like rope-based systems or free-spinning wheels.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into mechanical systems by building and testing various configurations with gears, pulleys, and both shaft types. They explore gear trains (multiple gears in sequence), pulley systems for mechanical advantage, and combinations of components to create function-al mechanisms. They document findings about shaft strength, gear meshing requirements, optimal Shaft Collar placement, and how different configurations affect mechanical performance.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated mechanical designs incorporating gear trains and pulley systems, iterate through testing cycles to optimise component se-lection and assembly, and communicate using precise engineering terminology (gear train, mesh, pitch, axle, drive shaft, idler gear, mechanical advantage, rotational axis). They may create technical diagrams showing gear arrangements with teeth engagement, annotated assembly instructions indicating shaft types and Shaft Collar positions, or digital presentations explaining how rotational forces transfer through their mechanical systems.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make strategic decisions about shaft selection based on mechanical requirements: choosing capped shafts for shorter, simpler mechanisms where one-end securing is adequate; selecting metal shafts for longer spans, heavier loads, or assemblies requiring support at both ends. They demonstrate mastery of gear and pulley mounting, ensuring components are properly secured with Shaft Collars positioned to allow smooth rotation whilst preventing unwanted movement, and safely construct increasingly complex mechanical systems.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate design criteria for mechanical systems including functional performance (smooth gear meshing, efficient force transmission, stable rotation), mechanical efficiency (appropriate component selection that achieves required function without unnecessary complexity—sustainability consid-eration), and assembly practicality (secure connections, proper shaft support). They evaluate designs through testing, assess whether mechanisms operate smoothly and reliably, and refine component choices based on performance evidence.

Challenge 4 - More Moving		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create mechanisms with gears and pulleys, identifying purposes for their designs (vehicles, lifting systems, spinning mechanisms), selecting appropriate components (gears, pulleys, shafts of suitable lengths), assembling their mechanisms, testing functionality, and refining their designs based on how smoothly components operate together.
ST2-DDT-02	Designs and uses algorithms, represents data and uses digital systems for a purpose	Students follow sequential procedures for building mechanisms with rotating components: selecting and measuring shaft lengths, sliding components onto shafts in correct order, positioning Shaft Collars appropriately, ensuring gears mesh correctly, and testing rotation. They demonstrate algorithmic thinking by understanding that assembly order matters and certain steps must be completed before others.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how energy is transferred through mechanical systems using gears, pulleys, and shafts. They observe that when force is applied to rotate one gear, energy transfers through meshed teeth to rotate connected gears, demonstrating how physical systems transmit and transform energy through direct contact and rotational motion.
ST2-DDT-02	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about mechanical systems (e.g., "What happens when we remove the Shaft Collars?" or "How does using metal shafts instead of capped shafts change how the mechanism works?"). They conduct tests by systematically modifying components and observing the effects on movement, gathering evidence about how different shaft types and securing methods affect mechanical function.
ST2-SCI-01	Uses and interprets data to describe patterns and relationships	Students observe and record how gears interact, noting that when one gear rotates, the meshed gear rotates in the opposite direction. They identify the relationship between shaft length and the need for Shaft Collars, recognising patterns in how components must be secured to function properly in mechanical assemblies.
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, iterative design processes to create functional mechanisms: analysing mechanical requirements, selecting appropriate gears, pulleys, and shaft types, assembling prototypes, testing for smooth operation and proper force transmission, identifying improvements (adjusting gear meshing, repositioning Shaft Collars, substituting shaft types), and refining designs through multiple iterations to achieve optimised mechanical performance.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for constructing mechanical systems, specifying precise sequences: measure required shaft length, select appropriate shaft type, slide first component (noting orientation), add subsequent components in order, position Shaft Collars at calculated distances, verify gear meshing, test rotation. They evaluate whether their assembly procedure was efficient and modify their algorithmic approach for improved construction outcomes, demonstrating advanced procedural thinking.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from testing different shaft types and configurations to explain how engineering knowledge of mechanical systems enables efficient mechanism design. They demonstrate that understanding component properties allows engineers to select appropriate parts for specific applications—using simpler capped shafts when adequate versus stronger metal shafts only when necessary—representing sustainable design practice through purposeful component selection that meets performance requirements without over-engineering.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose complex investigative questions about mechanical systems (e.g., "How does shaft length affect mechanism stability?" or "What happens when gears of different sizes mesh together?"), identify variables (shaft type and length, gear size, Shaft Collar position, number of gears in train, pulley attachment methods), design controlled experiments isolating these variables, and conduct systematic tests to gather data about how component selection affects mechanical performance.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret observations from mechanical testing to support explanations about gear ratios, force transmission, and component interactions. They construct evidence-based arguments for design decisions, citing specific examples of how metal shafts provided better support for longer mechanisms or how proper Shaft Collar placement prevented component slippage, demonstrating understanding of relationships between mechanical components and system performance.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create technical documentation explaining how gears, pulleys, and shafts function in mechanical systems, using sophisticated vocabulary (rotational energy transfer, gear train, mechanical advantage, force transmission, positive engagement, bearing surface). They produce engineering explanations comparing component properties, assembly instructions with technical specifications for shaft and Shaft Collar placement, or design journals documenting their analysis of how different configurations affect mechanical efficiency and performance.

Challenge 5 - Spin or Lock?		
Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how mechanical engineers design rotating systems by carefully selecting components that either lock parts together or allow free rotation. They explore how this principle appears in everyday mechanisms—understanding that wheels on cars must rotate freely on axles whilst remaining attached to the vehicle, demonstrating how engineers solve the challenge of combining fixed connections with rotational movement.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe the distinct properties and functions of Lock Plates versus Bearing Plates: Lock Plates prevent shafts from rotating, holding them rigidly in place to transmit rotational force; Bearing Plates allow shafts to spin freely whilst keeping them positioned, enabling smooth rotation with minimal friction. They explain that selecting the correct plate type determines whether force is transmitted through the shaft or whether components rotate independently.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore how Lock Plates and Bearing Plates create different mechanical behaviours by building the spinner mechanism and systematically testing what happens when they hold different parts. They experiment with swapping Lock Plates for Bearing Plates to observe how this changes the mechanism's function, discovering through hands-on investigation which plate type is needed for specific mechanical purposes.
AC9TDE4P02	Generate, communicate and compare designs	Students communicate their understanding of mechanical systems using technical terminology (Lock Plate, Bearing Plate, shaft, rotate, spin, lock, friction). They explain their observations about which plate type causes which component to move, and may create diagrams or annotations showing where Lock Plates secure rotation and where Bearing Plates allow free spinning in mechanical assemblies.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate plates based on desired mechanical function—choosing Lock Plates when components need to rotate together with the shaft, and Bearing Plates when components should remain stationary whilst the shaft spins through them. They safely assemble the spinner mechanism, learning to identify which side of each plate faces the shaft and ensuring components are properly secured.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their spinner mechanism against criteria such as smooth rotation, correct plate function (appropriate parts spinning versus staying stationary), and mechanical efficiency. They test whether swapping Lock Plates for Bearing Plates produces the intended change in behaviour, assessing whether their plate selections achieve the desired mechanical function.
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how mechanical engineers carefully consider whether to use Lock Plates or Bearing Plates based on competing factors: Lock Plates provide secure force transmission but create more friction and wear; Bearing Plates enable smooth, low-friction rotation but don't transmit force. Engineers must balance mechanical efficiency (minimising friction for sustainability), functional requirements (whether force transmission is needed), and component longevity (excessive friction causes wear) when selecting connection methods for rotating systems.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain how Lock Plates and Bearing Plates control the transformation and transmission of rotational energy: Lock Plates create mechanical coupling that transforms input rotation into output rotation of connected components, transmitting rotational energy through the system; Bearing Plates isolate components from rotational energy, allowing shafts to spin whilst surrounding parts remain stationary—essential for controlling where motion occurs in mechanical systems.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain the engineering principle underlying Lock Plates and Bearing Plates: both hold shafts in position but with critically different friction properties. Lock Plates use high-friction connections to prevent relative motion between shaft and component, creating rigid coupling for force transmission. Bearing Plates use low-friction interfaces that allow smooth relative rotation, functioning as simple bearings. They articulate that engineers exploit these friction differences to control mechanical behaviour, recognising that the same principle appears in Turntables (which combine both plate types) and comparing friction levels between different solutions.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into rotational systems by building mechanisms with various combinations of Lock Plates and Bearing Plates. They explore applications requiring each plate type (wheels that rotate freely, shafts that drive multiple components, mechanisms with both fixed and rotating parts), test friction differences between Lock/Bearing Plate assemblies versus Turntables, and document optimal plate selections for different mechanical requirements.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated mechanical designs requiring strategic placement of Lock Plates and Bearing Plates, iterate through testing cycles to optimise plate selection for desired rotation behaviour, and communicate using precise engineering terminology (bearing surface, friction coefficient, mechanical coupling, rotational isolation, torque transmission, radial support). They may create technical diagrams with annotations indicating plate types and rotation directions, cross-sectional drawings showing how plates interface with shafts, or digital presentations explaining the engineering principles governing friction-based mechanical control.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make sophisticated decisions about plate selection based on mechanical analysis: using Lock Plates where torque transmission is required (driving wheels, coupled rotations); employing Bearing Plates where low-friction rotation is essential (free-spinning wheels, rotating displays); and recognising when Turntables might be more appropriate despite higher friction. They demonstrate mastery of shaft and plate assembly, ensuring correct orientation for intended mechanical behaviour and safely constructing complex rotating systems.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate sophisticated design criteria for rotating mechanisms including mechanical performance (appropriate rotation behaviour, smooth operation, efficient force transmission where needed), friction management (minimising unnecessary friction for energy efficiency—sustainability consideration), and component selection (using simpler, appropriate solutions rather than over-engineering). They evaluate designs by testing rotation smoothness, measuring spin duration to assess friction, and refining plate selections based on quantitative performance evidence.

Challenge 5 - Spin or Lock?		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create functional spinning mechanisms, selecting appropriate plate types based on desired rotation behaviour, assembling components correctly, testing whether parts spin or remain stationary as intended, and modifying their designs by swapping plate types to achieve different mechanical functions.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how rotational energy moves through mechanical systems differently depending on whether Lock Plates or Bearing Plates are used. They observe that Lock Plates transmit rotational energy from the shaft to connected components, whilst Bearing Plates allow the shaft to rotate without transferring energy to surrounding parts, demonstrating how friction and mechanical connections control energy flow in physical systems.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about plate function (e.g., "What happens when we replace Lock Plates with Bearing Plates on the 5x Pitch Truss?" or "Which configuration allows the longest spin?"). They conduct fair tests by changing only one variable at a time (plate type or position) and observing the effects on rotational behaviour, gathering evidence about how different plates control movement in mechanical systems.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students observe and document the relationship between plate type and rotational behaviour: when Lock Plates attach a truss to a shaft, rotating the shaft causes the truss to spin with it; when Bearing Plates attach a truss to a shaft, the shaft spins but the truss remains stationary. They identify the pattern that Lock Plates create fixed connections whilst Bearing Plates enable independent rotation.
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated design processes to create optimised rotating mechanisms: analysing functional requirements (which parts must rotate together versus independently), selecting appropriate plate types based on mechanical principles, constructing prototypes, testing rotation behaviour and friction characteristics, identifying improvements (replacing plates that create unintended friction or insufficient coupling), and iterating through multiple design cycles to achieve mechanisms with precisely controlled rotational behaviour.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for designing rotating systems: identify required rotations (which components rotate, which remain stationary), analyse shaft connections (where force transmission is needed), select plate types accordingly (Lock Plates for coupling, Bearing Plates for isolation), assemble in sequence, test rotation behaviour, diagnose issues (unexpected friction, insufficient coupling), modify plate selections. They evaluate their decision-making process and refine their algorithmic approach for more efficient mechanical design.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from comparative friction testing to explain how engineering knowledge of mechanical bearings and friction reduction enables sustainable mechanism design. They demonstrate that understanding friction properties allows engineers to minimise energy loss in rotating systems—using Bearing Plates where appropriate reduces friction, requiring less input energy for sustained rotation, representing sustainable practice through friction management that improves mechanical efficiency and reduces wear.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about friction and rotation (e.g., "How does spin duration differ between Lock Plate and Bearing Plate assemblies?" or "Does using Turntables instead of separate Lock and Bearing Plates affect friction levels?"), identify variables (plate type, number of plates, shaft diameter, applied force, component mass), design controlled experiments that isolate friction effects, and conduct systematic tests measuring rotation duration or resistance to gather quantitative data about friction in different configurations.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret quantitative data from rotation tests (spin duration, ease of rotation, stopping resistance) to support explanations about friction principles in mechanical systems. They construct evidence-based arguments for plate selection decisions, citing specific test results showing that Bearing Plate assemblies spin longer/smoother than Lock Plate or Turntable assemblies, and explaining these differences using scientific principles about friction, surface contact, and energy dissipation.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the physics and engineering of friction-based mechanical control, using advanced vocabulary (bearing surface, friction coefficient, torque transmission, rotational coupling, mechanical isolation, contact friction, energy dissipation). They produce engineering analyses comparing plate types with scientific reasoning, technical reports documenting friction experiments with data and conclusions, or design journals explaining their decision-making process for achieving specific rotational behaviours through strategic plate selection.

