Career Exploration Extension
Grades 5-6
Kennywood/Roller Coasters Unit
Career: Mechanical Engineer

Videos

Mechanical Engineer http://ow.ly/jZhW50CMfro

Roller Coaster Design http://ow.ly/pQur50CF7Uo

Energy in a Roller Coaster Ride Interactive http://ow.ly/CGQF50CMfsh

Printable Resources & Evidence Piece

Read the attached articles and answer the discussion questions below. Try building a roller coaster of your own with household items and take a picture or video of the finished product!

- Science Friday | Challenge: Build A Roller Coaster www.sciencefriday.com/educational-resources/challenge-build-a-roller-coaster/
- Roller Coaster Engineer: Job Description and Education Requirements https://study.com/articles/Roller_Coaster_Engineer_Job_Description_and_Education_Requirements.html
- Big Rentz | How Are Roller Coasters Built https://www.bigrentz.com/blog/how-roller-coasters-built

Discussion Questions

1. What is the average salary of a roller coaster designer?
2. What degree do you need to design a roller coaster?
3. How do you become a roller coaster designer?
4. What is the first hill of the roller coaster called? What kind of energy is made?
5. What kind of materials can a roller coaster be made out of?

Roller Coaster Engineer: Job Description and Education Requirements

Sep 14, 2019

Roller Coaster Engineering Essential Information

A roller coaster engineer is an integral part of a design team focused on constructing thrill rides for amusement parks. When developing a roller coaster, these engineers must consider several important factors about the ride, including safety, environment, and excitement. The education typically needed for this profession is a bachelor's degree in electrical, structural, or mechanical engineering (https://study.com/directory/category/Engineering/Mechanical_Engineering.html). To make sure the rides are safe, these engineers test them out, making sure all of the weights and speeds are set correctly. Aspiring engineers often need a license, though requirements vary by state.

Education Requirements	Bachelor's degree
Other Requirements	Licensure required
Job Growth (2018-28)*	4% for all mechanical engineers
Mean Salary (2018)*	$92,800 annually for all mechanical engineers

*Source: *U.S. Bureau of Labor Statistics*

Roller Coaster Designer Job Description

Engineers work with a design team in a variety of tasks concerning the construction of roller coasters. The main duties involve deciding what type of roller coaster to use, determining how to place the track, developing the controls systems, and verifying that the ride is safe for the public. Generally, engineers try to make rides exciting by including special arrangements that enhance some elements of the ride. Loops in the track, embankments, and the use of natural scenery are some examples that may add to the thrill of a roller coaster.

To accomplish these endeavors, roller coaster design teams are comprised of engineering and drafting professionals who are responsible for all facets of the ride development process, including structure, electronics, and layout. Design teams are sometimes limited by predetermined conditions, such as park size or budget.

Safety is a major concern for a roller coaster engineering design team. Engineers are often required to test rides many times to make sure they meet the right speeds, weights, and forces set forth in the design. For example, engineers working on a roller coaster that launches the cars out of the station need to make sure that the launch speed is within a certain range so that the train achieves speeds high enough to mount track hills, but not cause rider whiplash.

Roller Coaster Engineer Salary and Job Outlook

Mechanical engineers, including roller coaster engineers, earn a mean annual income of $92,800 as of May 2018 and are expected to see four percent job growth during the 2018-2028 decade, according to the U.S. Bureau of Labor Statistics. For roller coaster engineers, the job outlook will naturally depend on the amount of new and renovated roller coasters at amusement parks and the financial success of the park in general.

How to Become a Roller Coaster Engineer

Education Requirements for Roller Coaster Engineers

No specific major exists in roller coaster engineering, though a design team is typically made up of structural, electrical, and mechanical engineers. Many universities offer bachelor's degree engineering programs in these disciplines. Students interested in designing roller coasters should consider including additional physics, mathematics, and drafting courses to their curricula.

According to the College Foundation of North Carolina, securing a job on a roller coaster design team is competitive. For this reason, earning a graduate degree in engineering might offer engineers an advantage over other applicants. Master's degree programs provide advanced studies in relevant topics for the profession, such as heat transfer, system dynamics, and fluid mechanics.

