Lesson 4:
Civil Engineering and Paper Roller Coasters

(Instruct/Play/Investigate/Test)

Vocabulary

- ★ **Gravity:** an invisible downward pull on objects
- ★ **Kinetic energy:** the energy from moving objects
- ★ **Mass:** the amount of matter contained in an object
- ★ **Potential energy:** energy stored in an object based on its position
- ★ **Public works:** the work a government does for a community, like schools and roads
- ★ **Weight:** the amount of downward force on an object caused by gravity

Public Works

Governments help a community to grow and thrive. Certain objects are needed in communities:

- schools
- parks
- hospitals
- roads
- highways
- docks

When the government builds these objects for a community, they are considered **public works**.

Civil Engineering

Engineers that design, make, and fix structures in a community are called civil engineers. These engineers must be problem solvers. They find solutions for many different types of problems. A civil engineer may be asked to find a solution for:

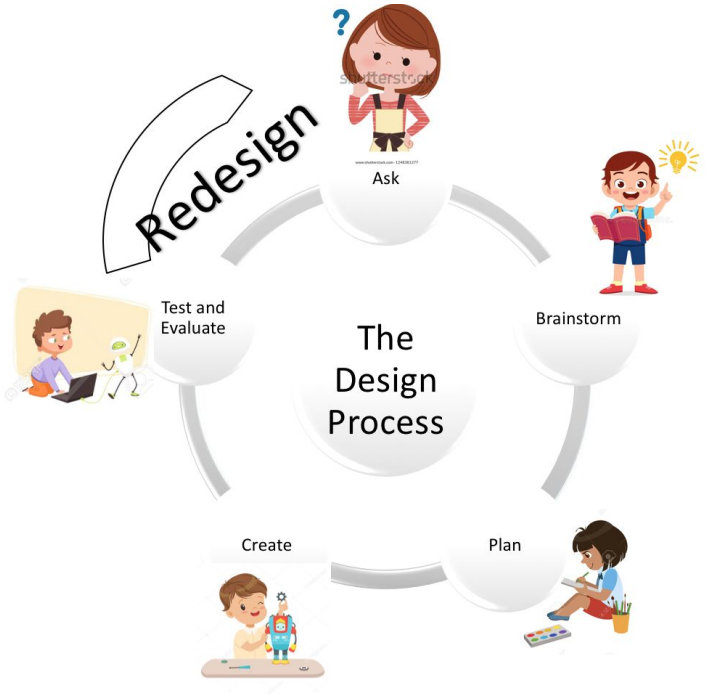
- expanding a community over a waterway
- making a sewer system for a new development
- remodeling a road system that will accommodate a growing population
- designing a dam system to prevent flooding in a community

Industries that Need Civil Engineers

Civil engineers can work in many different places. They help a variety of different industries operate, expand, and change over time. Just to name a few, these engineers can work with:

- construction companies
- railroad Companies
- airports
- water companies
- highway and road construction companies
- landfill and disposal
- water and sewage companies

Engineering Design Process



Civil engineers use the Engineering Design Process to solve problems. The steps include:

1. Ask: figure out the problem, constraints, and criteria
2. Brainstorm: potential solutions
3. Plan: using the best solution
4. Create: a prototype of the solution
5. Test and Evaluate: what works and does not work
6. Redesign: improve the solution

Civil Engineering in Action

A very large lake sits in the middle of your community. People are wanting a road that will get them across the lake, instead of driving all the way around. You are asked to make a plan to make this happen. You are given a budget and a list of workers and their skills.

Step 1: Ask

The Problem	You need to find a way make a road from one side of the lake to the other.
The Constraints	You need to stick to the budget and make sure the plan is something the workers can make.
The Criteria	It needs to safe, realistic, and easily accessible.

Civil Engineering in Action

How can we solve this problem?

Step 2: Brainstorm

1. under the water
2. through the water
3. over the water

Think about each option. Evaluate each solution and predict which option would be best.

Civil Engineering in Action

The best solution is to make a bridge.

Step 3 and 4: Plan and Create

To make this new road, you plan and make a bridge to get people and their vehicles across.

Civil Engineering in Action

You put your design to the test. It works! The problem is that the bridge is small and there's lots of traffic!.

Step 5 and 6: Test, Evaluate, & Redesign

Creating a larger bridge, with more lanes, allows you to fix your design so that it works better and solves the problem.

Activity Time!

Let’s be engineers!

You will be completing an activity called Paper Roller Coasters. In this activity, you will design and make a paper roller coaster. You will use the engineering design process to help you complete this activity.