Challenge 6 - Spinning

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how mechanical engineers and product designers use hand-powered mechanisms to create functional tools and devices. They explore how Hand Cranks provide human-powered input to drive machines—a sustainable approach seen in historical and modern products like hand mixers, manual drills, and emergency radios. They discover that engineers design mechanisms to convert human motion into useful mechanical work.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how the Hand Crank functions as an input device that converts human force into rotational motion. They explain that turning the Hand Crank applies force to the shaft, which transmits through the mechanism to spin connected components. They observe how different components (gears, pulleys, weighted objects) respond when attached to the spinning shaft, discovering that force flows from input (Hand Crank) through the system to output (spinning component).
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore creative opportunities for hand-powered mechanisms by testing various Snap components on the spinner. They experiment with attaching different parts (20T Gear, 60T Gear, 90mm Pulley, 30mm Pulley with Lock Plate, 45mm Pulley with Lock Plate) to discover which components can spin and what visual or functional effects they create. They investigate how to secure the Hand Crank with a Shaft Collar to prevent it from sliding during operation.
AC9TDE4P02	Generate, communicate and compare designs	Students generate creative ideas for hand-powered mechanisms such as mixers, hypnotising machines, displays, or artistic spinners. They communicate their designs using technical terminology (Hand Crank, input, output, shaft, rotate, Lock Plate) and may sketch or photograph their creations, explaining which components they selected for spinning and why certain parts created interesting visual or mechanical effects.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate spinning components based on their visual properties, weight, and attachment methods. They safely assemble Hand Crank mechanisms, ensuring the Hand Crank fits properly onto the capped shaft and securing it with a Shaft Collar. They learn that components with built-in locking shaft inserts (gears, large pulleys) attach directly, whilst smaller pulleys require Lock Plates for proper mounting.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their hand-powered mechanisms against criteria such as smooth operation, interesting visual effects, ease of cranking, and creative function. They test different spinning components to determine which creates the most appealing or functional result, and assess whether their mechanism achieves its intended purpose (mixing, displaying, hypnotising, entertaining).
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how mechanical engineers balance competing factors when designing hand-powered mechanisms: Hand Cranks provide sustainable, human-powered operation without requiring electricity or batteries (environmental benefit), but require physical effort and may limit speed or power output compared to motorised alternatives. Engineers must consider user ergonomics (handle size, cranking radius, required force), mechanical efficiency (minimising friction losses), and intended use (continuous versus intermittent operation) when designing hand-powered systems.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain how human mechanical energy (muscle power) is transformed into rotational motion through the Hand Crank mechanism. They describe the energy transformation pathway: chemical energy in muscles converts to kinetic energy in the turning motion, which transfers through the shaft as rotational energy to drive the spinning component—demonstrating that energy transformation principles apply to both human-powered and electrically-powered systems.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how the Hand Crank's ergonomic design affects its function: the handle extends perpendicular to the shaft, creating a lever arm that allows efficient force application; the crank fits onto capped shafts and can be secured with a Shaft Collar (both components measuring 0.5x pitch/12.5mm); and the handle's grip surface enables comfortable, sustained cranking. They articulate how different components affect spinning behaviour—components with locking shaft inserts (gears, large pulleys) mount directly and rotate with the shaft, whilst components lacking this feature require Lock Plates for coupling.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into hand-powered mechanisms by designing and testing various applications: kitchen tools (mixers, whisks, grinders), display devices (rotating signs, kinetic sculptures), educational demonstrations (gear ratio explorers, centrifugal force demonstrators), or mechanical advantage systems. They explore how component selection, shaft length, gear ratios, and mechanical coupling methods affect efficiency, speed, and torque in hand-powered systems, documenting optimal configurations for different purposes.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated designs for hand-powered mechanisms with specific purposes, iterate through testing cycles to optimise component selection and mechanical efficiency, and communicate using precise engineering terminology (input force, output rotation, mechanical advantage, rotational velocity, torque, ergonomic design, crank radius, angular momentum). They create technical documentation including force diagrams showing energy flow from Hand Crank through the mechanism, annotated assembly instructions specifying component mounting methods, or digital presentations explaining how their hand-powered inventions convert human energy into useful mechanical work.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make informed selections of spinning components based on mechanical analysis of their hand-powered system: choosing lightweight components for high-speed rotation, heavier components for momentum-based applications, gears when coupling to other mechanisms is needed, or pulleys when rope-driven systems are planned. They demonstrate mastery of Hand Crank assembly, precisely positioning and securing the Shaft Collar to prevent slippage whilst allowing smooth crank rotation, and properly mounting spinning components using appropriate attachment methods (direct shaft mounting or Lock Plate coupling).
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate comprehensive design criteria for hand-powered mechanisms including functional performance (smooth cranking motion, efficient energy transfer, adequate rotational speed), ergonomic considerations (comfortable hand position, reasonable force requirement, sustainable cranking duration), mechanical efficiency (minimal friction losses, appropriate component selection), and sustainability (human-powered rather than battery/electric dependent). They evaluate designs through user testing, measuring cranking effort, rotation speed, and operational smoothness, refining their mechanisms based on quantitative and qualitative performance evidence.

Challenge 6 - Spinning		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create hand-powered mechanisms: identifying a purpose for their spinner (mixing, displaying, entertaining), selecting appropriate components based on desired effects, assembling the mechanism with proper component mounting, testing operation by cranking, and modifying their design by trying different spinning components to improve visual appeal or functionality.
ST2-DDT-02	Designs and uses algorithms, represents data and uses digital systems for a purpose	Students follow procedural steps to build hand-powered mechanisms: attach Lock Plates or Bearing Plates to trusses, insert shaft through the assembly, add Hand Crank to one end, position and secure Shaft Collar, mount spinning component on the other end, test operation. They understand that assembly sequence matters and certain steps must be completed before others for successful construction.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how human energy (force applied to the Hand Crank) transfers through mechanical systems to create rotational motion. They observe that the energy input from turning the crank flows through the shaft to the spinning component, demonstrating energy transfer and transformation in physical systems. They explore how different components (heavier versus lighter) require different amounts of input energy to maintain rotation.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about hand-powered systems (e.g., "Which component is easiest to spin with the Hand Crank?" or "How fast can we make the spinner rotate?"). They create informal tests by comparing cranking effort required for different components, observing which parts spin longest after releasing the crank, or measuring how many cranks per second they can achieve with various configurations.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students observe and describe relationships between input (cranking speed and force) and output (spinning speed and duration). They recognise patterns such as faster cranking produces faster spinning, heavier components require more effort to spin, and some components create more interesting visual effects at certain speeds.
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, iterative design processes to create optimised hand-powered mechanisms: defining functional requirements and user needs, analysing energy transfer pathways, selecting components based on mechanical principles, constructing prototypes, testing cranking effort and output performance, identifying limitations (excessive friction, inadequate speed, uncomfortable ergonomics), modifying designs with targeted improvements (component substitution, friction reduction, gear ratio optimisation), and cycling through multiple iterations to achieve hand-powered mechanisms that efficiently convert human energy into desired mechanical outputs.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for designing hand-powered mechanisms: define mechanism purpose and required output, calculate force and speed requirements, select appropriate spinning components based on mass and mounting requirements, determine optimal shaft length, position Lock/Bearing Plates for proper rotation behaviour, mount Hand Crank with correct securing, test mechanical efficiency, measure performance metrics, diagnose issues (excessive friction, slippage, inadequate speed), modify component selections or assembly methods. They evaluate their design methodology and refine their algorithmic approach for more efficient mechanical engineering.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from testing hand-powered mechanisms to explain how engineering knowledge of mechanical energy transfer enables sustainable design. They demonstrate that hand-powered systems eliminate dependence on electrical energy or disposable batteries, representing truly sustainable operation. They explain that understanding mechanical efficiency (reducing friction, optimising gear ratios, selecting appropriate components) maximises useful work output from human energy input—a key principle in designing sustainable human-powered devices that minimise physical effort whilst achieving functional goals.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about hand-powered systems (e.g., "How does component weight affect cranking difficulty?" or "What spinning component creates the longest rotation after cranking stops?" or "Does crank handle length affect rotational speed?"), identify variables (component type and mass, cranking speed and force, shaft friction, crank radius, gear ratios), design controlled experiments isolating specific variables, and conduct systematic tests measuring rotation speed, cranking effort, spin duration, or mechanical efficiency.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret quantitative data from testing hand-powered mechanisms to support explanations about energy transfer, mechanical efficiency, and component behaviour. They construct evidence-based arguments for design decisions, citing specific measurements showing how different components affect system performance (e.g., "the 20T Gear required less cranking force than the 60T Gear but achieved higher rotational speed" or "the mechanism with Bearing Plates spun 30% longer after cranking stopped than the version with Turntables"), explaining these differences using principles of rotational inertia, friction, and mechanical advantage.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the physics and engineering of hand-powered mechanisms, using advanced vocabulary (mechanical energy transfer, rotational kinetics, angular velocity, torque multiplication, ergonomic input device, mechanical efficiency, energy dissipation, sustainable power source). They produce engineering analyses explaining energy transformation pathways from human input to mechanical output, technical reports documenting comparative testing of different components with performance data and efficiency calculations, instruction manuals for operating hand-powered devices, or design portfolios explaining how their mechanisms demonstrate sustainable engineering through human-powered operation and efficient mechanical design.