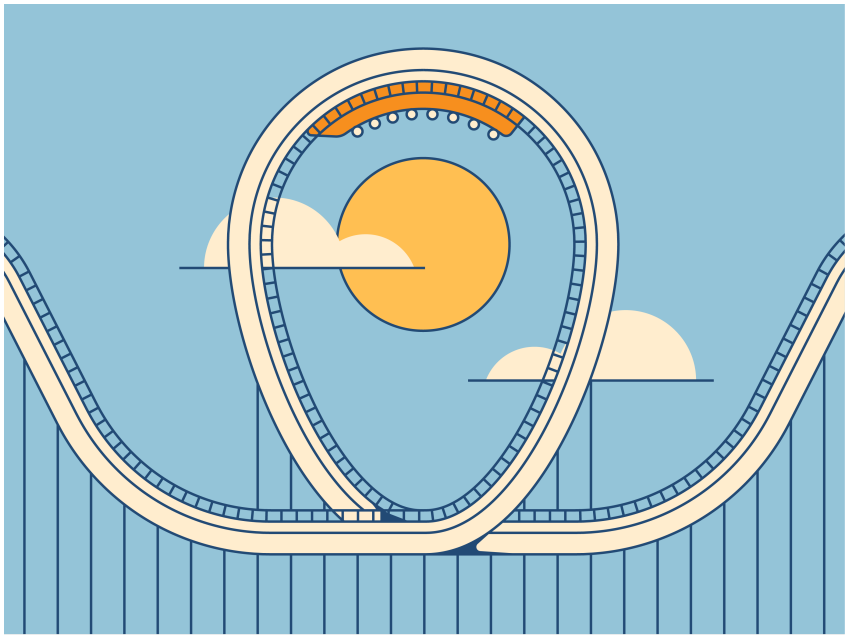
Licensure Requirements

Roller coaster engineers need to obtain state licensure. Graduation from a state-approved bachelor's degree program typically qualifies engineers to begin the path to becoming licensed. New engineers take an entry-level licensure test that allows them to work under the supervision of a fully licensed engineer. With at least four years' experience in the field, a final professional test completes the licensing process. While only one engineer on a roller coaster design team is necessary to supervise all other engineering team members, full licensure might help in obtaining employment in the

https://study.com/articles/Roller_Coaster_Engineer_Job_Description_and_Education_Requirements.html

How Are Roller Coasters Built

Date: August 12, 2020 by: Lior Zitzman
https://www.bigrentz.com/blog/how-roller-coasters-built



Roller coasters are an American staple of fun and ingenuity. Their popularity has been around for centuries, with a vibrant and rich history. They date back to ice sledding in the 1400s in Russia. It finally came over to America in the early 1800s with the Mauch Chunk Switchback Railway in Pennsylvania, although it was initially intended to haul coal up a mountain.

By the early 20th century, there were 1500 wooden roller coasters around the country. Currently, Kingda Ka is the tallest roller coaster on Earth, becoming a marvel of ingenuity and construction.

In essence, a roller coaster is a machine that utilizes gravity and inertia to speed a train car through a track.

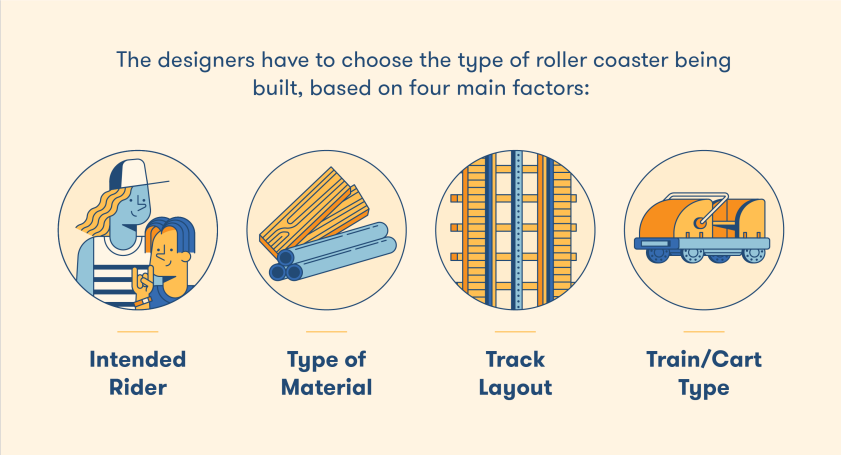
Construction technology has come a long way since the Mauch Chunk Switchback Railway, though. More intricate designs, faster speeds and taller structures are now the norm.

