by WorldStrides®

Family Lab:
Complex Machines Challenge

LAB MANUAL

Welcome to Envision by WorldStrides Family Labs!

Dear Scholar,

Welcome to Envision's Family Lab: Complex Machines! Get ready to dive into the fascinating world of STEM and discover the ways STEM can be found in your everyday life! Are you up to the challenge?

Today, you will take on the role of an engineer and build your own complex machine! A complex machine is a machine made up of simple machines and various cause-and-effect relationships. You are challenged to only use items found within your house (with your family's permission), to make one big complex machine.

You will complete the challenge by using the steps listed in this lab manual. This lab manual is designed to be a resource for how to successfully complete this challenge. By the end of this lab you will be an expert on simple machines and cause-and-effect relationships, and have built your very own complex machine.

Professionals in the world of STEM use simple and complex machines every day to solve real-world problems. If you enjoyed your role as an engineer, we encourage you to explore different careers in the world of STEM, such as scientist, engineer, medical professional, architect, forensic scientist, mathematician, and many other exciting career paths!

Remember, staying safe is very important, so make sure you ask for help from your family as needed when building your complex machine. By completing this Family Lab, we hope that you have fun and learn something new about the exciting world of STEM!

Good Luck!

Yolanda Golden

Yolanda Golden
Vice President, Educational Experience
National Youth Leadership Forum: Pathways to STEM

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Know Before You Go!

To complete this challenge and build your own complex machine, first you need to understand what a complex machine is.

- [ ] **Step 1: Read the resources in the section below and watch the videos to learn about Simple Machines.**

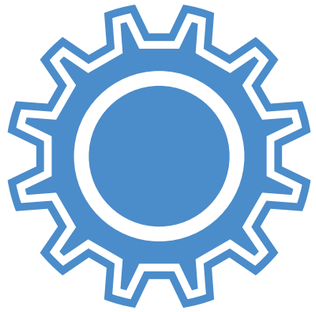
Let's start by learning about simple machines. If we break down the words simple machine, we can get a better understanding of what a simple machine is.

SIMPLE — *Adjective* - Basic; easily understood or done; presenting no difficulty.

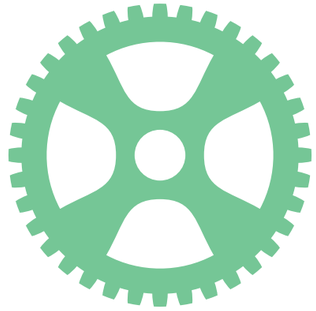
MACHINE — *Noun* - A tool or device for performing a task.

If we put that together, a simple machine is a basic tool and we use them to make a task easier.

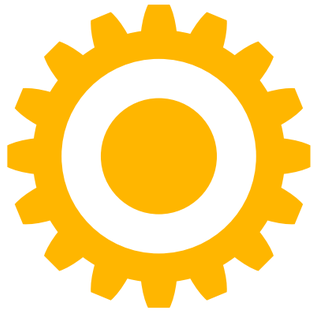
There are six simple machines. On the next page, you will see pictures and descriptions of each simple machine.



VIDEO 1



VIDEO 2



VIDEO 3

Click on each of the gears below to watch a video and learn more about simple machines.

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RIDDLE TIME

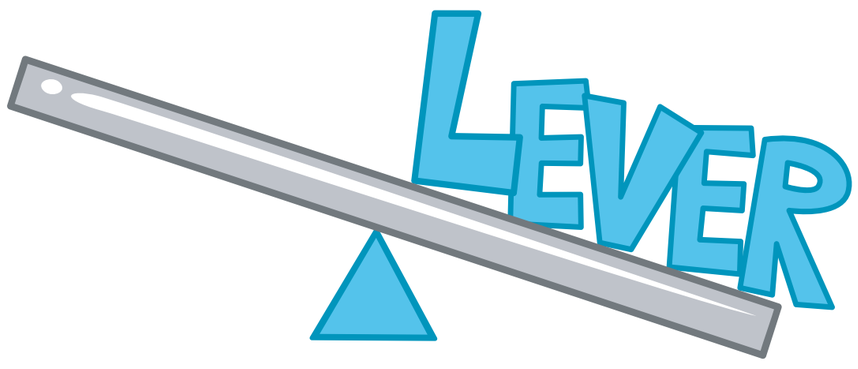
Question: In a one-story green house, there was a green person, a green dog, a green fish, a green computer, a green chair, a green table, a green telephone–everything was green. What color were the stairs?