Challenge 7 - Spin Faster

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how mechanical engineers use gear trains to control speed and force in machines. They explore how gears of different sizes working together can increase rotational speed (as in this challenge) or increase turning power, discovering that engineers carefully select gear combinations based on whether speed or force is more important for the machine's purpose—such as bicycles that need different gears for flat roads versus steep hills.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how gear trains transfer and transform rotational force between gears of different sizes. They explain that when a large driving gear (60T) meshes with a small driven gear (20T), the driven gear rotates three times for each rotation of the driving gear, increasing speed. Conversely, when a small driving gear meshes with a large driven gear, rotation slows but turning power increases. They discover that gear size ratios determine whether a gear train increases speed or torque.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore how gear ratios affect mechanical performance by building the gear train from Challenge #6 and adding gears to increase spinning speed. They test both configurations (60T driving 20T for speed, and 20T driving 60T for torque), comparing cranking effort, output speed, and resistance to stopping. They experiment with different gear arrangements to observe how tooth count ratios affect mechanical advantage.
AC9TDE4P02	Generate, communicate and compare designs	Students communicate their understanding of gear trains using technical terminology (driving gear, driven gear, gear train, gear ratio, speed, torque, mesh). They explain which gear configuration makes the spinner rotate faster and which makes it harder to stop, potentially creating diagrams showing gear arrangements with arrows indicating rotation directions and annotating speed differences.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate gear combinations based on desired mechanical output—choosing the large-to-small configuration (60T to 20T) when speed is needed, or small-to-large configuration (20T to 60T) when torque is required. They safely assemble gear trains ensuring teeth mesh properly, gears are secured on shafts correctly, and the Hand Crank operates smoothly without binding.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their gear train configurations against criteria such as output speed, cranking effort required, torque (resistance to stopping), and smooth operation. They test both gear arrangements, compare performance characteristics, and determine which configuration best meets specific design goals (maximum speed versus maximum turning power), supporting their conclusions with evidence from testing.
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how mechanical engineers analyse complex trade-offs when designing gear systems: gearing for speed (large to small) provides faster output but requires more input effort and reduces torque; gearing for torque (small to large) provides greater turning power but reduces speed. Engineers must balance these competing factors based on application requirements—electric vehicles need torque for acceleration and hill climbing, whilst factory machinery might need speed for production efficiency. Students understand that optimal gear selection depends on prioritising either speed or force, and that sustainable design might favour mechanical advantage to reduce motor size or human effort.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain how gear trains transform mechanical energy by redistributing it between rotational speed and torque. They describe the energy conservation principle: input power (force × speed) equals output power minus friction losses, meaning that increasing output speed through gearing necessarily decreases output force proportionally. They articulate that this transformation principle applies whether the input energy comes from human power (Hand Crank), electric motors, or other sources—demonstrating universal mechanical principles.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how gear properties determine their function in gear trains: tooth count establishes gear ratios (the 60T gear has three times as many teeth as the 20T gear, creating a 3:1 ratio); meshed teeth create positive engagement that reliably transmits rotation without slippage; and the circular pitch (tooth spacing) must match between gears for proper meshing. They articulate that driving gear position (connected to input/Hand Crank) versus driven gear position (connected to output/spinner) determines whether the gear train multiplies speed or torque, and explain how gear trains enable mechanical systems to match input capabilities to output requirements.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into gear ratios by building multiple gear train configurations, calculating theoretical speed/torque ratios, testing actual performance, and comparing predictions to results. They explore compound gear trains (multiple gear pairs in series), investigate how adding intermediate gears affects rotation direction without changing ratio, and document relationships between gear tooth counts, rotation speeds, and turning forces. They may design mechanisms requiring specific gear ratios to achieve target speeds or forces.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated gear train designs for specific mechanical requirements, iterate through testing cycles to optimise gear selection and arrangement, and communicate using precise engineering terminology (gear ratio, mechanical advantage, velocity ratio, torque multiplication, driving gear, driven gear, idler gear, compound gear train, pitch circle). They create technical documentation including gear ratio calculations, annotated diagrams showing gear arrangements with tooth counts and ratio formulas, rotation direction indicators, or digital presentations explaining how their gear trains achieve desired speed or torque outputs through calculated mechanical advantage.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make sophisticated decisions about gear selection based on mechanical requirements analysis: calculating required gear ratios to achieve target speeds or torques, selecting appropriate gear combinations from available options (20T and 60T), determining optimal gear positioning for desired mechanical advantage, and ensuring proper shaft alignment for reliable gear meshing. They demonstrate mastery of gear train assembly, achieving smooth, quiet operation through precise gear spacing and alignment, and safely constructing increasingly complex multi-stage gear systems.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate sophisticated design criteria for gear-driven mechanisms including performance specifications (target rotation speed or torque output, gear ratio accuracy, mechanical efficiency), operational characteristics (smooth operation, minimal noise, acceptable cranking effort), and engineering effectiveness (achieving required mechanical advantage with available gears, minimal friction losses). They evaluate designs through quantitative testing (measuring rotation speeds, calculating actual versus theoretical ratios, comparing cranking forces), and refine gear selections based on performance data and mechanical analysis.

Challenge 7 - Spin Faster

Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to modify their spinner mechanism from Challenge #6, identifying the opportunity to increase speed through gear ratios, adding gears in the appropriate configuration (large driving small), testing the speed increase, evaluating performance, and potentially iterating by switching gear positions to explore different mechanical advantages for different applications.
ST2-DDT-02	Designs and uses algorithms, represents data and uses digital systems for a purpose	Students follow systematic procedures for building gear trains: count teeth on available gears, calculate gear ratios, determine which configuration provides desired output (speed or torque), position gears so teeth mesh correctly, ensure driving gear connects to Hand Crank and driven gear connects to output, test operation. They demonstrate algorithmic thinking by understanding that gear selection and arrangement order determine mechanical outcomes.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how rotational energy is transformed as it passes through gear trains. They observe that gear trains don't create or destroy energy but redistribute it—trading speed for force or force for speed. When geared for speed, the same input energy produces faster rotation but less turning power; when geared for torque, it produces slower rotation but greater turning power, demonstrating the principle of energy conservation in mechanical systems.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about gear ratios and mechanical advantage (e.g., "Which gear arrangement spins faster?" or "Which configuration is harder to stop from turning?"). They create fair tests by using consistent cranking speeds, comparing rotation speeds of different gear arrangements, and testing resistance by attempting to stop the spinner whilst maintaining steady cranking, gathering evidence about how gear ratios affect speed and torque.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students observe and describe the mathematical relationship between gear sizes and rotation: when the 60T gear drives the 20T gear, the output spins three times faster (60÷20=3); when reversed, the output spins three times slower but with three times the turning power. They recognise the inverse relationship between speed and torque in gear trains—increases in one result in decreases in the other.
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, iterative design processes to create optimised gear-driven mechanisms: analysing mechanical requirements (required speed or torque specifications), calculating necessary gear ratios using mathematical relationships, selecting appropriate gear combinations, constructing prototypes with precise gear meshing, testing performance through speed and torque measurements, identifying limitations (inadequate ratio, excessive friction, misaligned gears), modifying designs with calculated improvements (different gear combinations, improved alignment, friction reduction), and iterating through multiple design cycles to achieve gear systems that meet quantified performance targets.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for engineering gear trains: identify performance requirement (target speed or torque), calculate required gear ratio (output÷input), determine which available gears provide closest ratio (using tooth count ratios), decide driving and driven gear positions based on whether speed or torque increase is needed, position gears for optimal meshing, secure gears on shafts with appropriate locking, test and measure actual performance, calculate efficiency (actual ratio÷theoretical ratio), diagnose issues (poor meshing, slippage, excessive friction), modify based on results. They evaluate their engineering methodology and refine their algorithmic approach for more accurate mechanical design.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from gear ratio testing to explain how engineering knowledge of mechanical advantage enables sustainable machine design. They demonstrate that understanding gear ratios allows engineers to match mechanical systems to tasks efficiently—using speed-increasing gears when rapid motion is needed (reducing time and energy consumption) or torque-increasing gears when force is needed (reducing motor size, material use, and energy requirements). They explain that this principle enables sustainable design through right-sizing machines: achieving required performance without over-engineering, excessive power consumption, or unnecessary material use.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about gear mechanics (e.g., "Does the 3:1 gear ratio produce exactly three times the rotation speed?" or "How does mechanical efficiency compare between speed-increasing and torque-increasing configurations?" or "Does gear meshing quality affect energy transfer?"), identify variables (gear sizes and ratios, input speed, output speed and torque, meshing distance, friction), design controlled experiments with measured inputs and outputs, and conduct systematic tests gathering quantitative data about rotational speeds, gear ratios, torque differences, and mechanical efficiency.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret quantitative data from gear train testing to support mathematical and physical explanations about mechanical advantage. They construct evidence-based arguments using calculated gear ratios and measured performance data, citing specific results (e.g., "the 60T-to-20T configuration produced output rotation 2.9 times faster than input rotation, closely matching the theoretical 3:1 ratio calculated from tooth counts") and explaining minor discrepancies using friction, meshing efficiency, and measurement precision. They use data to demonstrate the speed-torque trade-off principle in gear systems.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the mathematics and physics of gear trains, using advanced vocabulary (gear ratio, mechanical advantage, velocity ratio, torque multiplication, angular velocity, rotational mechanics, mechanical efficiency, power transmission, teeth engagement). They produce engineering analyses including gear ratio calculations with formulae and worked examples, technical reports documenting gear train experiments with quantitative data, performance graphs, and efficiency analyses, comparative evaluations of different gear configurations with mathematical justifications, or design portfolios explaining how their gear systems achieve specific mechanical advantages through calculated tooth count ratios and the fundamental relationship between speed and torque in mechanical systems.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the physics and engineering of hand-powered mechanisms, using advanced vocabulary (mechanical energy transfer, rotational kinetics, angular velocity, torque multiplication, ergonomic input device, mechanical efficiency, energy dissipation, sustainable power source). They produce engineering analyses explaining energy transformation pathways from human input to mechanical output, technical reports documenting comparative testing of different components with performance data and efficiency calculations, instruction manuals for operating hand-powered devices, or design portfolios explaining how their mechanisms demonstrate sustainable engineering through human-powered operation and efficient mechanical design.

Challenge 8 - Rolling

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how automotive and transportation engineers design wheeled vehicles to meet mobility needs. They explore how wheels reduce friction compared to dragging objects, making transportation more efficient and requiring less energy—a sustainable design principle. They discover that engineers must consider wheel size, axle design, and weight distribution when creating vehicles, whether designing children's toys, wheelchairs, or automobiles.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how the wheel and axle system functions as a simple machine that reduces friction and enables rolling motion. They explain that Bearing Plates allow wheels to rotate freely on the axle whilst Lock Plates would prevent rotation, demonstrating how component selection affects mechanical function. They observe how the rubber tire stretched over the 90mm Pulley provides grip and cushioning, and how the tire's properties (flexibility, traction) affect the vehicle's performance.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore vehicle design by building a simple car and testing how it rolls. They experiment with different wheel configurations, car widths and lengths, and weight distribution to observe effects on rolling performance and stability. They investigate what happens when Lock Plates are used instead of Bearing Plates, discovering through hands-on testing why free-rolling wheels are essential for vehicle function.
AC9TDE4P02	Generate, communicate and compare designs	Students generate creative ideas for vehicle enhancements such as driver's seats, doors, trunks, cargo areas, or decorative features. They communicate their designs using technical terminology (wheel, axle, Bearing Plate, tire, chassis, wheelbase) and may sketch, photograph, or digitally document their vehicle designs, explaining which features they added and why certain modifications improved functionality or aesthetics.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate components for their vehicle: choosing trusses for the chassis, 90mm Pulleys for wheel bases, 100mm Tires for wheel surfaces, Bearing Plates to enable rotation, and shafts of suitable length for the wheelbase. They safely stretch tires over pulleys without over-extending the rubber, assemble wheels onto axles with proper Bearing Plate orientation, and construct stable chassis structures using the Ring Tool.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their vehicle designs against criteria such as rolling performance (smooth, straight motion), structural stability (doesn't tip over), wheel function (rotates freely), and creative features (useful or interesting additions). They test their vehicles by rolling them across surfaces, observing performance, and making improvements based on how well the vehicle meets functional and creative design goals.
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how transportation engineers balance competing factors when designing wheeled vehicles: larger wheels roll more easily over obstacles but add weight and require more materials; wider wheelbases increase stability but reduce manoeuvrability and increase material use; rubber tires provide good traction and cushioning but eventually wear out and create waste. Engineers must consider performance requirements, material efficiency, manufacturing complexity, durability, and end-of-life recyclability when designing sustainable transportation solutions—balancing functionality with environmental impact.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain how the wheel and axle system transforms input energy (pushing force or gravitational potential energy on slopes) into rolling kinetic energy. They describe how this simple machine reduces energy losses to friction by replacing sliding friction with rolling friction, making vehicles far more energy-efficient than dragging equivalent loads. They articulate that this principle applies whether vehicles are human-powered, gravity-powered, or motor-driven—demonstrating how mechanical systems enable efficient energy transformation.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how component properties determine vehicle function: Bearing Plates provide low-friction rotation essential for free-rolling wheels; the 90mm Pulley provides a rigid wheel structure; the 100mm Tire (stretched over the pulley) adds grip through rubber's high-friction surface whilst the circular shape enables rolling motion; and the tire's groove locks onto the pulley to prevent slippage between components. They articulate that the wheel-and-axle system requires precise component selection—Bearing Plates rather than Lock Plates, appropriate shaft lengths for wheelbase width, and secure tire mounting—demonstrating how material properties and assembly methods affect mechanical performance.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into vehicle design by building and testing multiple configurations: experimenting with different wheelbase widths and lengths, testing two-wheel versus four-wheel designs, investigating weight distribution effects, exploring steering mechanisms, and examining how different surfaces affect rolling performance. They document findings about optimal wheel spacing for stability, chassis configurations for different purposes (speed versus cargo capacity), and design features that improve vehicle performance, preparing for Challenge #11's winch integration.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated vehicle designs for specific purposes (racing cars, cargo transporters, off-road vehicles, passenger carriers), iterate through testing cycles to optimise performance characteristics, and communicate using precise engineering terminology (wheelbase, chassis, axle, wheel diameter, centre of gravity, weight distribution, rolling resistance, traction, suspension). They create technical documentation including top-view and side-view drawings with dimensions, annotated diagrams explaining wheel assembly and Bearing Plate orientation, performance data tables comparing different configurations, or digital presentations explaining how their vehicle designs apply wheel-and-axle principles for efficient transportation.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make informed decisions about vehicle construction based on engineering analysis: selecting appropriate wheelbase width for intended use (wider for stability, narrower for manoeuvrability), choosing chassis length to accommodate features whilst maintaining structural integrity, determining optimal wheel size for ground clearance and rolling efficiency, and planning for future modifications like the winch system in Challenge #11. They demonstrate mastery of wheel assembly—safely stretching tires over pulleys without damage, positioning Bearing Plates correctly for free rotation, and selecting shaft lengths that provide proper wheel spacing whilst remaining secure.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate sophisticated design criteria for wheeled vehicles including functional performance (rolls smoothly and straight, appropriate stability for intended use, wheels rotate freely), structural integrity (chassis supports features without flexing, wheels remain properly aligned), creative design (includes useful or interesting features), and material efficiency (achieves performance goals with minimal components—sustainability consideration). They evaluate designs through quantitative testing (measuring rolling distance, tracking straightness, assessing stability during turns) and qualitative assessment (aesthetic appeal, feature usefulness), refining their vehicles based on comprehensive performance evidence.

