

## Introduction

Imagine that you just got into bed and realized that you forgot to turn off the lights. Sure, you could just get up again — but wouldn't it be fun to build a chain reaction machine like the one above? Chain reaction machines are made up of everyday objects and designed to accomplish a simple task in a silly and complicated way. Movement is created by storing and transferring energy, while using gravity and simple machines like levers and pulleys to help it along. We've broken down these complex concepts into some simple activities. Build, reset, and try again. And most of all, have fun as you make your own unique chain reaction machine!

## Design Challenge

Explore stored energy and energy transfer as you build a series of chain reactions.

### Subject:

Engineering

### Ages:

8+

### Time:

30+ minutes

### Key concepts:



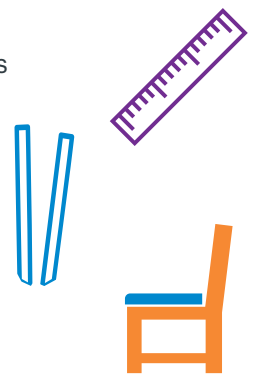


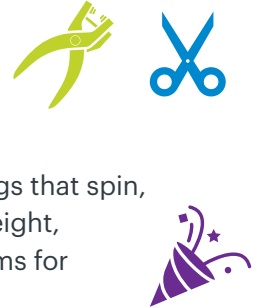
Simple machines, energy transfer, stored energy, potential and kinetic energy, perseverance, cause and effect

## Materials

Chain reactions can include everything from toys to kitchen utensils. Take a look at the [Chain Reaction Challenge Cards](#) at the end of this activity for some inspiration. Thinking about simple machines or motions you want to include in your device can help, but you can also just look around for items that spark your interest.

## Things you can use

We included some categories to inspire you as you look for things. Choose some things from each category, but don't limit yourself to the items on this list. Use whatever you have on hand — be creative!

Things that roll	Ramps, tubes, and tracks	Supports and structure
<ul style="list-style-type: none"> <li><input type="checkbox"/> Marbles</li> <li><input type="checkbox"/> Spools</li> <li><input type="checkbox"/> Corks</li> <li><input type="checkbox"/> Small balls (ex: golf, ping pong)</li> <li><input type="checkbox"/> Toys with wheels</li> <li><input type="checkbox"/> Bottles and cans</li> </ul> 	<ul style="list-style-type: none"> <li><input type="checkbox"/> Cardboard</li> <li><input type="checkbox"/> Tubes (foam, paper or cardboard)</li> <li><input type="checkbox"/> Toy tracks and ramps</li> </ul> 	<ul style="list-style-type: none"> <li><input type="checkbox"/> Cardboard</li> <li><input type="checkbox"/> Kitchen utensils</li> <li><input type="checkbox"/> Rulers</li> <li><input type="checkbox"/> Chopsticks</li> <li><input type="checkbox"/> Craft sticks</li> <li><input type="checkbox"/> Tables, chairs, and boxes</li> <li><input type="checkbox"/> Building blocks and other toys</li> </ul> 
Things to knock over	Connectors	Other useful items
<ul style="list-style-type: none"> <li><input type="checkbox"/> Books</li> <li><input type="checkbox"/> Dominos</li> <li><input type="checkbox"/> Containers and boxes</li> <li><input type="checkbox"/> Blocks and other toys</li> </ul> 	<ul style="list-style-type: none"> <li><input type="checkbox"/> Rubber bands</li> <li><input type="checkbox"/> Pipe cleaners (chenille stems)</li> <li><input type="checkbox"/> Tape</li> <li><input type="checkbox"/> String</li> <li><input type="checkbox"/> Magnets</li> </ul> 	<ul style="list-style-type: none"> <li><input type="checkbox"/> Scissors</li> <li><input type="checkbox"/> Hole punch</li> </ul> <p>Toy figures, things that spin, things to add weight, decorations, items for a grand finale!</p> 

### Paper engineering

Supplies limited? Try to build with just cardboard or paper. Check out our [3D Paper Engineering guide](#) from 2020 for tips on folding paper. See if you can use it to make paper chutes, springs, funnels or even trap doors!