Although it may seem a little complex at how roller coasters are built, their construction isn't far too complicated. Check out exactly how roller coasters are made, or jump straight to the infographic below.

The Design Process

As with all construction projects, before roller coasters are built, every aspect is designed first. This is to ensure maximum safety and thrills are implemented in the final ride.

Choosing Coaster Type



Figuring out the different aspects that make up the type of roller coaster is essential, as it can drastically affect the overall design of the ride. There are **four aspects** to be considered when choosing a roller coaster type, and they are:

1. **Intended Rider** – Depending on who the roller coaster's intended riders are, the ride can end up being very different. If they're going to be children, then the ride will have gentle hills and slopes. However, older riders look for intense speeds and extreme heights in their rides.

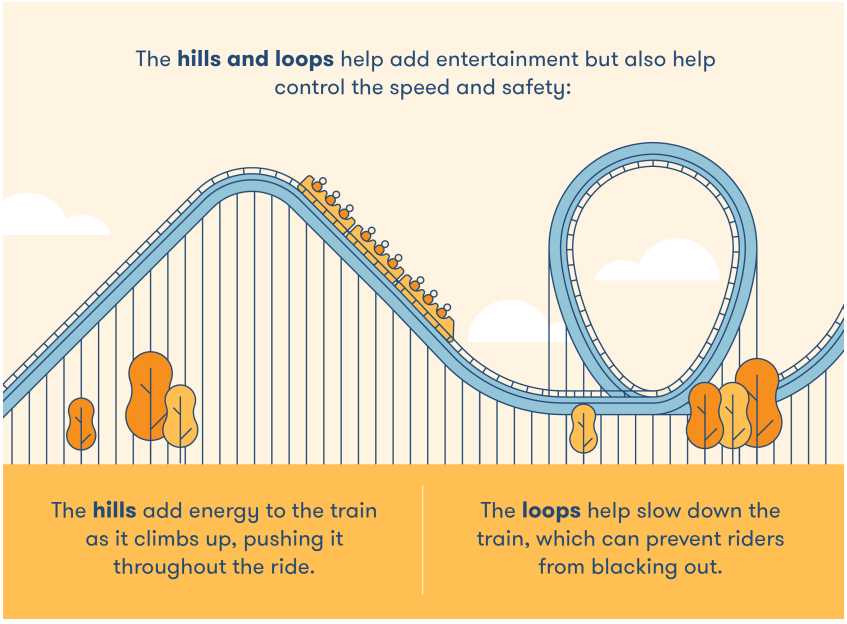
2. **Material** – Wood and steel are the two primary materials used for roller coaster construction. However, steel is used more due to its versatility and ability to provide elements such as smoother rides and going upside down.

3. **Train/Cart Type** – The train is the vehicle that transports the passengers through the ride. There are 18 different types of roller coaster trains, ranging from the classic side friction roller coaster, like Leap the Dip, or the modern inverted roller coaster, like Batman the Ride, where the track is located above the riders' heads.

4. **Track Layout** – The track layout of a roller coaster influences the entire ride. For example, a figure 8 track consists of at least one figure 8 shape in the course, and the corkscrew track contains sequential, helix-like loops that look like a corkscrew.

The designers can figure out these three aspects in any order or at the same. In this stage, it's all about figuring out what they want to build.

Adding the Hills and Loops



Part of the thrill of a roller coaster is the giant hills, big loops and sharp turns. These aspects aren't just designed for the thrill, though. They affect and change the train's speed and elevation throughout the ride.

The first hill of a roller coaster – known as the lift hill– is typically the largest. As the train comes down, kinetic energy is built up, which provides enough energy for the train to go throughout the entire ride. Without a big enough lift hill, the roller coaster won't be able to complete its ride.

Then, the loops help control the speed and force of the train throughout the ride.