Challenge 8 - Rolling		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create a functional wheeled vehicle: identifying the need for transportation/mobility, selecting appropriate components for wheels and chassis, assembling the basic car structure, testing rolling performance, and enhancing their design with additional features or modifications that improve function or appearance. They iterate by testing different configurations and refining based on performance observations.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how rolling motion converts potential energy (from pushing or releasing on a slope) into kinetic energy with minimal loss to friction. They observe that wheels reduce friction between the vehicle and ground compared to sliding, demonstrating how the wheel and axle system enables efficient energy transfer and sustained motion with less force input—a fundamental principle in transportation physics.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about vehicle performance (e.g., "Does a wider wheelbase make the car more stable?" or "How does adding weight affect rolling distance?" or "What happens if we use Lock Plates instead of Bearing Plates?"). They create fair tests by modifying one variable at a time (wheel spacing, car length, added weight, surface type) and observing effects on rolling behaviour, gathering evidence about how design features affect vehicle performance.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students collect and interpret data from vehicle testing, observing patterns such as: vehicles with wider wheelbases are more stable; lighter vehicles roll farther; vehicles with freely rotating wheels (Bearing Plates) perform better than those with locked wheels (Lock Plates). They describe relationships between design features (wheelbase width, vehicle mass, wheel rotation quality) and performance outcomes (stability, rolling distance, straight-line tracking).
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, iterative design processes to create optimised wheeled vehicles: analysing performance requirements (speed, stability, cargo capacity, terrain capability), applying mechanical principles to initial designs, constructing prototypes with calculated wheel spacing and chassis dimensions, testing performance through rolling trials and stability assessments, identifying limitations (insufficient stability, poor tracking, inadequate features), modifying designs with targeted improvements (wheelbase adjustments, weight redistribution, structural reinforcement, feature additions), and cycling through multiple iterations to achieve vehicles that meet specified performance criteria whilst incorporating creative enhancements.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for engineering wheeled vehicles: define vehicle purpose and performance requirements, calculate optimal wheelbase dimensions based on stability needs, select appropriate chassis length and structure, determine wheel mounting positions, select Bearing Plates for wheel axles and Lock Plates for chassis rigidity, assemble wheels (stretch tire onto pulley, mount on shaft with Bearing Plates), construct chassis with proper wheel spacing, test rolling performance and stability, measure and analyse results, diagnose issues (wobbling, poor tracking, tipping), modify design based on analysis. They evaluate their engineering methodology and refine their algorithmic approach for more effective vehicle design.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from vehicle performance testing to explain how engineering knowledge of friction, rolling motion, and mechanical efficiency enables sustainable transportation design. They demonstrate that understanding the wheel-and-axle principle allows designers to minimise energy waste—vehicles using rolling motion require far less force to move than sliding equivalents, representing sustainable design through friction reduction. They explain that optimising wheel size, weight distribution, and bearing quality further improves efficiency, demonstrating how scientific knowledge about mechanics enables transportation solutions that minimise energy consumption and material use whilst maximising performance.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about vehicle mechanics (e.g., "How does wheelbase width affect stability during turns?" or "What is the optimal weight distribution for maximum rolling distance?" or "How do different surface textures affect traction and rolling resistance?"), identify variables (wheelbase dimensions, vehicle mass and distribution, wheel size, surface type, slope angle, bearing quality), design controlled experiments with measured parameters, and conduct systematic tests gathering quantitative data about rolling distance, stability angles, straight-line accuracy, or energy efficiency.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret quantitative data from vehicle testing to support explanations about mechanical principles and design effectiveness. They construct evidence-based arguments for design decisions, citing specific test results (e.g., "vehicles with wheelbase width equal to 150% of vehicle length remained stable at tilt angles up to 25°, whilst narrower designs tipped at 15°" or "replacing Lock Plates with Bearing Plates increased rolling distance by 300%"), and explaining these differences using physics principles about friction, centre of gravity, rotational inertia, and energy conservation.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the physics and engineering of wheeled vehicles, using advanced vocabulary (wheel and axle simple machine, rolling friction, sliding friction, rotational inertia, centre of gravity, weight distribution, wheelbase geometry, bearing efficiency, traction coefficient, mechanical advantage). They produce engineering analyses explaining how wheels reduce friction and improve transportation efficiency with physics principles, technical reports documenting vehicle performance experiments with quantitative data on rolling distance, stability limits, and efficiency calculations, design specifications for vehicles with dimensional drawings and parts lists, or design portfolios explaining how their vehicles demonstrate mechanical engineering principles through wheel-and-axle systems that convert input energy into efficient rolling motion whilst maintaining stability and incorporating functional or creative features.

Challenge 9 - Sliding

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how structural and mechanical engineers design linear motion systems to meet transportation and mechanical needs. They explore how Linear Motion Brackets enable sliding movement in everyday applications like drawer slides, train tracks, elevator systems, and linear actuators. They discover that engineers must design smooth, stable tracks to support sliding mechanisms effectively, considering factors like friction, alignment, and structural support to ensure reliable operation.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how Linear Motion Brackets function by fitting their rails into the grooves of trusses, enabling sliding motion with minimal friction. They explain that the brackets must remain aligned with the track for smooth operation, and that longer tracks require additional structural support to prevent sagging or twisting. They observe how gravity acts as a force pulling the monorail downward whilst the track constrains it to move only in the sliding direction, demonstrating controlled linear motion.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore linear motion systems by building a monorail that slides on a truss track. They experiment with adding passengers (stick figures from Challenge #3) or cargo to the monorail, testing how added weight affects sliding smoothness. They investigate track stability by building longer tracks (up to 60 pitches/1500mm with six 10x Pitch Trusses), discovering that extended tracks require reinforcement with plates and support structures to maintain straightness and prevent flexing.
AC9TDE4P02	Generate, communicate and compare designs	Students generate creative ideas for monorail enhancements such as passenger compartments, cargo containers, station platforms, or aesthetic features. They communicate their designs using technical terminology (Linear Motion Bracket, track, slide, rail, groove, linear motion, support structure) and may sketch or photograph their monorail systems, explaining track layouts, reinforcement methods, and how they incorporated measurement principles (calculating track length using the 25mm pitch system).
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate components for their monorail system: choosing 10x Pitch Trusses for long track sections, Linear Motion Brackets (positioned in pairs for stability) to create the sliding car, plates to lock brackets onto the car and reinforce track joints, and additional trusses to support extended tracks. They safely assemble the monorail, ensuring Linear Motion Bracket rails are properly seated in truss grooves and that the track remains straight and well-supported for smooth sliding operation.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their monorail systems against criteria such as sliding smoothness (moves freely without binding), track stability (remains straight under load without sagging), structural integrity (supports added features without failing), and track length (maximum distance achieved whilst maintaining performance). They test by sliding the monorail back and forth, adding weight to assess load capacity, and measuring track straightness, making improvements based on performance observations.

Challenge 9 - Sliding

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how structural engineers balance competing factors when designing linear motion systems: longer tracks provide greater travel distance but require more material and structural support; smooth sliding requires precise alignment and minimal friction but increases manufacturing complexity; heavy-duty tracks can carry larger loads but use more materials and energy to construct. Engineers must consider performance requirements (load capacity, travel distance, speed), structural efficiency (achieving strength with minimal material—sustainability), maintenance needs (friction causes wear), and cost constraints when designing transportation systems like monorails, elevators, or automated manufacturing lines.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain how linear motion systems convert energy into controlled directional movement. They describe how gravitational potential energy (when the monorail is raised) converts to kinetic energy during sliding, and how friction between rails and grooves dissipates energy as heat whilst providing controlled resistance. They articulate that motorised linear systems (like real monorails or elevators) use electrical energy to overcome friction and gravity, demonstrating how mechanical systems channel and control energy to produce useful linear motion.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how Linear Motion Bracket design enables controlled sliding: the bracket's rails fit precisely into truss grooves, constraining motion to one linear direction whilst minimising friction through smooth plastic-on-plastic contact; pairs of brackets provide stability by supporting both sides of the sliding car; and the bracket's geometry allows plates to lock it onto structures whilst maintaining sliding capability. They articulate that track straightness is critical—any bending, twisting, or misalignment increases friction and causes binding—requiring structural engineering principles about beam support, deflection under load, and the relationship between span length and required reinforcement to maintain track integrity.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into linear motion systems by designing and testing various monorail configurations: building tracks of different lengths to determine support requirements, experimenting with different bracket positioning (one versus two brackets per side, bracket spacing), testing load capacity by adding weighted trusses or structures, investigating friction reduction methods (ensuring perfect alignment, minimising binding points), and exploring creative applications (passenger transport, cargo delivery, automated systems). They document structural requirements for different track lengths, optimal support spacing ratios, and load limits.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated monorail system designs for specific purposes (passenger transport with stations, cargo delivery with loading platforms, automated manufacturing with precise positioning), iterate through testing cycles to optimise track structure and support placement, and communicate using precise engineering terminology (linear motion, guide rail, support span, deflection, load-bearing capacity, friction coefficient, structural rigidity, cantilever, beam support). They create technical documentation including track layout diagrams with dimensions and support locations, structural analysis sketches showing force distribution and deflection points, cross-sectional views of Linear Motion Bracket engagement with track grooves, or digital presentations explaining how their monorail systems demonstrate structural engineering principles for supporting extended linear structures.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make sophisticated structural engineering decisions: calculating maximum unsupported track span before deflection occurs, determining optimal support structure spacing based on load requirements, selecting appropriate reinforcement methods (plates over joints, perpendicular support trusses, triangulated bracing), and ensuring Linear Motion Bracket alignment throughout track length. They demonstrate mastery of structural assembly, creating straight, well-supported tracks that maintain alignment under load, positioning brackets for smooth sliding with minimal friction, and constructing increasingly complex linear motion systems that balance travel distance with structural integrity.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate sophisticated design criteria for linear motion systems including functional performance (smooth sliding throughout track length, adequate load capacity, minimal friction), structural requirements (track remains straight under load, supports prevent deflection beyond acceptable limits, system maintains alignment during operation), efficiency considerations (achieves required travel distance with minimal materials—sustainability), and creative features (useful stations, cargo systems, or passenger accommodations). They evaluate designs through quantitative testing (measuring track deflection, calculating support spacing ratios, testing maximum load capacity) and qualitative assessment, refining structural support systems based on performance evidence and engineering principles.