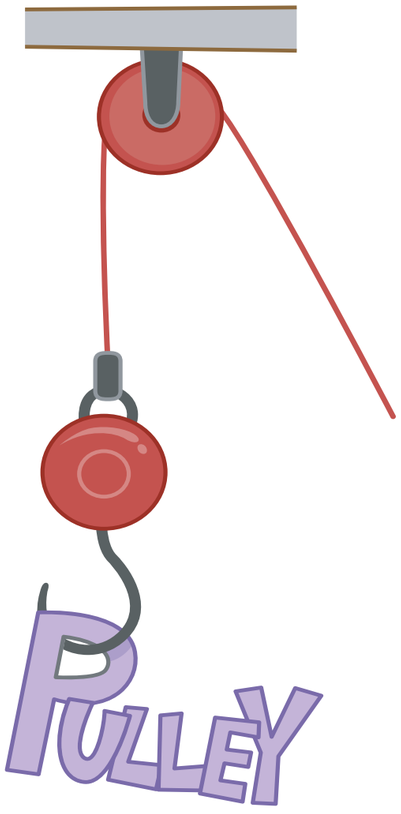
Question: What has hands but can't clap?

Answers on Page 11 of Lesson Plan

Six Simple Machines

Rollover or tap on each image to learn about the simple machine.





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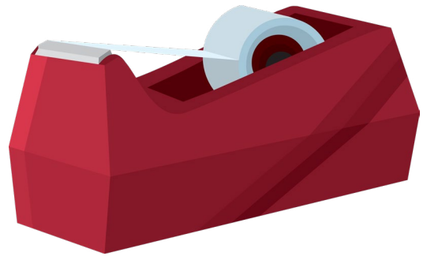
Simple Machines at Home

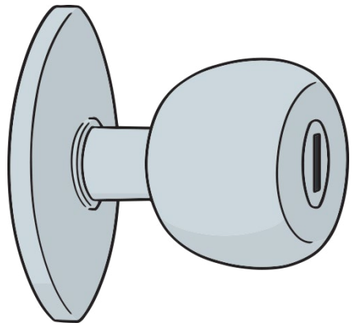
☐ **Step 2: Find an example of each simple machine around your house.**

Look around your house to see if you can find examples of the six simple machines. As you find them, collect them to use during the challenge.

- ☐ **Inclined Plane**
- ☐ **Wedge**
- ☐ **Lever**
- ☐ **Wheel & Axle**
- ☐ **Pulley**
- ☐ **Screw**

Can you identify these simple machines?





Answers on Page 11 of Lesson Plan

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Complex Machines

Step 3: Read the resources in the section below and watch the videos to learn about complex machines.

Now that you understand what a simple machine is, and have found examples from your daily life, let's talk about how simple machines work together to create a complex machine.

Simple machines make up all other machines, by combining the six simple machines is endless ways.

To understand how they work together, you need to first understand cause-and-effect relationships. A **cause-and-effect relationship** is the connection between two objects, with the action of one object causing a reaction from the second object.

Think about what happens when you kick a ball; your foot kicking the ball **(the cause)** makes the ball to roll or move **(the effect)**. This is an example of a cause-and-effect relationship. This is exactly how simple machines work together to build a complex machine.

A complex machine is a machine built by combining simple machines together in cause-and-effect relationships. When two or more simple machines are combined, an action by one simple machine causes an effect on another simple machine.