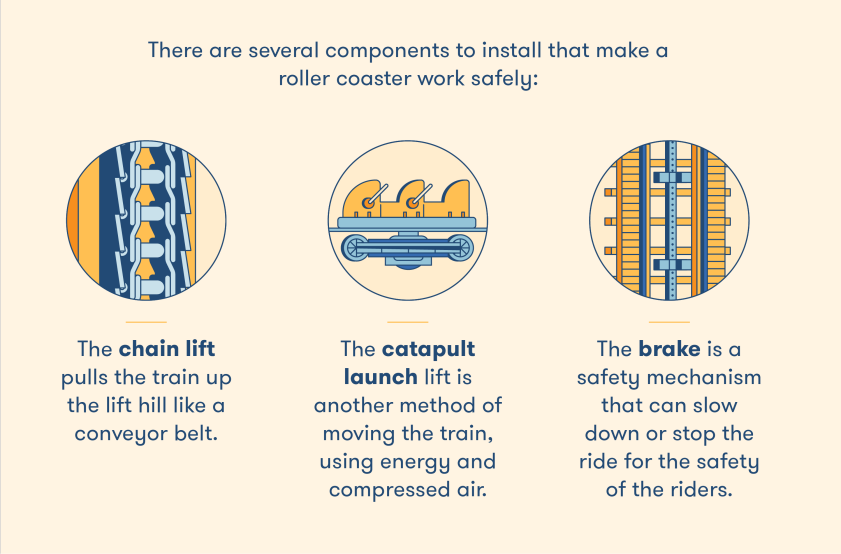
Werner Stengel designed the full, 360-degree vertical loops used today in roller coasters in 1975. Stengel designed the loop, called the clothoid loop, to have a smaller curvature radius at the top, which causes the speed to slow down and allows the riders to stay in their seats while they're upside down.

To understand how this works, picture swinging a bucket of water over your head without spilling any on yourself. The inertia causes the gravity to press down on the water, even while upside down. The same is done to people when the ride is

However, that's not the only purpose of the loops: they can keep people from passing out. Too much g-force can cause someone to pass out. By slowing down the ride through the use of the vertical loops, the g-force is reduced. The bigger and faster the roller coaster, the more this effect would be noticeable.

Sometimes, amusement parks will have so many rides that designers will have to "thread" the roller coaster through other attractions. This can affect the coaster's overall design, which can add or hinder the hills or loops on the ride if they aren't calculated into the design.

The Lifts and Brakes



The roller coaster is a passenger train with connected cars moving on tracks. However, as there is typically no engine, gravity and momentum keep the ride moving.

Here's a look at the different types of lifts that help bring the train up the hills and the braking systems are designed to help stop them.

1. **Chain Lift** – This is the most traditional way of getting the train to move up the lift hill. They resemble a bike chain or long conveyor belt and are responsible for the clacking sound that's heard when going up a hill.

2. **Catapult-launch Lift** – This is another way of moving the train up a hill in newer roller coasters. They're typically used in newer rides with space or height restrictions, using energy and compressed air to launch the train forward. There are six types of **launch systems**:

   Electromagnetic systems launch using strong electromagnets that store lots of electricity. There are also two types of electromagnetic systems: Linear Induction Motor (**LIM**), which are older and less complex, and Linear Synchronous Motor (**LSM**), which are newer and more efficient, but also a little more complex.

   Hydraulic launch systems use several pumps filled with hydraulic fluid and nitrogen, several launch cables and an engine (essentially a large wheel) to propel the train forward.

   Pneumatic systems are like hydraulics but use air instead of liquid. They're usually simpler but less powerful than hydraulics, but the acceleration is consistent.

   Flywheel systems use a large flywheel attached to a cable that rotates quickly to launch the train.

   Catapult systems launch by dropping a weight, winding the cable and then pulling the train to its maximum speed. These roller coasters aren't very tall and only go about 60 mph.