Challenge 9 - Sliding		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create a functional monorail system: identifying the need for linear transportation, selecting appropriate components (Linear Motion Brackets, trusses for track and supports, plates for reinforcement), assembling the basic monorail and track, testing sliding performance, and enhancing their design with longer tracks, additional features (passengers, cargo, stations), or improved structural support based on testing outcomes.
ST2-DDT-02	Designs and uses algorithms, represents data and uses digital systems for a purpose	Students follow systematic procedures for building monorail systems: position Linear Motion Brackets on trusses (creating the car), insert 10x Pitch Truss through the bracket rails (creating the track), add plates to secure brackets to the car structure, test sliding motion, extend track by connecting additional trusses, add support structures when track length increases, retest performance. They demonstrate algorithmic thinking by understanding that construction sequence and structural planning are essential for successful extended track systems.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how forces and energy affect linear motion systems. They observe that gravitational force pulls the monorail downward onto the track, friction between the Linear Motion Bracket rails and truss grooves provides controlled sliding resistance, and the track structure must be strong enough to support the load without bending—demonstrating how multiple forces interact in mechanical systems to enable controlled motion.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about linear motion systems (e.g., "How does track length affect stability?" or "Does adding weight to the monorail change how smoothly it slides?" or "How many support structures are needed for a 60-pitch track?"). They create fair tests by comparing sliding performance on tracks of different lengths, testing with various loads, or measuring the effect of adding reinforcement structures, gathering evidence about factors affecting linear motion performance.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students collect and interpret data from monorail testing, observing patterns such as: longer tracks require more support structures; heavier monorails slide more smoothly due to gravity but stress the track more; tracks with proper reinforcement slide better than unsupported tracks. They describe relationships between track length, structural support, load weight, and sliding performance, potentially using measurement data (track length in millimetres or pitches, number of support structures

Challenge 9 - Sliding		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, iterative design processes to create optimised linear motion systems: analysing requirements (required travel distance, load capacity, available space), applying structural engineering principles to calculate support spacing, designing initial track layouts with planned reinforcement, constructing prototypes with measured component placement, testing structural performance through deflection measurement and load trials, identifying failure modes (track sagging, binding due to misalignment, insufficient load capacity), modifying designs with calculated improvements (adding supports at determined intervals, improving alignment methods, reinforcing weak points with plates or bracing), and iterating through multiple cycles to achieve linear motion systems that provide smooth sliding over extended distances whilst maintaining structural integrity under load.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for engineering linear motion systems: define travel distance requirement and load specifications, calculate track length needed (using 25mm pitch units), determine maximum unsupported span based on beam deflection principles, calculate number of support structures required (track length ÷ maximum span), select Linear Motion Bracket configuration (quantity and positioning for stability), assemble track sections with joints reinforced by plates, position support structures at calculated intervals, mount Linear Motion Brackets with precise alignment, test sliding performance and measure any deflection or binding, diagnose structural issues (excessive span, misalignment, inadequate reinforcement), modify support spacing or alignment based on measurements. They evaluate their structural engineering methodology and refine their algorithmic approach for more accurate prediction of support requirements.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from structural testing to explain how engineering knowledge of beam mechanics, load distribution, and deflection enables sustainable linear motion system design. They demonstrate that understanding structural principles allows engineers to determine optimal support spacing—preventing over-engineering (too many supports wasting material) and under-engineering (insufficient supports causing failure). They explain that this knowledge represents sustainable practice: achieving required structural performance with minimal material use, reducing construction costs and environmental impact whilst ensuring reliable operation, demonstrating how scientific understanding of forces and structural mechanics enables resource-efficient engineering solutions.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about linear motion systems and structural mechanics (e.g., "What is the maximum unsupported span before track deflection causes binding?" or "How does support spacing affect maximum load capacity?" or "Does bracket positioning (one versus two per side) affect sliding friction?"), identify variables (track length and span, number and position of supports, load mass and distribution, bracket quantity and spacing, track straightness), design controlled experiments measuring deflection and friction, and conduct systematic tests gathering quantitative data about structural performance, support requirements, and load limits.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret quantitative data from structural and friction testing to support explanations about beam mechanics and linear motion principles. They construct evidence-based arguments for structural design decisions, citing specific measurements (e.g., "unsupported 10x Pitch Truss tracks deflected 5mm at midpoint under 75g load, causing friction and binding, whilst tracks with support every 5 pitches showed less than 1mm deflection and smooth sliding" or "using two Linear Motion Brackets per side reduced lateral wobble by 80% compared to single-bracket configurations"), explaining these results using structural engineering principles about cantilever beams, distributed loads, and the relationship between span length, deflection, and required support density.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the structural mechanics and physics of linear motion systems, using advanced vocabulary (linear motion constraint, guide rail system, beam deflection, unsupported span, load-bearing capacity, structural rigidity, cantilever mechanics, distributed load, point load, friction coefficient, alignment tolerance, support density). They produce engineering analyses explaining how structural support prevents deflection and enables smooth linear motion with physics and mathematics principles, structural design specifications with calculated support spacing ratios and load limits, technical reports documenting beam deflection experiments with quantitative data and support requirement calculations, construction guides with precise assembly instructions and alignment procedures, or design portfolios explaining how their monorail systems demonstrate structural engineering principles through calculated support placement that maintains track straightness under load whilst achieving extended travel distances with material-efficient construction.

Challenge 10 - Drawbridge		
Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how civil engineers and designers create drawbridges and lifting mechanisms to meet community needs for both access and water navigation. They explore how drawbridges solve the problem of allowing both road traffic and tall boats to pass through the same location, discovering that engineers must design mechanisms that are easy to operate, stable when closed, and secure when raised. They consider how historical and modern drawbridges serve communities whilst managing competing requirements.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how rope systems enable lifting through tension forces: pulling the rope creates upward force that raises the bridge deck against gravity. They explain that Hinges allow the bridge to rotate upward whilst remaining attached to the frame, and that Rope Anchors secure rope to the bridge structure, enabling force transmission from rope to bridge. They observe that the bridge's weight creates a downward force requiring human effort to overcome, and that friction between rope and truss edges affects lifting difficulty.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore drawbridge mechanisms by building a rope-operated lifting system. They experiment with different bridge configurations (varying bridge length or weight), rope lengths (0.5m versus 1m), and pulling methods. They test what happens when they add features like pulleys (as suggested in the Engineering Tip) to reduce friction, discovering how different mechanical arrangements affect lifting ease and bridge stability.
AC9TDE4P02	Generate, communicate and compare designs	Students generate creative ideas for enhancing their drawbridge such as adding castle structures to support the frame, creating latches to hold the bridge upright, designing decorative elements, or improving stability with additional structural supports. They communicate their designs using technical terminology (Hinge, Rope Anchor, rope, tension, lifting mechanism, stability, frame) and may sketch or photograph their structures, explaining which modifications improved structural integrity or functionality.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate components for their drawbridge system: choosing Hinges to create the rotating connection between bridge and frame, Rope Anchors to secure rope to the bridge, rope of suitable length to reach from the bridge to the pulling position, and additional trusses or weighted trusses to stabilise the base. They safely assemble the drawbridge, learning the Rope Anchor attachment method (drop rope end inside truss, insert anchor into rope end, click anchor into truss, secure with Connector).
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their drawbridge designs against criteria such as operational function (bridge raises and lowers smoothly), structural stability (frame doesn't tip over during operation), mechanical efficiency (reasonable pulling force required), and secure connections (Hinges and Rope Anchors remain attached during use). They test by repeatedly raising and lowering the bridge, assessing stability issues, and making improvements based on performance observations such as widening the base or adding weight for better balance.

Challenge 10 - Drawbridge		
Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how civil engineers balance competing factors when designing drawbridges and lifting mechanisms: structural stability versus operational mobility (bridges must be stable when closed but moveable when opening); ease of operation versus mechanical complexity (simple rope systems are easier to maintain but require more human effort than counterweighted or motorised systems); material efficiency versus strength requirements (minimising materials for sustainability whilst ensuring adequate strength for loads and repeated operation); and accessibility versus cost (manual operation is cheaper but may not accommodate all users). They understand that sustainable drawbridge design requires optimising these factors whilst ensuring long-term durability and reasonable maintenance requirements.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain how lifting mechanisms transform mechanical energy: human muscle energy converts to kinetic energy in the pulling motion, which creates tension force in the rope system, transferring energy to the bridge structure and converting it to gravitational potential energy as the bridge rises. They describe how friction dissipates some energy as heat (especially when rope drags over truss edges), making the system less efficient, and how pulleys reduce this energy loss by replacing sliding friction with rolling motion—demonstrating principles applicable to both human-powered and motor-driven lifting systems.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how component properties enable drawbridge function: Hinges provide the pivot point allowing rotational movement whilst maintaining connection between bridge and frame; Rope Anchors create secure attachment points that withstand tension forces during lifting; rope's flexibility allows it to bend around corners whilst its tensile strength resists breaking under load; and the rope's colour-coded ends (orange for 0.5m, blue for 1m) enable quick identification of appropriate lengths. They articulate that friction between materials significantly affects performance—rope dragging over truss edges creates high friction that increases lifting difficulty, whilst pulleys reduce friction by converting sliding to rolling motion, demonstrating how mechanical engineers analyse material interactions to optimise system efficiency.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into lifting mechanisms and structural stability by building and testing various drawbridge configurations: experimenting with different numbers of Hinges (two versus four for stronger connection), testing pulley systems to reduce friction and required effort, investigating counterweight systems that balance bridge weight, exploring latch mechanisms to secure the raised bridge, designing castle or fortress structures that both support and conceal the drawbridge mechanism, and documenting relationships between bridge dimensions, base width, lifting effort, and structural stability requirements.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated drawbridge designs incorporating multiple engineering challenges (stable base structures, efficient lifting mechanisms, secure latching systems, aesthetic castle features), iterate through testing cycles to optimise mechanical advantage and structural stability, and communicate using precise engineering terminology (tension force, pivot point, mechanical advantage, centre of gravity, base-to-height ratio, friction reduction, pulley system, counterweight, load distribution, moment arm). They create technical documentation including force diagrams showing tension in ropes and gravitational forces on the bridge, side-view sketches illustrating pivot geometry and lifting angles, stability calculations comparing base width to structure height, or digital presentations explaining how their drawbridge designs solve competing requirements of operational function and structural stability through mechanical engineering principles.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make sophisticated engineering decisions about drawbridge construction: selecting appropriate rope lengths based on bridge height and lifting mechanism geometry, determining optimal Hinge quantity and positioning for adequate support and smooth rotation, choosing base dimensions using stability calculations (wider bases for taller structures), incorporating pulleys at strategic locations to redirect rope paths and reduce friction, and designing structural reinforcement (plates over joints, triangulated supports, weighted base components) that maintains stability during lifting operations. They demonstrate mastery of rope-based mechanical systems, properly securing Rope Anchors to withstand repeated tension loads and constructing increasingly complex lifting mechanisms that balance operational efficiency with structural integrity.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate sophisticated design criteria for drawbridge systems including functional performance (smooth lifting and lowering operation, adequate range of motion, reliable rope system), mechanical efficiency (reasonable human effort required, minimal friction losses, optional mechanical advantage through pulleys), structural requirements (stable during operation without tipping, secure Hinge and Rope Anchor connections, adequate base support), and creative integration (castle or fortress aesthetics that enhance rather than compromise structural function). They evaluate designs through quantitative assessment (measuring lifting force required, calculating stability ratios, testing connection strength through repeated operations) and qualitative evaluation (operational smoothness, aesthetic appeal), refining mechanical and structural elements based on comprehensive performance evidence.