Do any complex machines come to mind?
Write your answers in the space below

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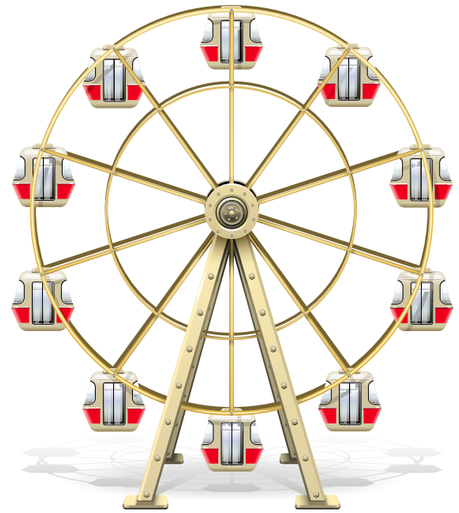
Did you know that the Ferris Wheel is considered one of the greatest engineering accomplishments in the world?

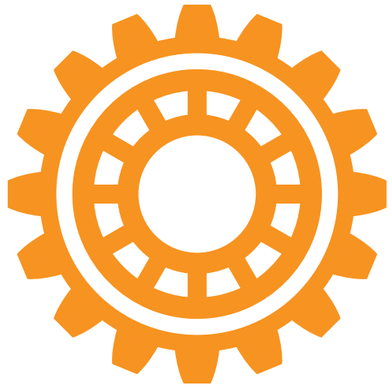
George W. Ferris created the first Ferris Wheel in Pittsburgh, Pennsylvania, in 1893. The wheel was supported by two 140-foot steel towers and connected by a 45-foot axle which was the largest single piece of forged steel ever made at that time.

And it's an example of wheel & axle!

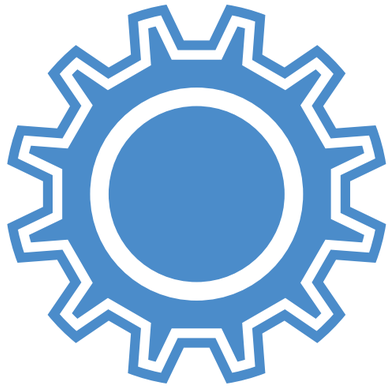


Complex Machines

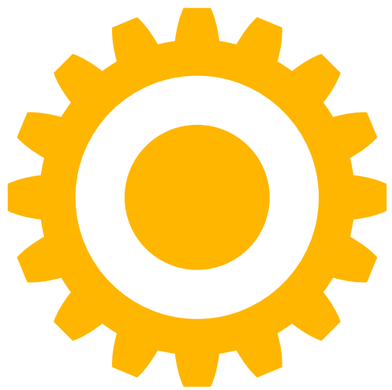
Click on each of the gears below to watch videos about complex machines, so you can see how complex machines are built. While you watch the videos pay close attention to the simple machines and the cause-and-effect relationships that you see. This will help give you ideas to create your own complex machine.