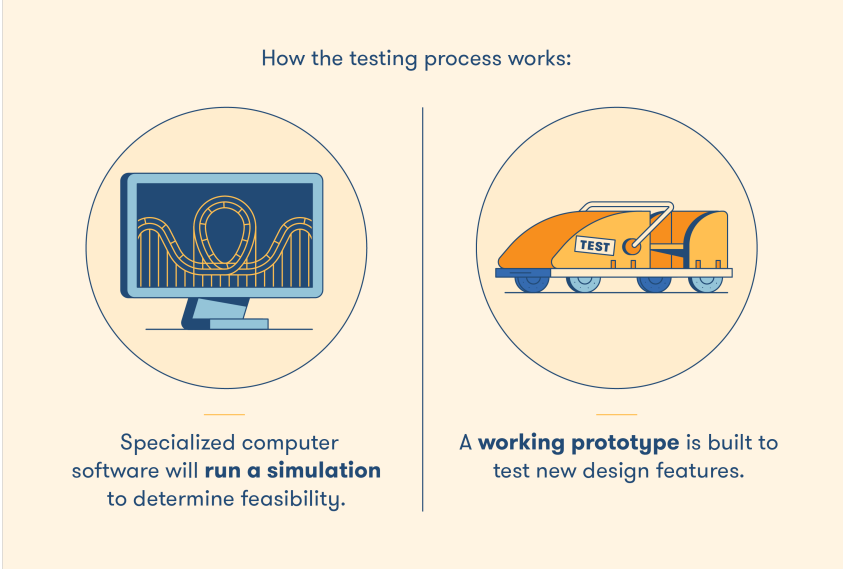
   Friction wheels use a motorized wheel that either keeps the trains speed or moves it faster using friction between the wheels and the train.

3. **The Brake System** – A roller coaster uses a brake system to slow down or stop it. There are two main categories of brake systems:

   - **Trim brakes** slow down the train. **Block brakes** stop the train
   - altogether.

The type of roller coaster the designer chooses to build will influence the kind of lift and brake system that's used for the ride.

Testing the Design



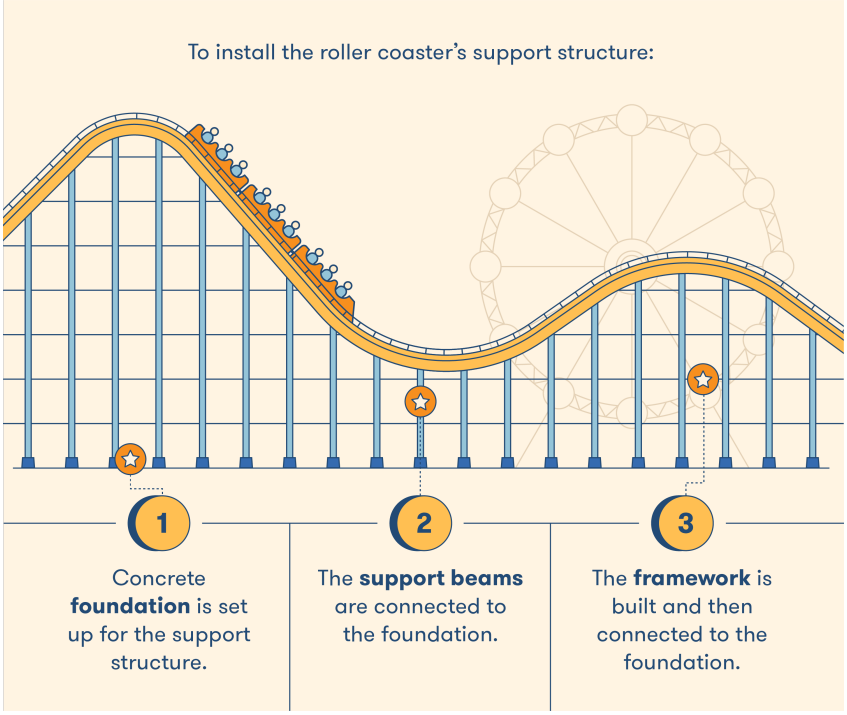
Once everything in the design phase is chosen, all that's left is to test it out. A simulation can be done with specialized computer software dedicated to roller coasters, which is how most tests are done. However, if new features are designed, a working prototype needs to be built in order to assess the feasibility of the new design.

If the prototype doesn't work, it can either be because the design of the new feature still needs to be worked out or it proves to be unsafe. Nevertheless, if the prototype fails, then the designer has to go back and reevaluate the design. If the prototype works successfully, then the manufacturing phase can begin.

The Manufacturing Process

Once the design of a roller coaster is complete, the site location is cleared of anything in the way. Building the actual roller coaster is done by first creating the support structure, which consists of the support beams and frameworks, and then the track, which is made up of the track and other parts that move the ride safely.