Challenge 10 - Drawbridge		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create a functional drawbridge: identifying the need for a bridge that can open and close, selecting appropriate components (Hinges for rotation, Rope Anchors for lifting, rope for operation), assembling the basic structure, testing lifting operation and stability, and enhancing their design with improvements (base reinforcement, pulley systems, castle structures, latching mechanisms) based on testing outcomes and identified weaknesses.
ST2-DDT-02	Designs and uses algorithms, represents data and uses digital systems for a purpose	Students follow systematic procedures for building rope-operated lifting mechanisms: construct bridge frame with upright supports, attach bridge deck to frame using Hinges, drop rope end inside bridge truss, insert Rope Anchor into rope end, click Rope Anchor into truss, secure with Connector, test lifting operation, identify stability issues, add base reinforcement if needed, retest. They demonstrate algorithmic thinking by understanding that component assembly order and structural planning affect whether the mechanism functions properly.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how forces interact in lifting systems: human effort creates tension force in the rope, which transfers to the bridge through the Rope Anchor; gravitational force pulls the bridge downward, requiring continuous tension to hold it raised; and friction between rope and truss edge creates resistance. They observe that energy from human pulling converts to gravitational potential energy as the bridge rises, demonstrating energy transformation in mechanical systems.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about lifting mechanisms and structural stability (e.g., "Does using a pulley make the bridge easier to lift?" or "How does adding weight to the base affect stability?" or "Does bridge length affect how hard it is to pull?"). They create fair tests by comparing lifting effort with and without modifications, testing stability with different base configurations, or measuring the relationship between bridge weight and required pulling force.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students observe and describe relationships in drawbridge systems: heavier bridges require more pulling force to lift; wider bases are more stable and less likely to tip; rope friction over sharp edges makes lifting harder; and using pulleys (if explored) reduces required pulling effort. They recognise patterns such as the inverse relationship between stability and centre of gravity height—lower, wider bases provide better stability.

Challenge 10 - Drawbridge

Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, iterative design processes to create optimised drawbridge systems: analysing competing requirements (operational mobility and structural stability), applying mechanical engineering principles to initial designs (calculating moment arms, stability ratios, mechanical advantage opportunities), constructing prototypes with planned dimensions and mechanisms, testing both lifting operation and structural stability, identifying failure modes (tipping during operation, excessive friction, inadequate Hinge support, rope slippage), modifying designs with calculated improvements (widening base using stability formulas, adding pulleys at friction points, increasing Hinge quantity, incorporating counterweights or latches), and iterating through multiple cycles to achieve drawbridge systems that successfully balance operational function with structural stability whilst incorporating creative architectural features.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for engineering rope-operated lifting mechanisms: define bridge specifications (length, intended load), calculate stability requirements (minimum base width based on structure height and centre of gravity), design lifting mechanism (rope attachment points, Hinge positioning, optional pulley locations), construct frame with calculated base dimensions, attach bridge deck using Hinges positioned for smooth rotation, install rope system (determine rope length, position Rope Anchors, route through pulleys if used), test lifting operation and measure required force, assess structural stability during lifting (observe for tipping, measure tilt angles), diagnose issues (excessive friction, instability, binding), calculate and implement modifications (add pulleys to reduce friction by measured percentage, widen base to achieve stable ratio). They evaluate their mechanical engineering methodology and refine their algorithmic approach for more accurate prediction of mechanical advantage and structural requirements.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from mechanical testing to explain how engineering knowledge of forces, moments, and mechanical advantage enables sustainable lifting mechanism design. They demonstrate that understanding friction principles allows engineers to incorporate pulleys that significantly reduce required effort—achieving the same lifting result with less energy input, representing sustainable practice through efficiency improvement. They explain that understanding centre of gravity and stability principles enables structural designs that remain stable without excessive material use, and that rope-based systems provide durable, maintainable solutions requiring no electrical power—demonstrating how scientific knowledge enables sustainable mechanical design through friction reduction, structural optimisation, and human-powered operation.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about lifting mechanisms and structural mechanics (e.g., "How does pulley placement affect required lifting force?" or "What base width-to-height ratio prevents tipping during operation?" or "Does increasing Hinge quantity from two to four significantly improve lifting smoothness?" or "How does rope friction over edges compare to friction through pulleys?"), identify variables (bridge mass and length, rope length and friction, pulley quantity and position, Hinge quantity, base dimensions, lifting angle), design controlled experiments measuring forces and stability, and conduct systematic tests gathering quantitative data about mechanical advantage, friction coefficients, stability limits, and structural performance.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret quantitative data from mechanical and structural testing to support explanations about forces, moments, and mechanical advantage. They construct evidence-based arguments for design decisions, citing specific measurements (e.g., "incorporating a pulley reduced required lifting force from 400g to 250g—a 37.5% reduction demonstrating mechanical advantage" or "drawbridges with base width less than 1.5 times the frame height tipped during lifting, whilst those exceeding this ratio remained stable, confirming centre of gravity calculations"), explaining these results using physics principles about tension forces, friction coefficients, moment arms, torque, and stability criteria based on centre of gravity position.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the physics and engineering of lifting mechanisms and structural stability, using advanced vocabulary (tension force, gravitational force, moment arm, torque, mechanical advantage, friction coefficient, pulley system, centre of gravity, stability ratio, pivot point, angular rotation, load distribution, counterweight system, force multiplication). They produce engineering analyses explaining how pulleys provide mechanical advantage and reduce friction with quantitative calculations, structural stability reports including centre of gravity calculations and base-to-height ratio requirements with supporting mathematics, comparative studies documenting friction measurements (rope-over-edge versus rope-through-pulley) with efficiency calculations, design specifications for drawbridge systems with force diagrams and dimensional requirements, or engineering portfolios explaining how their drawbridge designs demonstrate mechanical engineering principles through rope-based lifting systems that achieve force multiplication via pulleys, maintain structural stability through calculated base dimensions, and integrate functional mechanisms with creative architectural features representing historical or modern bridge engineering.

Challenge 11 - Winching		
Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how mechanical engineers design winch systems to meet lifting and pulling needs in various industries. They explore how winches appear in tow trucks, boat trailers, construction cranes, and rescue equipment, discovering that engineers use rotating drums (spools) to wind rope, converting rotational motion into linear pulling force. They understand that winches provide mechanical advantage, allowing humans or small motors to lift or pull heavy loads that would otherwise be impossible to move.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how the Spool functions as a rotating drum that winds rope to create lifting force: as the Spool rotates, rope wraps around it, shortening the free rope length and pulling the load upward against gravity. They explain that the Hand Crank provides input rotation, the shaft transmits this rotation to the Spool, and the rope secured inside the Spool converts rotational motion into linear pulling motion. They observe that heavier loads (like the 3x Pitch Weighted Truss at 75g) require more cranking effort, demonstrating the relationship between load weight and required input force.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore winch mechanisms by building a hand-powered lifting system and testing its load capacity. They experiment with winding and unwinding the rope, observing how many crank rotations are needed to lift the load different heights. They investigate the challenge posed in the explore section: adapting the winch to mount on the car from Challenge #8, discovering that they need to widen the wheelbase or position the winch above the wheels to make it fit whilst maintaining vehicle functionality.
AC9TDE4P02	Generate, communicate and compare designs	Students generate creative ideas for winch applications such as vehicle-mounted rescue winches, crane systems for construction sites, boat-launching mechanisms, or cargo elevators. They communicate their designs using technical terminology (Spool, winch, winding, Hand Crank, rope, load, lifting capacity, rotational motion, linear motion) and may sketch or photograph their mechanisms, explaining how rotational input converts to linear pulling output and how they solved mounting challenges.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate components for their winch system: choosing a Hand Crank for input, a shaft to connect the crank to the Spool, the Spool as the winding drum, rope of suitable length, and a weighted truss as the load. They safely assemble the winch, learning the rope attachment method (drop rope end into Spool centre, insert shaft through both rope end and Spool to secure). They practice safe cranking techniques, ensuring the structure remains stable during winding operations.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their winch designs against criteria such as lifting capability (successfully raises the load), operational smoothness (cranking rotates Spool without binding), rope security (doesn't slip from Spool during winding), and structural stability (frame remains stable during operation). They test by lifting loads of various weights, counting crank rotations required for specific lift heights, and assessing whether their vehicle-mounted winch (if attempted) maintains car functionality whilst providing pulling capability.

Challenge 11 – Winching

Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 – Design and Technologies Alignment		
Years 5–6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how mechanical engineers balance competing factors when designing winch systems: larger Spool diameter winds more rope per rotation (faster lifting) but requires more cranking torque; adding gears for mechanical advantage reduces required effort but slows lifting speed and increases complexity; hand-powered winches are sustainable (no electricity) but limit lifting capacity to human strength; and robust construction ensures durability but increases weight and material use. Engineers must consider load capacity requirements, available power source (human versus motor), operational speed needs, portability constraints, and maintenance accessibility when designing winches for specific applications—balancing performance with sustainability through appropriate sizing and mechanical advantage that achieves required capability without over-engineering.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain the energy transformation pathway in winch systems: input energy (human muscle power or electrical motor energy) converts to rotational kinetic energy in the Hand Crank/drive shaft, transfers through the shaft to the Spool as rotational kinetic energy, converts to linear kinetic energy as rope winds and the load moves upward, and finally transforms to gravitational potential energy as the load gains height. They articulate that this demonstrates the principle that rotational motion can be systematically converted to linear motion through rope-winding mechanisms, a fundamental concept applicable to both human-powered and motor-driven winch systems.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how Spool design enables rope winding: the central cavity accepts the rope end, the shaft passes through both Spool and rope end to create a secure anchor point preventing rope slippage during winding, and the cylindrical drum provides a smooth winding surface with predictable rope accumulation per rotation. They articulate that rope properties (flexibility, tensile strength) enable it to wrap around the Spool whilst resisting breaking under load tension, and that the Spool radius directly affects mechanical advantage—larger radius winds more rope per rotation but requires more torque. They explain the engineering trade-off: winches demonstrate the conversion of rotational to linear motion, with the Spool acting as the critical interface component where circular motion becomes pulling force.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into winch mechanisms by designing and testing various configurations: building winches with different gear ratios (adding gears between Hand Crank and Spool to change mechanical advantage), measuring the force-distance trade-off quantitatively (comparing cranking effort to lift height), exploring vehicle integration challenges (modifying car chassis from Challenge #8 to accommodate winches whilst maintaining mobility), investigating compound pulley systems combining winches with pulleys for greater mechanical advantage, testing maximum load capacity, and documenting relationships between Spool diameter, gear ratios, cranking effort, lifting speed, and maximum sustainable load.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated winch system designs for specific applications (vehicle recovery winches, construction cranes, material elevators, boat launching systems), iterate through testing cycles to optimise mechanical advantage and lifting capacity, and communicate using precise engineering terminology (winch drum, rotational-to-linear conversion, mechanical advantage, gear ratio, load capacity, winding radius, rope velocity, input torque, output force, power transmission, force multiplication). They create technical documentation including side-view mechanical diagrams showing rope path and winding pattern, force analysis diagrams illustrating input torque and output tension, gear ratio calculations when incorporating speed/torque modifications, dimensional drawings for vehicle-mounted winch integration, or digital presentations explaining how their winch designs demonstrate the principle of converting rotational energy to linear pulling force through rope-winding mechanisms with calculated mechanical advantage.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make sophisticated engineering decisions about winch construction: selecting appropriate shaft lengths to accommodate Spool width and Hand Crank positioning, determining optimal rope length based on required lift height and Spool capacity, calculating whether gears should be added to reduce cranking effort (accepting slower lifting), designing structural frames that withstand lifting forces without tipping or flexing, and solving vehicle integration challenges through chassis widening, component repositioning, or elevated mounting. They demonstrate mastery of rope-spool assembly, properly securing rope inside the Spool to prevent slippage during high-tension winding, and constructing increasingly complex lifting systems that balance load capacity with operational efficiency and structural integrity.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate sophisticated design criteria for winch systems including functional performance (adequate load capacity for intended use, reliable rope winding without slippage, smooth cranking operation), mechanical specifications (appropriate mechanical advantage for available input force, acceptable lift speed, quantified maximum load capacity), structural requirements (frame stability under maximum load, secure component mounting, adequate rope capacity on Spool), integration constraints (vehicle-mounted winches must not compromise mobility), and sustainability considerations (human-powered operation eliminating electricity dependence, appropriate sizing that achieves capability without excessive materials). They evaluate designs through quantitative testing (measuring maximum load capacity, calculating mechanical advantage ratios, documenting force-distance relationships, testing structural stability under load), and refine mechanical and structural elements based on measured performance data and engineering calculations.