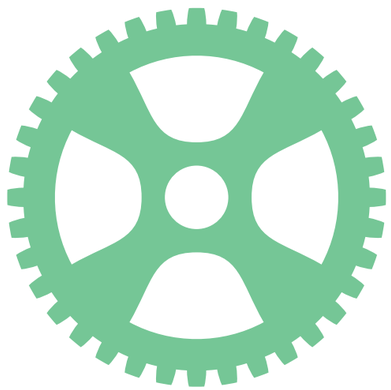
VIDEO 1



VIDEO 2



VIDEO 3



VIDEO 4

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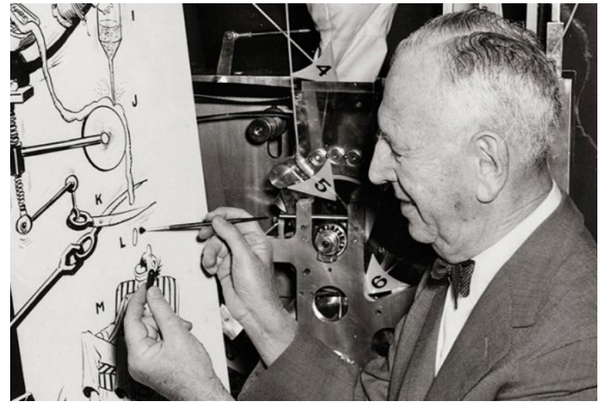
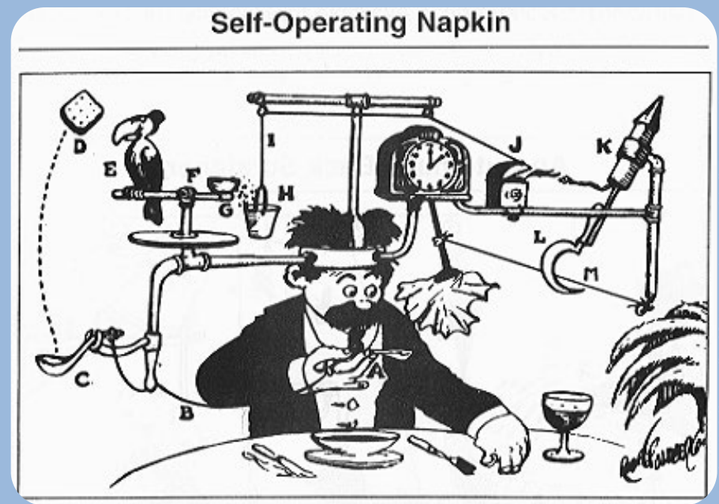
Rube Goldberg

Rube Goldberg (1883 - 1970) was an American cartoonist, sculptor, author, engineer, and inventor. He is best known for his popular cartoons depicting complicated gadgets performing simple tasks in indirect and elaborate ways, like the "Self-Operating Napkin" cartoon below. These cartoons led to the expression "Rube Goldberg machines" to describe similar gadgets.



Norman Rockwell Museum
https://www.illustrationhistory.org/artists/rube-goldberg



Rube Goldberg. "Self-Operating Napkin". Originally published in *Collier's*, September 26 1931

Soup spoon (A) is raised to mouth, pulling string (B) and jerking ladle (C), which throws cracker (D) past toucan (E). Toucan jumps after the cracker and the perch (F) tilts, upsetting seeds (G) into the pail (H). Extra weight in pail pulls cord (I), which opens and ignites lighter (J), setting off skyrocket (K), which causes sickle (L) to cut string (M), allowing pendulum with attached napkin to swing back and forth, thereby wiping the man's chin.

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The Bicycle

A Classic Complex Machine

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Complex Machines at Home

☐ **Step 4: Find an example of a complex machine around your house.**

Look around your house to see if you can find an example of a complex machine. Identify the simple machines used to make up the complex machine.

How many simple machines are in the complex machine you found?

If you are not able to find a complex machine around your house, think about a complex machine that you have seen somewhere else in your daily life.

WORD SEARCH

Want to complete the puzzle on your computer or tablet?
Use the highlighter tool in your PDF reader to highlight the words.

V O G L L D T A Y H Y P O T H E S I S B
M S P A S B I V Y J I L E S L M C E F S
B P A T T E R N V P M N X V X R V M Y A
A C R C R E A T E D P X P D X W Y A C M
L D S I X Q F C V G R O E A B K X T V S
A R C D P E B A Z F E Y R T T L P H O P
N G I E U O K U E A D F I A K V F O I E
C H E S V Q Q S Z V I W M M O T R Z O E
E X N I F E M E W V C I E I F E N J Y D
V B C G O W E B Y B T Z N L G C K O S D
O Z E N B O N E T W M I T L R H L Z B M
Z O V R S N G K J A Z M K V V N K A T O
I M Z N E D I E H J N P S R G O K X E L
A O J W R E N N Q G R R A J O L M I A K
S F O J V R E G E C R O M K P O P M M H
K O D J A J E I J P B V Z F P G B A W O
Z R U W T C R N B L K E X Q W Y B G O M
F C O Z I Z I E O A Y E F F E C T I R V
B E W T O O N E V N U M D D P N V N K L
U E M C N C G R Y Q K W R K B B V E S K

Word Bank

Engineering	Improve	Math	Engineer
Technology	Imagine	Wonder	Predict
Teamwork	Create	Plan	Balance
Science	Design	Ask	Effect
Hypothesis	Data	Observation	Speed
Experiment	Cause	Force	Pattern

Answers on Page 11 of Lesson Plan

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Step 5: Read the challenge guidelines below.
Make sure you understand all elements of the challenge before getting started.