Installing the Support Structure



The support system is where everything from the roller coaster is going to be placed. Everything is installed from

the bottom up, starting with the foundation. Holes are dug with an excavator and filled with concrete to set up a foundation, with wooden forms constructed to hold the form.

If the soil is sandy, piles of wood are driven into the ground to use as a foundation instead of concrete. Nevertheless, connector plates are attached to the foundation to connect to the support beams.

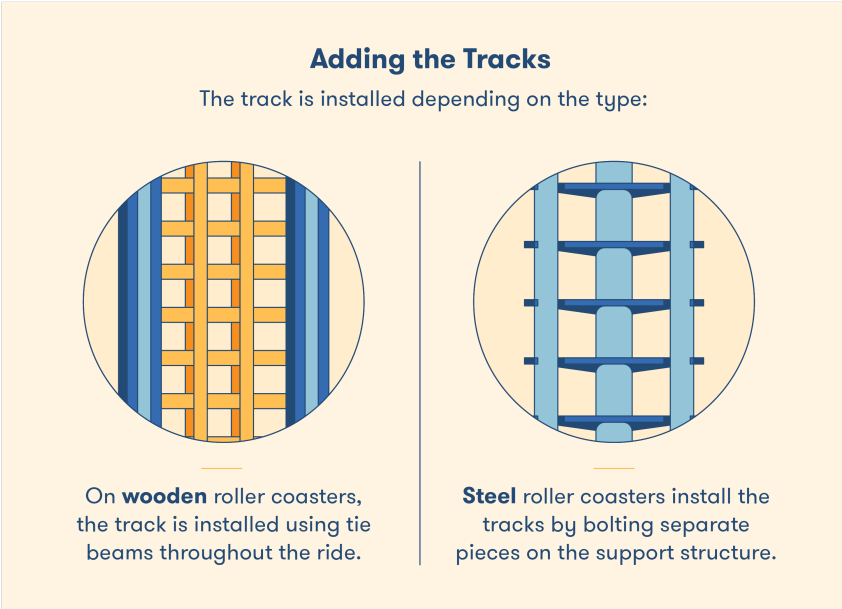
Depending on the type of material the designers decided to use, the installation may be slightly different.

- For **wooden** roller coasters, the lumber is shipped to the site where it is cut and installed on the site.
- For **steel** roller coasters, the parts are made in a factory to specifications and then shipped to the site to be assembled.

Nevertheless, the lower, main portions of the support structure will be lowered using cranes onto the connector plates that are attached to the support structures. The lower portions may be braced using wooden beams as the upper sections are installed.

The framework's design is calculated based on rider type, g-force and the amount of energy that the train uses. Typically, the support structure framework consists of cross beams connected to the support columns, not unlike how the superstructure is built in a skyscraper.

Installing the Track



Once the main support structure is in place, the tracks are installed on top. How they're installed depends on the type of material that's being used.

- On **wooden** roller coasters, tie beams – beams connecting and strengthening two columns – are installed across the length of the track, throughout the length of the ride.
- Roller coasters made of **steel** have the track sections shipped separately to the site ready in pieces. The pieces are connected, then bolted/welded on the support structure.

Part of the safety that comes with the roller coaster is the way the tracks keep the train wheels from derailing. Typically, wooden roller coasters have wide lips on the wheels that keep them from slipping out of the tracks, preventing sideways movement.

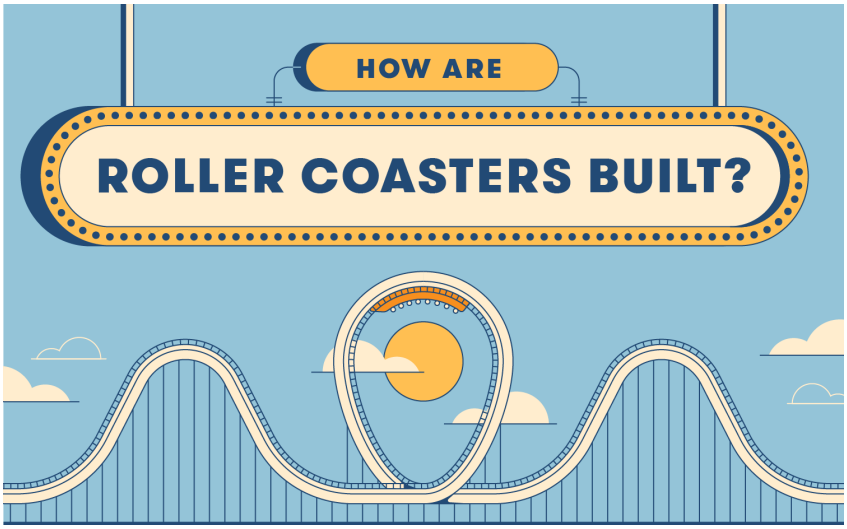
Once the track is installed, the chain lift or launch lift is installed along with any safety mechanisms and braking systems.