### The Tech Challenge

This activity guide can be used to prepare students for the 2022 Tech Challenge: Kinetic Commotion, presented by Amazon.

This lesson will...

- Give students experience with building simple machines.
- Familiarize them with stored energy and energy transfer.
- Introduce students to triggers (release mechanisms).



## Instructions

### Explore

1. Sometimes it's easiest to break a chain reaction into pieces and parts. Take a look at the [Chain Reaction Challenge Cards](#) (see page 6) and choose one to try.
2. Think about the materials you can use and how you might solve the challenge on the card.
3. Once you have some ideas, sketch a design or just start building!

### Make it personal...

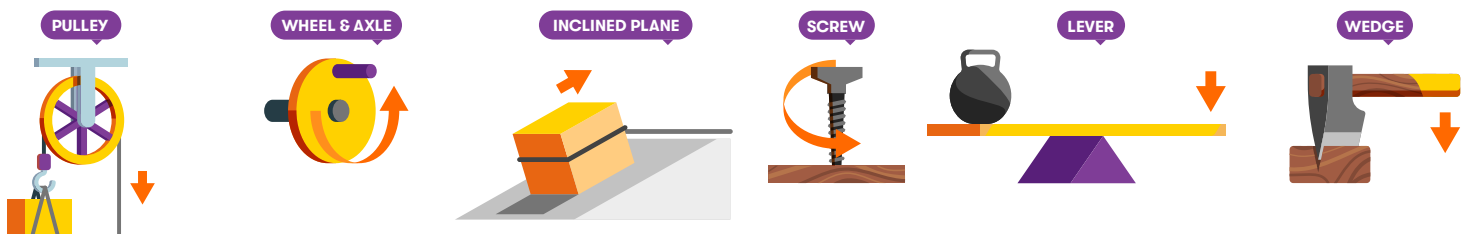
Take a minute to work backwards and think about the story behind your device. What's your goal? Do you want to unroll a birthday message for a friend? Flip a switch? Raise a flag?

Add silly elements to your chain reaction by choosing random, unrelated items and trying to incorporate them. How could you use a kitchen spatula and a toy duck in your design, for example? What are some of your favorite things and how could you add them in?

### Create and test

1. Start building the device on your [Chain Reaction Challenge Card](#).
2. Consider the simple machines you can use as you build.
3. Engineers test, redesign, and test over and over! Ask yourself:
  - *Where is this working?*
  - *Where is it not working?*
  - *What can I adjust and change to get the reaction I want?*
4. Once you've met the challenge on one of the cards, you can try another one. Experiment and play around with different cards.
5. When you're ready, you can put things together into a chain reaction!

## Simple Machines



### Try it as a team

Chain reactions are a great opportunity for both in-person and virtual collaboration.

- **Tag, you're it!** Have each person or group make their own reaction and combine them together into a larger chain like The Tech's staff did in this [video, "Make a Rube Goldberg Machine!"](#).
  - If you are doing this in person, remember that any time you move a part of the chain reaction, it will change the results, so try to build on surfaces that are easy to combine or right next to each other.
- **All together now:** Even if you're working together as a team, you can split things up so that everyone has a role.

## Chain reaction

1. Now it's time to put together everything you've been experimenting with. Create a chain reaction machine by connecting at least three reactions from a single starting action.
2. Use these tips as you build:
  - Think about where you are connecting each section with the others.
  - Don't forget to test each section individually before you put them together.
  - Try adding new components in front of or behind existing sections.
3. As you build ask yourself:
  - *How are these materials working? Are there other materials that would fit better?*
  - *Do I need to adjust where things are placed so that they run more smoothly?*
4. Use what you learn from testing to improve your chain reaction machine.

### Energy transfer

A chain reaction is a great example of energy being transferred from one item to another. When your chain reaction device runs, energy will be transferred from stored energy (*potential energy*) to motion (*kinetic energy*).