The Challenge!

Your challenge is to build your own complex machine based on the guidelines below. These guidelines identify the required parts of your complex machine and what you need to do to successfully complete the challenge.

Do you think you're up to it?

Guidelines

In your complex machine you must:

- Use 4 of the simple machines you found around your house
- Include an incline plane and a lever
- Have 5 different cause-and-effect relationships
- Use materials found around your house - don't use any items without getting permission from your family first!
- Solve the problem that you define

Helpful Tips and Important Reminders

- Safety is the most important thing to keep in mind, make sure you ask for help from an adult as needed!
- If you get stuck while brainstorming, designing, or building, ask for help from your family.
- Gather all of your materials before you start to design, and lay them out so you can look at them all. Seeing all of your available materials will help you brainstorm.
- Try grouping your materials into groups, such as items that roll, items that are ramps, items that move, items for building, items that connect/ secure, etc. This will help with your brainstorming of how to connect the parts of your machine.
- Check with your family to see where you can or cannot build your machine, you want to make sure you don't accidentally break anything if possible!
- This challenge is all about trial and error, embrace that! It is normal for things not to work on the first try.
- **Remember to have fun!**

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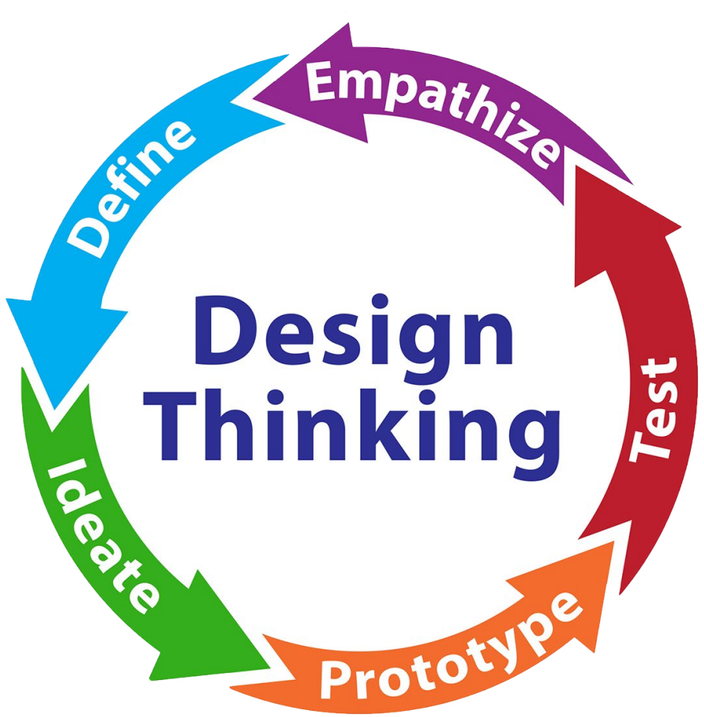
Let's Get Started!

To build the best complex machine, you need to first create a plan for how you will build it. To help you create your plan, let's learn about the Design Thinking Process. This is the same process that engineers use when they come up with a design and are building their own machines, systems, or structures. The steps of this process will help you complete the challenge.

☐ **Step 6: Watch the video and read the explanations on Page 21 to learn about the Design Thinking Process.**

Click on the picture below to watch the video.



The Design Thinking Process

Empathize: Gain an understanding of the problem you're trying to solve by observing and asking questions.

Define: Put together the information you gathered, to form a one-sentence description of the problem you're solving.

Ideate: Brainstorm! Generate ideas, think outside the box, and remember that no idea is a bad idea when you're coming up with new solutions to solve a problem.

Prototype: Experiment with a solution. Then go to the next step and test. You may come back and repeat this step many times, if your test doesn't go the way you want it to.

Test: Try out your prototype! If your prototype doesn't work the way you want it to, you may need to go back a step and build another prototype to test.

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FUN FACT

The word engineer comes from a Latin word meaning 'cleverness'.

Build Your Complex Machine

Now you are ready to begin the challenge!