Safety mechanisms like the anti-rollback system or sensors are used to determine if the roller coaster has stopped working.

Once all of that is completed, the actual train cars will be shipped to the site. Test runs will be performed to make sure that everything is working as it should. Some personalization, like lighting, camera setup, and paint will be added based on the coaster's theme. Then the roller coaster will be ready to ride.

It should be noted that if the track isn't correctly installed, extensive injury and damage can occur. It's why everything from the support structure to the track installation has to be done precisely. Luckily, roller coaster injuries are incredibly rare, with only 1.2 riders injured per million.

Finding out how roller coasters are built is a marvel as it shows precisely how construction trendscontinue to be newly applied. That trend of roller coasters being taller, faster and longer will continue, finding new ways to provide riders with brand new thrills!



Roller coasters are rides that require gravity to provide the energy. But there is a lot more to it than just loops and twists.

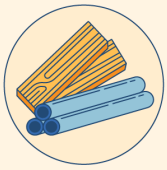
THE DESIGN PROCESS

Before a roller coaster is built, the type, shape and lifts need to be designed.

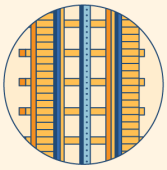
Choosing Coaster Type

The designers have to choose the type of roller coaster being built, based on four main factors:

Intended Rider



Type of Material

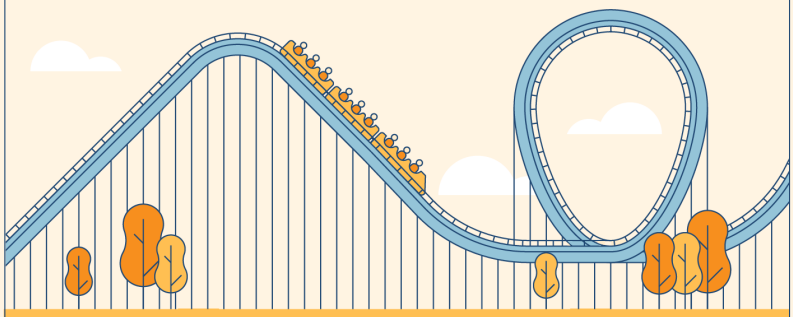


Track Layout

Train/Cart Type

Hills and Loops

The **hills and loops** of a roller coaster add entertainment, but also help control the speed and overall safety:

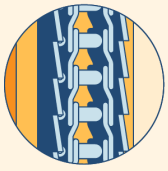


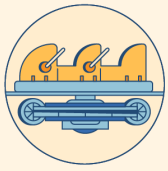
The **hills** add energy to the train as it climbs up, pushing it throughout the ride.

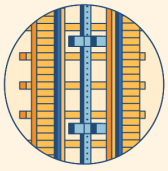
The **loops** help slow down the train, which can prevent riders from blacking out.

The Lifts and Brakes

There are several components to install that make a roller coaster work safely:







The **chain lift** pulls the train up the lift hill like a conveyor belt.

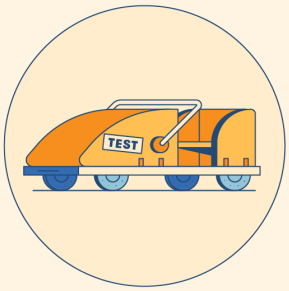
The **catapult launch** lift is another method of moving the train, using energy and compressed air.

The **brake** is a safety mechanism that can slow down or stop the ride for the safety of the riders.

Testing

How the testing process works:

Specialized computer software will **run a simulation** to determine feasibility.