Challenge 11 - Winching

Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create functional winch mechanisms: identifying the need for mechanical lifting assistance, selecting appropriate components (Hand Crank, shaft, Spool, rope, load), assembling the basic winch, testing lifting performance, and potentially modifying their design to mount on a vehicle (requiring chassis modifications, strategic component positioning, or creative engineering to integrate winching and rolling functions).
ST2-DDT-02	Designs and uses algorithms, represents data and uses digital systems for a purpose	Students follow systematic procedures for building winch mechanisms: construct support frame for Hand Crank and Spool, insert shaft through Spool, drop rope end into Spool centre, thread shaft through rope end to secure it, attach Hand Crank to shaft, position load on rope end, test winding operation, count rotations needed for specific lift heights, record observations. They demonstrate algorithmic thinking by understanding that rope must be secured before winding, and that systematic testing reveals quantitative relationships between input (rotations) and output (lift height).
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how winch systems transform and transfer energy: human muscle energy converts to rotational kinetic energy in the Hand Crank, which transfers through the shaft to the Spool as rotational energy, then converts to linear kinetic energy as the rope winds, finally transforming to gravitational potential energy as the load rises. They observe that energy flows through the mechanical system from input (cranking) to output (lifted load), demonstrating energy transformation and conservation in physical systems.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about winch performance and mechanical advantage (e.g., "How many crank rotations are needed to lift the load 10cm?" or "Does the winch lift heavier loads than we could lift by hand?" or "What happens if we add gears between the Hand Crank and Spool?"). They create fair tests by measuring lift height per crank rotation, comparing cranking effort for different loads, or testing whether adding mechanical advantage through gears changes the force-distance relationship.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students observe and describe relationships in winch systems: more crank rotations produce greater lift height; heavier loads require more effort to crank but lift the same distance per rotation; winding rope onto the Spool shortens the rope length by a predictable amount per rotation. They recognise the pattern that rotational motion (circular cranking) consistently converts to linear motion (vertical lifting) through the rope-winding mechanism.

Challenge 11 - Winching

Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, iterative design processes to create optimised winch systems: analysing lifting requirements (load mass, lift height, available input force), applying mechanical engineering principles to calculate required mechanical advantage and gear ratios, designing initial winch configurations with selected components and optional gears, constructing prototypes with measured dimensions and calculated ratios, testing lifting performance through load trials and effort assessment, identifying limitations (excessive cranking effort, inadequate lift speed, structural instability under load, rope slippage, vehicle integration conflicts), modifying designs with calculated improvements (adding specific gear ratios to reduce effort by measured percentages, increasing Spool diameter to improve winding speed, reinforcing frame to withstand higher loads, redesigning chassis for successful vehicle integration), and iterating through multiple cycles to achieve winch systems that successfully lift target loads with reasonable effort whilst meeting integration or portability requirements.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for engineering winch systems: define load specifications (mass to lift, lift height required), calculate work required (load mass × lift height × gravitational constant), determine available input force (sustainable human cranking effort), calculate required mechanical advantage (load force ÷ available input force), select gear configuration to achieve calculated advantage (choosing gear tooth count ratios), determine Spool specifications (diameter affects rope wound per rotation), design structural frame (must withstand maximum load tension), assemble components (secure rope in Spool, connect gears if used, attach Hand Crank, construct stable frame), test lifting performance (measure cranking effort, count rotations to target height, verify load capacity), calculate actual mechanical advantage from measurements, diagnose performance issues (excessive effort indicating insufficient mechanical advantage, slow lifting indicating over-gearing, structural flexing indicating inadequate frame strength), modify based on calculations and test data. They evaluate their mechanical engineering methodology and refine their algorithmic approach for more accurate prediction of required mechanical advantage and optimal gear selection.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from mechanical testing to explain how engineering knowledge of rotational-to-linear motion conversion, mechanical advantage, and force-distance relationships enables sustainable lifting solutions. They demonstrate that understanding winch mechanics allows engineers to design human-powered systems capable of lifting loads far exceeding human strength alone—achieving heavy lifting without electrical power consumption, representing sustainable practice through mechanical advantage that amplifies human capability. They explain that understanding gear ratios and mechanical advantage principles enables engineers to optimise winch design: selecting appropriate gear reductions that balance effort with speed, sizing components to meet load requirements without over-engineering, demonstrating how scientific knowledge enables sustainable mechanical design through efficient force multiplication and appropriate system sizing.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about winch mechanics and mechanical advantage (e.g., "How does Spool diameter affect rope wound per Hand Crank rotation?" or "What gear ratio provides optimal balance between cranking effort and lifting speed?" or "How does load mass affect the maximum sustainable cranking force?" or "Does rope thickness affect winding capacity and mechanical advantage?"), identify variables (Spool diameter, gear ratios, load mass, rope length and diameter, Hand Crank radius, number of rotations, structural stability), design controlled experiments with measured inputs and outputs, and conduct systematic tests gathering quantitative data about mechanical advantage, force-distance relationships, lifting capacity, winding efficiency, and the trade-offs between speed and force in winch systems.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret quantitative data from winch testing to support explanations about mechanical advantage, energy conservation, and rotational-to-linear motion conversion. They construct evidence-based arguments for design decisions, citing specific measurements (e.g., "direct Hand Crank to Spool connection lifted 75g load with moderate effort over 8 rotations, whilst adding a 3:1 gear reduction (60T to 20T) reduced effort by 65% but required 24 rotations for the same height, confirming the force-distance trade-off principle" or "Spool diameter of 50mm wound approximately 157mm of rope per rotation, closely matching the calculated circumference of πd"), explaining these results using physics principles about mechanical advantage, work (force × distance), conservation of energy, and the mathematical relationships governing circular-to-linear motion conversion.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the physics, mathematics, and engineering of winch mechanisms, using advanced vocabulary (rotational-to-linear motion conversion, mechanical advantage, force multiplication, work principle, gear ratio, torque amplification, load capacity, winding drum, rope velocity, input effort, output force, conservation of energy, force-distance trade-off, circumferential distance, angular rotation). They produce engineering analyses explaining how winches provide mechanical advantage through gear ratios with supporting calculations and work-energy principles, technical specifications for winch systems including load capacity calculations, required gear ratios with mathematical derivations, and structural strength requirements, comparative studies documenting quantitative testing of different gear configurations with measured mechanical advantage ratios and efficiency calculations, design reports explaining vehicle-mounted winch integration challenges with engineering solutions and trade-off analyses, or comprehensive engineering portfolios explaining how their winch designs demonstrate fundamental mechanical engineering principles: converting rotational motion to linear force through rope-winding mechanisms, achieving force multiplication through calculated gear ratios that balance cranking effort with lifting speed, and applying work-energy conservation principles showing that reduced effort necessarily requires increased distance (more rotations) to achieve the same lifting work output.

Challenge 12 - Clamping Cardboard		
Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 3-4		
AC9TDE4K01	Examine design and technologies occupations and factors including sustainability that impact on the design of products, services and environments to meet community needs	Students examine how product designers and engineers combine structural frameworks with surface materials to create functional and aesthetically pleasing designs. They explore how cardboard and other craft materials provide sustainable, recyclable options for prototyping and construction, discovering that combining rigid structural frames (Snap trusses) with flexible surface materials (cardboard) allows designers to create strong, lightweight products efficiently. They understand that this approach appears in architecture, product packaging, furniture design, and theatrical set construction.
AC9TDE4K02	Describe how forces and the properties of materials affect function in a product or system	Students describe how Cardboard Clamps function by gripping materials in a flexible slot that accommodates varying thicknesses whilst the clamp body snaps securely into trusses like Connectors. They explain that cardboard's properties—lightweight, rigid when supported, easy to cut and shape—make it ideal for adding surfaces to truss frameworks. They observe that the truss framework provides structural strength whilst cardboard provides surface area, demonstrating how combining materials with different properties creates functional products.
AC9TDE4P01	Explore needs or opportunities for designing, and test materials, components, tools, equipment and processes needed to create designed solutions	Students explore creative opportunities by building structures that combine Snap components with cardboard and craft materials. They experiment with cutting cardboard to different sizes and shapes, testing how well Cardboard Clamps hold various thicknesses and materials (cardboard, popsicle sticks, pipe cleaners). They investigate whether to make trusses visible or hide them behind cardboard, discovering different aesthetic and structural approaches. They may explore the Engineering Tip's suggestion of building cardboard ramps to test inclined plane principles with their cars.
AC9TDE4P02	Generate, communicate and compare designs	Students generate creative ideas for cardboard-enhanced structures such as castles (incorporating the drawbridge from Challenge #10), vehicles with cardboard bodies, buildings, displays, or theatrical sets. They communicate their designs using technical terminology (Cardboard Clamp, framework, surface material, structural support) and may sketch plans showing where cardboard panels will attach to truss frameworks, photograph construction stages, or create design portfolios explaining their creative and structural decisions.
AC9TDE4P03	Select and use materials, components, tools, equipment and techniques to safely make designed solutions	Students select appropriate materials for their designs: choosing cardboard thickness suitable for their purpose (thinner for flexibility, thicker for rigidity), cutting cardboard to fit Cardboard Clamp positions or creating notches to accommodate clamps, and selecting complementary craft materials (pipe cleaners for details, popsicle sticks for structural elements). They safely use scissors or cutting tools to shape cardboard, properly insert cardboard into Cardboard Clamp slots, and snap clamps into trusses to create secure cardboard-to-framework connections.
AC9TDE4P04	Use given or co-developed design criteria including sustainability to evaluate design ideas and solutions	Students evaluate their cardboard-enhanced structures against criteria such as structural integrity (cardboard securely attached and properly supported), creative design (interesting or functional use of cardboard elements), appropriate material selection (cardboard thickness suitable for purpose), and aesthetic quality (clean cuts, thoughtful design, effective combination of materials). They test whether cardboard panels remain secure during handling, assess whether their structures achieve intended creative or functional goals, and consider how using recyclable cardboard represents sustainable design practice.