Bringing an idea from something you brainstormed to reality is harder than it sounds. The design thinking process can help you along this journey by helping you organize your thoughts and map out the stages of the work.

☐ **Step 7: Determine the problem that you are trying to solve with your complex machine.** Use the first two steps of the Design Thinking Process below to help you define your problem.

Empathize

When building your complex machine, you need to determine what problem you are trying to solve.

- What is the final goal of your machine?
- What will it do? Are you trying to ring a bell? Pop a balloon? Open a door? Water a plant?

You need to first decide what your end goal is and what problem you are trying to solve. Use the are below to brainstorm.

Define

Once you have chosen your problem, then you need to describe what that problem is. Write your problem out in one sentence.

The problem I am trying to solve is...

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WORD JUMBLE

Unscramble the words below

iominot _____ **norbimrtas** _____

nahlecelg _____ **rfeco** _____

shicyps _____ **mnoebic** _____

ortpepyo _____ **aldo** _____

Answers on Page 11 of Lesson Plan

Time to Design!

☐ **Step 8: Plan out and design your complex machine.**
Use the next two steps of the Design Thinking Process to help you plan out your design.

Ideate/Brainstorm

Think about the questions below and write down any answers that come to mind. This is the anything goes part of the process, so write down all of your wild ideas to get the creative wheels turning

Think about your problem. What is the best way to solve your problem?
For example, if your problem is how to ring a bell, first think about what cause-and-effect relationship will make the bell ring. That is the first think you want to solve for.

What can you use to accomplish your goal? How can you think outside the box to build a machine that works the way you want it to?

Look at the simple machines that you have found around your house. How do you think that you could put them together to create a complex machine? What is needed to make one simple machine connect to the other?

What is the best location for your machine? Will you build it in your bedroom, in another room in your home, or maybe outside in your yard?

What are some items you can use for your machine? What do you have access to? How can you be creative with the items in your home?

Step 9: Gather your materials! Before moving onto the prototype step, be sure to gather the materials that you will use to build your complex machine.

Design Prototype

First, sketch out what your machine might look like below. Once you like your idea on paper, then start laying out the parts of your machine in the order that they will go.

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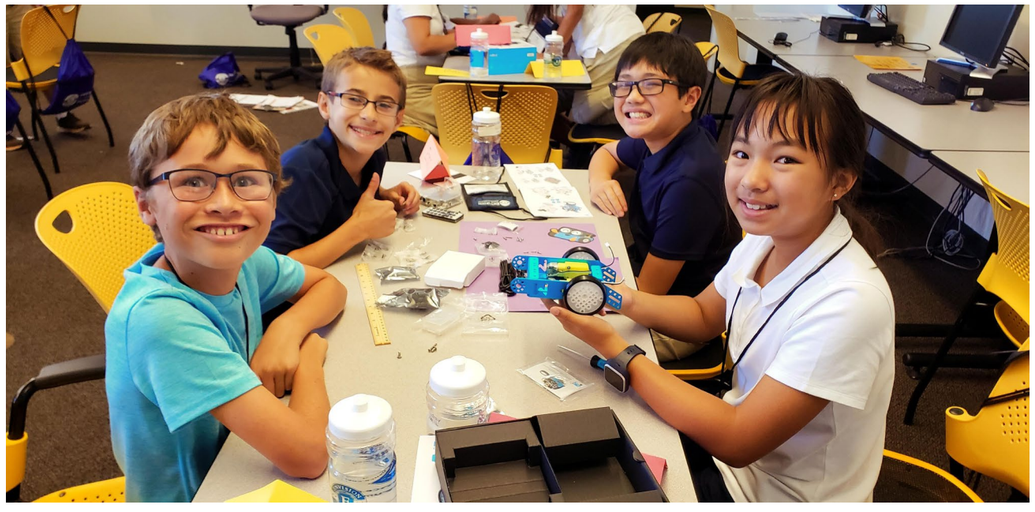
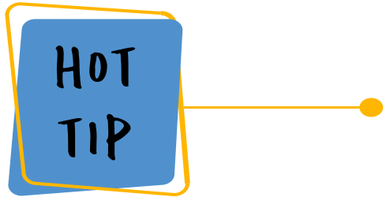
Build and Test!