Paper Roller Coasters

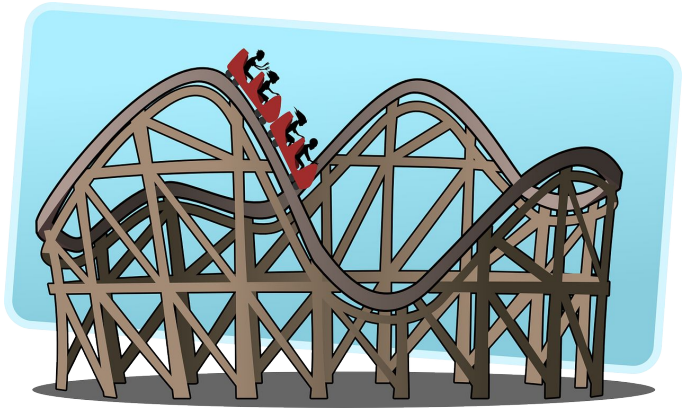
Energy & Gravity

Kinetic energy, potential energy, and gravity all come into play for roller coasters.

As the roller coaster moves along the track, it has a lot of **kinetic energy**. Kinetic energy is energy in motion. Kinetic energy is greater as the roller coaster gets to the bottom of a large hill.

The roller coaster contains a lot of **potential energy** at the start of the ride or at the top of a large hill. Potential energy is energy stored in an object based on its position.

Gravity pulls downward on the roller coaster. Gravity is an invisible downward pull. This force causes the roller coaster to accelerate as it goes down a hill and decelerate was it goes up a hill.



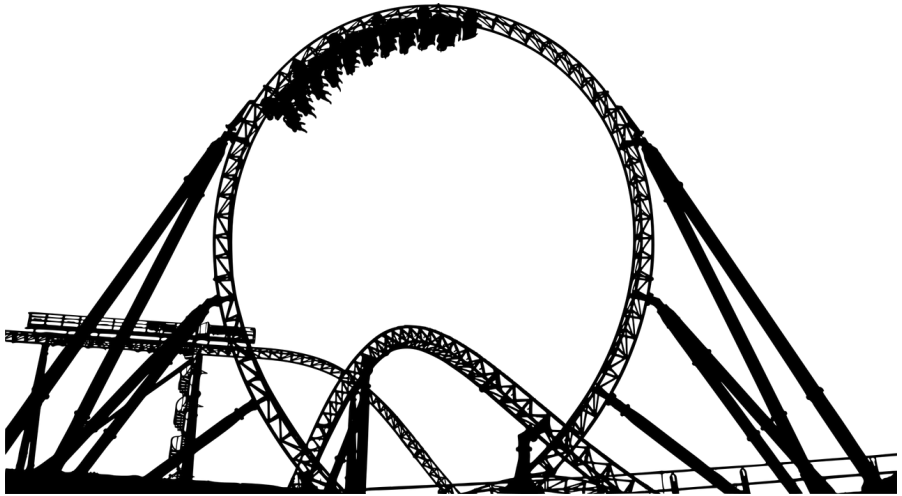
Potential energy is the energy stored in an object based on its position. The bike at the top of the hill has potential energy to move down the hill, based on its position.

Supporting the Weight

Roller coasters must be able to support the weight of its cars and its passengers. Weight is based on the gravitational pull and is always a downward pull. But other forces can change direction as the car moves along the track.

Thinking about this:

When designing your track, you must consider the changing forces on the roller coaster cars and track as they move along different parts of the track.



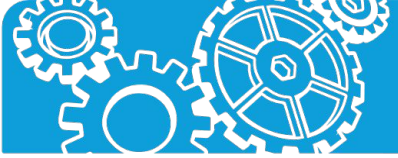
Let's Build a Roller Coaster

Today, you are going to build a paper roller coaster.

You will:

- use a maximum of three sheets of construction paper
- have at least one loop
- have a hill (anywhere in the roller coaster) at least 12" tall
- use at least 4 feet of track

How fast can you get the marble to complete the entire track?



Let’s Build a Roller Coaster

What can you use paper to build a roller coaster? Let’s find out! Here’s what you will need:

- 3 sheets of construction paper
- a ruler
- a pencil
- cardboard
- tape
- a marble

Step 1: Ask

Begin with Step 1 of the Engineering Design Process.

Ask:

- What is the problem?
- What are the constraints?
- What are the criteria for success?

Step 2: Brainstorm

Complete Step 2 of the Engineering Design Process.

Brainstorm:

- How can you use paper to make a roller coaster?
- How can you design the track so that the marble makes it from the beginning to the end?
- How can you make the track so the marble moves quickly?

Step 3: Plan

Move onto Step 3 of the Engineering Design Process.

Plan:

- What is your best idea(s) for solving this problem?
- Develop a plan to help make your idea come to life.

Step 4: Create

Now you are ready for Step 4 of the Engineering Design Process.

Create:

- get your supplies together
- make a prototype of your roller coaster

Step 5: Test and Evaluate

Next, complete Step 5 of the Engineering Design Process.

Test and Evaluate:

- What worked?
- What did not work?
- Did you solve your problem?
- Was the criteria and constraints met?

Step 6: Redesign

Now, Step 6 of the Engineering Design Process.

Redesign:

- What can you do to improve your designs?

Reflect and Share

All good scientist reflect on their experiments.

- How did the experiment work?
- How long did it take for your marble to complete the whole roller coaster track?
- What was your greatest challenge?
- How tall was your tallest hill?
- How did energy and gravity relate to this project?
- How did this project relate to civil engineering?

Share your designs and results with other:

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