Challenge 12 - Clamping Cardboard		
Outcome Code	Outcome Description	How this lesson meets the outcome
Australian Curriculum V9.0 - Design and Technologies Alignment		
Years 5-6		
AC9TDE6K01	Explain how people in design and technologies occupations consider competing factors including sustainability in the design of products, services and environments	Students explain how designers balance competing factors when combining structural frameworks with surface materials: cardboard provides lightweight, sustainable, recyclable surfaces but has limited strength and durability; using more cardboard reduces truss visibility (better aesthetics) but may add unnecessary weight; cutting cardboard precisely to fit Cardboard Clamp positions creates cleaner designs but requires more time and skill; and incorporating notches for clamps creates seamless appearance but weakens cardboard edges. Designers must consider structural requirements, aesthetic goals, material sustainability (cardboard is renewable and recyclable), production efficiency, and intended lifespan when deciding how to combine rigid frameworks with flexible surface materials—balancing performance, appearance, and environmental impact.
AC9TDE6K02	Explain how electrical energy can be transformed into movement, sound or light in a product or system	Students explain how simple machines like inclined planes (if exploring the Engineering Tip's ramp challenge) transform gravitational potential energy to kinetic energy. They describe how positioning a car at the top of a cardboard ramp stores gravitational potential energy (mass × gravity × height), which converts to kinetic energy (motion) as the car rolls down, with some energy dissipated as heat through friction between wheels and ramp surface. They articulate that steeper ramps produce faster motion (more rapid energy conversion) whilst gentler slopes produce slower motion (gradual energy conversion), demonstrating how slope angle affects energy transformation rate.
AC9TDE6K05	Explain how characteristics and properties of materials, systems, components, tools and equipment affect their use when producing designed solutions	Students explain how Cardboard Clamp design enables versatile material attachment: the flexible slot accommodates cardboard of varying thicknesses plus alternative materials like popsicle sticks or pipe cleaners; the clamp body snaps into trusses identically to Connectors, making it familiar and easy to position; and the clamping mechanism provides adequate grip force to secure lightweight materials without crushing them. They articulate that cardboard's properties make it ideal for rapid prototyping and sustainable construction—it's inexpensive, recyclable, easily cut and shaped, provides good surface area-to-weight ratio, and can be decorated or painted—whilst its limitations (susceptible to moisture, limited strength, can tear at stress points) require proper structural support from truss frameworks. They explain the synergistic relationship: trusses provide strength and structure efficiently in three dimensions, whilst cardboard provides two-dimensional surfaces efficiently, combining their complementary strengths.
AC9TDE6P01	Investigate needs or opportunities for designing, and the materials, components, tools, equipment and processes needed to create designed solutions	Students conduct comprehensive investigations into composite structure design by creating various cardboard-enhanced projects: designing architectural models combining truss frameworks with cardboard walls and roofs, building vehicle bodies that enclose mechanical components whilst maintaining functionality, constructing theatrical set pieces that balance visual impact with structural stability and portability, creating product prototypes that demonstrate form and function. They explore advanced cardboard techniques (scoring for controlled folding, laminating multiple layers for strength, creating geometric forms), investigate which craft materials work effectively with Cardboard Clamps, test structural limits (maximum unsupported cardboard spans, optimal clamp spacing), and document best practices for integrating rigid frameworks with flexible surface materials.
AC9TDE6P02	Generate, iterate and communicate design ideas, decisions and processes using technical terms and graphical representation techniques, including using digital tools	Students generate sophisticated designs combining structural engineering with creative cardboard work (castles incorporating functional drawbridges from Challenge #10, vehicles with aerodynamic cardboard bodies, architectural models with interior details, kinetic sculptures with moving cardboard elements), iterate through prototyping cycles to optimise structural support and aesthetic integration, and communicate using precise terminology (composite structure, framework-to-surface integration, material properties, structural support density, surface panel, clamping mechanism, sustainable materials, prototype construction, geometric netting). They create technical documentation including exploded-view drawings showing truss framework and cardboard panel relationships, dimensioned cutting templates for cardboard components, assembly sequences illustrating framework construction followed by panel attachment, material selection justifications explaining cardboard versus alternative options, or digital presentations explaining how their designs demonstrate sustainable engineering through recyclable materials, efficient structural design, and composite construction techniques that optimise strength-to-weight ratios.
AC9TDE6P03	Select and use suitable materials, components, tools, equipment and techniques to safely make designed solutions	Students make sophisticated decisions about composite structure construction: selecting cardboard thickness based on structural requirements and desired flexibility (thin cardboard for curved surfaces, thick cardboard for rigid panels requiring minimal support), calculating optimal Cardboard Clamp spacing to prevent panel sagging whilst minimising clamp quantity, planning cutting strategies that minimise waste and utilise cardboard grain direction for strength, deciding whether to create notched cutouts for clamps (seamless appearance but more complex fabrication) or use rectangular panels (simpler but visible edges), and incorporating sustainable practices by reusing cardboard from packaging or recycled sources. They demonstrate mastery of precision cardboard work, measuring and cutting accurately to achieve clean edges and proper fit, safely operating cutting tools, and constructing increasingly complex composite structures that successfully integrate engineered frameworks with creative surface treatments.
AC9TDE6P04	Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	Students negotiate sophisticated design criteria for cardboard-enhanced structures including structural performance (adequate framework support prevents cardboard sagging, secure Cardboard Clamp attachment withstands handling, overall structure remains stable), aesthetic quality (clean cardboard cuts and edges, thoughtful integration of framework and surfaces, cohesive design that balances visibility and concealment of structural elements), creative achievement (design fulfils intended purpose effectively, incorporates interesting or innovative features), material efficiency (minimises cardboard waste through careful planning, uses appropriate thickness for each application), and sustainability (utilises recyclable/recycled cardboard, demonstrates reuse of materials, achieves performance goals with minimal resource consumption). They evaluate designs through functional testing (structural integrity under use, durability of cardboard-clamp connections), aesthetic assessment (visual appeal, craftsmanship quality), and sustainability analysis (material source, waste generated, end-of-life recyclability), refining their composite structures based on comprehensive performance evidence and sustainable design principles.

Challenge 12 - Clamping Cardboard

Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 2 (Years 3-4)		
ST2-DDT-01	Uses a design process to create products to address user needs or opportunities	Students use a design process to create cardboard-enhanced structures: identifying creative or functional goals (castle, vehicle body, building, display), planning cardboard panel sizes and positions, selecting appropriate Snap framework components for structural support, cutting cardboard to required shapes, assembling the framework, attaching cardboard panels using Cardboard Clamps, testing structural integrity and appearance, and refining their design by adjusting cardboard placement, adding decorative elements, or reinforcing weak points.
ST2-DDT-02	Designs and uses algorithms, represents data and uses digital systems for a purpose	Students follow systematic procedures for integrating cardboard with Snap structures: design overall structure and identify where cardboard surfaces are needed, construct truss framework to support cardboard panels, measure and cut cardboard to required dimensions, insert cardboard edges into Cardboard Clamp slots, snap Cardboard Clamps into trusses at planned positions, test security of attachments, add decorative or functional details. They demonstrate algorithmic thinking by understanding that framework construction should precede cardboard attachment and that planning panel sizes before cutting improves efficiency and material use.
ST2-SCI-01	Uses information to investigate the solar system and the effects of energy on living, physical and geological systems	Students investigate how forces affect composite structures combining rigid frameworks with flexible surfaces. They explore how the truss framework distributes forces and provides structural support, whilst cardboard provides surface area without adding excessive weight. If exploring the Engineering Tip about inclined planes (ramps), they investigate how gravitational force causes cars to roll down slopes, observing that steeper ramps increase speed whilst gentler slopes extend rolling time, demonstrating energy transformation from potential to kinetic energy.
ST2-PQU-01	Poses questions to create fair tests that investigate the effects of energy on living things and physical systems	Students pose questions about material combinations and structural design (e.g., "Does cardboard thickness affect how well it stays in the Cardboard Clamps?" or "Which materials besides cardboard work in the clamps?" or "How does ramp angle affect car rolling speed?"). They create fair tests by comparing different cardboard thicknesses in clamps, testing various craft materials' compatibility with clamps, or measuring car rolling distance on ramps of different angles, gathering evidence about material properties and simple machine principles.
ST2-DAT-01	Uses and interprets data to describe patterns and relationships	Students observe and describe relationships in composite structures: thicker cardboard requires more force to insert into Cardboard Clamps but provides greater rigidity; cardboard panels need truss framework support at regular intervals to prevent sagging; and (if exploring ramps) steeper inclines produce faster rolling speeds whilst shallower inclines produce slower speeds but potentially longer total distances. They recognise patterns in how structural frameworks and surface materials work together to create functional designs.

Challenge 12 - Clamping Cardboard		
Outcome Code	Outcome Description	How this lesson meets the outcome
NSW NESA Science and Technology K-6 (2024) Alignment		
Stage 3 (Years 5-6)		
ST3-DDT-01	Uses design processes to create, evaluate and modify designed solutions	Students employ sophisticated, iterative design processes to create optimised composite structures: analysing design goals (functional requirements, aesthetic objectives, structural constraints), applying material science and structural engineering principles to plan framework-surface integration, sketching designs with dimensioned cardboard panels and planned Cardboard Clamp positions, constructing truss frameworks with calculated support spacing, fabricating cardboard components with precision cutting and optional notching, assembling composite structures by attaching panels to frameworks, testing structural integrity (checking for panel sagging, evaluating clamp security, assessing overall stability), identifying improvements (inadequate support causing deflection, poor cardboard-framework integration, aesthetic issues with visible framework), modifying designs with calculated enhancements (adding framework supports at measured intervals, improving cardboard cutting techniques, refining clamp positioning for better appearance), and iterating through multiple cycles to achieve composite structures that successfully balance structural performance, creative expression, material efficiency, and sustainable construction practices.
ST3-DDT-02	Creates, evaluates and modifies algorithms to code or control digital devices and systems	Students create detailed algorithms for engineering composite cardboard-framework structures: define project goals (castle, vehicle, building, etc.) and identify required surfaces, analyse structural requirements (which panels need support, where loads will occur), design truss framework (calculate support spacing to prevent cardboard deflection based on thickness and span), create dimensioned cardboard cutting plans (measure panel sizes, plan cuts to minimise waste, consider grain direction), decide integration method (visible framework versus concealed with notched cardboard), construct framework with planned dimensions and Cardboard Clamp positions, fabricate cardboard panels (measure, mark, cut accurately, create notches if needed), attach panels to framework (insert in clamps, snap clamps into trusses, verify security), test structural performance (check for sagging, assess stability, evaluate appearance), measure and document results (deflection under load, clamp spacing effectiveness, material utilisation efficiency), diagnose issues (insufficient support, poor fit, weak attachment), calculate and implement modifications (add support trusses at calculated positions, adjust clamp spacing, refine cutting technique). They evaluate their composite structure engineering methodology and refine their algorithmic approach for more accurate prediction of support requirements and efficient material utilisation.
ST3-SCI-01	Uses evidence to explain how scientific knowledge can be used to develop sustainable practices	Students use evidence from material testing and structural analysis to explain how engineering knowledge of composite structures, material properties, and load distribution enables sustainable design practices. They demonstrate that understanding how to combine materials with complementary properties—using rigid truss frameworks where strength is needed and lightweight cardboard where surface area is needed—minimises material use whilst achieving structural and functional goals, representing sustainable practice through efficient material allocation. They explain that cardboard's recyclability, biodegradability, and renewable source (trees/recycled paper) make it environmentally preferable to plastics for prototyping and temporary structures, and that understanding structural principles allows designers to use minimal framework support whilst maintaining adequate strength, demonstrating how scientific knowledge enables sustainable design through composite construction, appropriate material selection, and structural optimisation.
ST3-PQU-01	Poses questions to identify variables and conducts fair tests to gather data	Students pose sophisticated investigative questions about composite structures and material integration (e.g., "What is the maximum unsupported cardboard span before sagging occurs for different thicknesses?" or "How does Cardboard Clamp spacing affect panel stability and appearance?" or "Does cardboard grain direction affect strength when used as structural panels?" or "How does ramp angle affect both car speed and total rolling distance?" or "What is the optimal cardboard thickness for creating curved versus flat surfaces?"), identify variables (cardboard thickness and grain orientation, panel dimensions, clamp spacing and position, framework support density, ramp angle, material type in clamps), design controlled experiments with measured parameters, and conduct systematic tests gathering quantitative data about structural deflection, load capacity, material compatibility, and simple machine performance.
ST3-DAT-01	Interprets data to support explanations and arguments	Students interpret quantitative data from structural and material testing to support explanations about composite construction, material properties, and engineering principles. They construct evidence-based arguments for design decisions, citing specific measurements (e.g., "cardboard panels with Cardboard Clamp spacing exceeding 100mm sagged 8mm under their own weight, whilst panels with 50mm clamp spacing showed less than 1mm deflection, demonstrating the relationship between support density and structural rigidity" or "cars rolled 35% faster down 45° ramps than 20° ramps but travelled 28% less total distance, confirming the energy trade-off between conversion rate and friction losses" or "corrugated cardboard oriented with flutes perpendicular to load supported 3.2 times more weight than parallel orientation, validating grain direction importance"), explaining these results using engineering principles about beam mechanics, material anisotropy, energy conservation, and the synergistic properties of composite structures.
ST3-CWT-01	Creates written texts to communicate understanding of scientific and technological concepts and processes	Students create sophisticated technical documentation explaining the engineering, material science, and design principles of composite structures, using advanced vocabulary (composite construction, framework-to-surface integration, material anisotropy, structural support density, load-bearing framework, surface cladding, grain direction, span-to-thickness ratio, deflection under load, clamping mechanism, sustainable materials, recyclable construction, material properties, synergistic design, structural optimisation). They produce engineering analyses explaining how composite structures optimise material use by assigning structural loads to frameworks and surface functions to lightweight panels with supporting physics and material science principles, technical specifications for cardboard-framework integration including calculated support spacing ratios based on cardboard thickness and load requirements with mathematical derivations, construction guides with precise fabrication instructions including cutting templates, clamp positioning diagrams, and assembly sequences, sustainability reports analysing environmental benefits of cardboard use (recyclability, renewable source, biodegradability, low energy manufacturing) with comparative data versus alternative materials, design portfolios documenting creative projects with technical explanations of structural decisions, or comprehensive engineering reports explaining how their composite structures demonstrate sustainable design principles through efficient material allocation (rigid components only where strength is needed, lightweight surfaces only where area is needed), appropriate material selection (recyclable cardboard for temporary or prototype applications), and structural optimisation (achieving adequate performance with minimal support framework through calculated spacing and thickness selection), representing best practices in sustainable engineering design.

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