☐ **Step 10: Build and test your complex machine to see if you have successfully completed the challenge!**
Use the final steps of the Design Thinking Process to help you finalize your complex machine and complete the challenge.

Build Prototype

Once you have all of the parts where they go, then build your machine. You may have to come back and re-build a few times, and that is normal, it is all part of the process.





When laying out the parts and building your machine, start at the end and work backwards. This helps you make sure that you are able to solve your problem successfully.

Test

Test your machine. Does it solve your problem and accomplish the final goal you set in the "Define" stage? If it doesn't, how can you adjust your complex machine and make it better? Test and try out different set-ups for your complex machine to see what works and continue making changes until you successfully solve your problem.

Remember, it might not work the first time, and that is a good thing! An important part of the invention process is failure, as without it we won't learn how things really work. As you make mistakes and try different things, you will get a better understanding of how each of the parts of your machine work, which will allow you to create the best machine possible.

Notes for future improvements:

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CONGRATULATIONS!

If your complex machine successfully solves your problem, you have completed the challenge! Amazing job creating your own complex machine!

We encourage you to take a video of your complex machine in action to share your hard work with your family and friends.

Want to share your creation with Envision by WorldStrides?
Connect with us on Instagram, Twitter, and Facebook using hashtag #EnvisionFamilyLabs

Connect with Us

@envisionexperience @envisionexp Envision Experience

More Complex Machines!

Did you have fun completing this challenge and are interested in another challenge? If so, we have a challenge for you!

Challenge 1: Create another complex machine solving the same problem, but using completely different items and any simple machines that you did not use the first time. Challenge yourself to make it completely different and try not to use any of the same items as the first time. Make sure you have at least 5 different cause-and-effect relationships.

Challenge 2: Create a complex machine solving a new problem using the exact same materials. Are you able to reuse the materials that you used the first time in a way that you are able to solve a new problem? Make sure you have at least 5 different cause-and-effect relationships.

Challenge 3: Create a complex machine solving a new problem and using completely different materials. Make sure you have at least 5 different cause-and-effect relationships and use at least 4 simple machines.

As an extra challenge to any of the above challenges, try using all 6 simple machines in your complex machine. You can also challenge yourself by increasing the number of cause-and-effect relationships in your complex machine.

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Notes

Resource Page

Simple Machines YouTube Videos

Video 1: Learning Junction. (2018 June 22). *Learn about Simple Machines* [Video]. YouTube. https://www.youtube.com/watch?v=aoXnhyY5RTk

Video 2: Scratch Garden. (2018 November 27). *The Simple Machines Song* [Video]. YouTube. https://www.youtube.com/watch?v=iQu3GY509ZM

Video 3: Clarendon Learning. (2019 May 25). *Simple Machines for Kids* [Video]. YouTube. https://www.youtube.com/watch?v=LSfNYpCprw4

Complex Machines YouTube Videos

Video 1: SciShow Kids. (2018 December 19). *The Coolest Machine Ever!* [Video]. YouTube. https://www.youtube.com/watch?v=5mGn6mrlrfw&t=30s

Video 2: BJ 초딩TV. (2018 July 28). *Easy Rube Goldberg Machine* [Video]. YouTube. https://www.youtube.com/watch?v=vn-g1Mn2_3g

Video 3: Delos Santos, Arthur. (2013 March 10). *Simple Rube Goldberg Machine* [Video]. YouTube. https://www.youtube.com/watch?v=w_12tenPbxM

Video 4: Dunn, Kelly. (2017 October 27). *Rube Goldberg Easy Examples* [Video]. YouTube. https://www.youtube.com/watch?v=OHwDf8njVfo&feature=youtu.be

Engineering Design Thinking Process YouTube Video

Crash Course Kids. (2015 May 29). *The Engineering Process: Crash Course Kids #12.2* [Video]. YouTube. https://www.youtube.com/watch?v=fxJWin195kU&list=PLhz12vamHOnZ4ZDC0d-S6C9HRN5Qrm0jHO&index=2

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