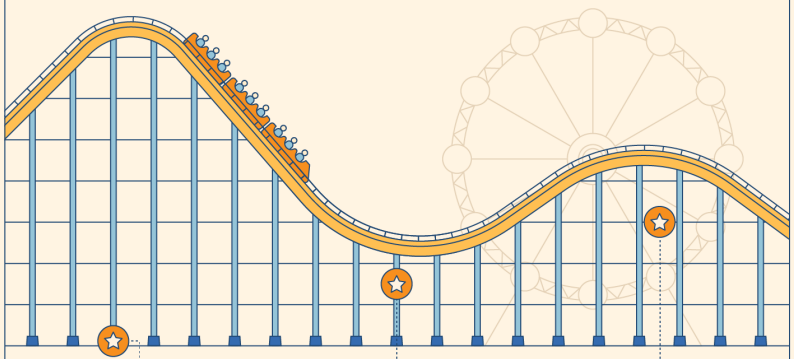
A **working prototype** is built to test new design features.

THE MANUFACTURING PROCESS

Once the design of the roller coaster is tested and approved, construction can begin.

The Support Structure

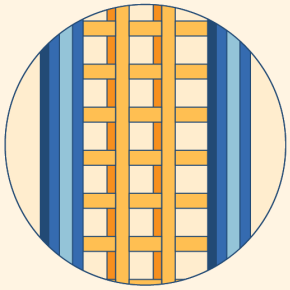
To install the roller coaster's support structure:



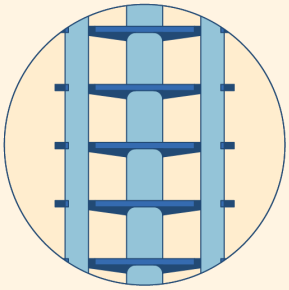
1. Concrete **foundation** is set up for the support structure.
2. The **support beams** are connected to the foundation.
3. The **framework** is built and then connected to the foundation.

Adding the Tracks

The track is installed depending on the type:



On **wooden** roller coasters, the track is installed using tie beams throughout the ride.



Steel roller coasters install the tracks by bolting separate pieces on the support structure.

https://www.bigrentz.com/blog/how-roller-coasters-built

BIG RENTZ

Challenge: Build A Roller Coaster

by Ariel Zych, on July 24, 2020

GRADE LEVEL
All

MINUTES
15 min - 1 hr

SUBJECT
Engineering and Tech

Activity Type:

Engineering design challenge, Family activity, DIY

Roller Coaster Boomerang GIF By Lake Compounce. Credit: Giphy

Roller coasters are fun, fast, and are a great example of physics in action. Your challenge is to build a roller coaster out of materials you can find in your home.

Your Roller Coaster Should:

– **Include a "car"** – any object that rolls or slides along the track without falling off the sides

– **Include a "track"** that carries the car as it rolls without the car falling off the sides

– **Incorporate at least one hill, turn, loop, jump, or dip** in the track

– **Be an original use of all materials** (no out-of-the-box roller coaster toys please!)

Car Material Ideas:

– Marbles
– Ping pong, bouncy, golf, or even tennis balls
– Any small toy that rolls or has wheels
– Any smooth object that fits in or on your track (a small rock, a lip balm container)
– A rolling roller coaster car of your own design

Track Material Ideas:

– Empty toilet paper or paper towel rolls, cut in half long ways
– Pool noodles cut in half long ways
– Wire, wire closet hangers
– Paper or cardboard, folded in half

Feeling Stuck? Try This First: Paper, A Small Ball, Tape

1. Cut a piece of printer or construction paper into three long strips 2-4 inches wide
2. Tape them together into one long strip of paper, then fold in half lengthwise to make a track
3. Tape one end of the track to the ground, and the other end up on a chair or coffee table, so that the fold forms a v-shaped track that your ball can roll down
4. Release a small ball at the top of your track and watch it roll down. You just made a roller coaster!

Now Challenge Yourself:

– Make the highest roller coaster you can
– Make a roller coaster with one or two loops
– Make a roller coaster with a jump from one track to another
– Make your roller coaster end with a slow, gentle stop

https://www.sciencefriday.com/educational-resources/challenge-build-a-roller-coaster/