Here are some different ways energy might be transferred in your chain reaction.



gravitational  
potential energy



elastic  
potential energy



motion  
kinetic energy



sound  
kinetic energy

### Getting frustrated?

Each time your chain reaction fails, you learn something new about how to make it better. So when you feel stuck, take a break and try one of these strategies.

- Step back and take a deep breath. Sometimes a little snack break is all you need!
- Look at things in a different way — from up above or down on the floor, maybe even upside down.
- Resetting and trying again is a big part of making a working chain reaction. Secure objects in place with tape once you've figured out exactly where you need them.
- As you build, you might have to make tradeoffs. You might give up one material to use another or compromise on the number of reactions because you don't have time to complete them all. This is what engineers do to make sure they meet their goals.

Sometimes it's good to remember that failure and perseverance (not giving up) are an important part of the engineering process.



## Looking for inspiration?

There are many images and videos showing “chain reactions” online. From homemade to professional, there’s lots to spark your imagination.

Here are a few of our favorites. See if you can find your own!

- [Audri’s Rube Goldberg Monster Trap](#), YouTube
- [Energy Transfer Machines NBC News Learn video](#), YouTube
- [Splash, Pop, Fizz: Rube Goldberg Machines](#), TeachEngineering video, YouTube
- [“This Too Shall Pass”](#) music video on Ok Go Sandbox
- [Honda - The Cog](#) video, YouTube

## Explore more

- **Switch it up:** Try changing one of the materials you’re using. What happens? How can you keep things moving with different components or even different simple machines?
- **More reliable:** Can you make your reaction repeat at least three times? How many times in a row can it do the same thing?
- **Self-starter:** Triggers are built-in mechanisms that release the stored energy in your device. Take a look at some of the examples below and add in a trigger to start your machine!

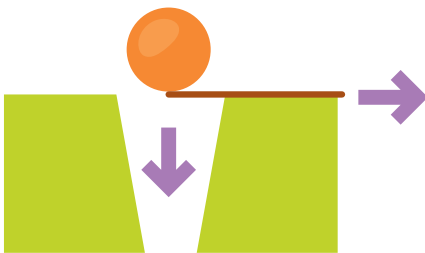
**Trigger:** A built-in mechanism that releases the stored energy in your device.

A trigger...

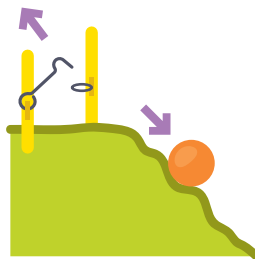
- Releases a device's stored energy (**potential energy**).
- Is the same no matter who starts it.

Some examples:

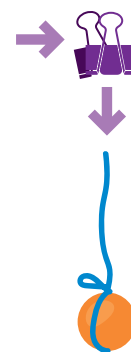
removing a stick



flipping a latch



opening a clip



**Share Your Results!** Keep us posted about your design challenges on Facebook with **#TheTechChallenge**.



**The Tech  
Challenge**  
Presented by Amazon

## Domino effect

Knock over a series of items.



**Tip:** Use tape “hinges” to keep your items in the right spot during multiple tests.

## Inclined planes

Roll something!  
Up or down!



**Tip:** Have something to catch your rolling item so you don't have to keep finding it.

## Pulleys

Use string to lift or lower something.



**Tip:** Keep the area around strings clear and try using counterweights to slow things down.

## Pendulum

Swing something.



**Tip:** Use stiff material instead of string to improve aim.

## Round and round

Spin something. Slow things down or knock them over chaotically!



**Tip:** Spinning can speed things up. It can also be unpredictable, so test parts on their own first.

## Levers

Move, nudge, lift, or even push something.



**Tip:** Secure with tape to keep the base in place during multiple tests.

## Landing Zone

Drop or launch something.



**Tip:** Test where an object lands multiple times before deciding where to place the next object.

## More motion

What other movements and mechanisms can you think of?



**Tip:** Take a look at some everyday objects. What motions and reactions do you see?

## Grand finale

What is your goal?  
What task do you want to complete?



**Tip:** If the final action isn't easy to reset, save yourself a messy clean-up and test the mechanism by itself.