BioEd℠

# Think like an Engineer

TEACHER'S GUIDE

## Roller Coasters

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Baylor College of Medicine

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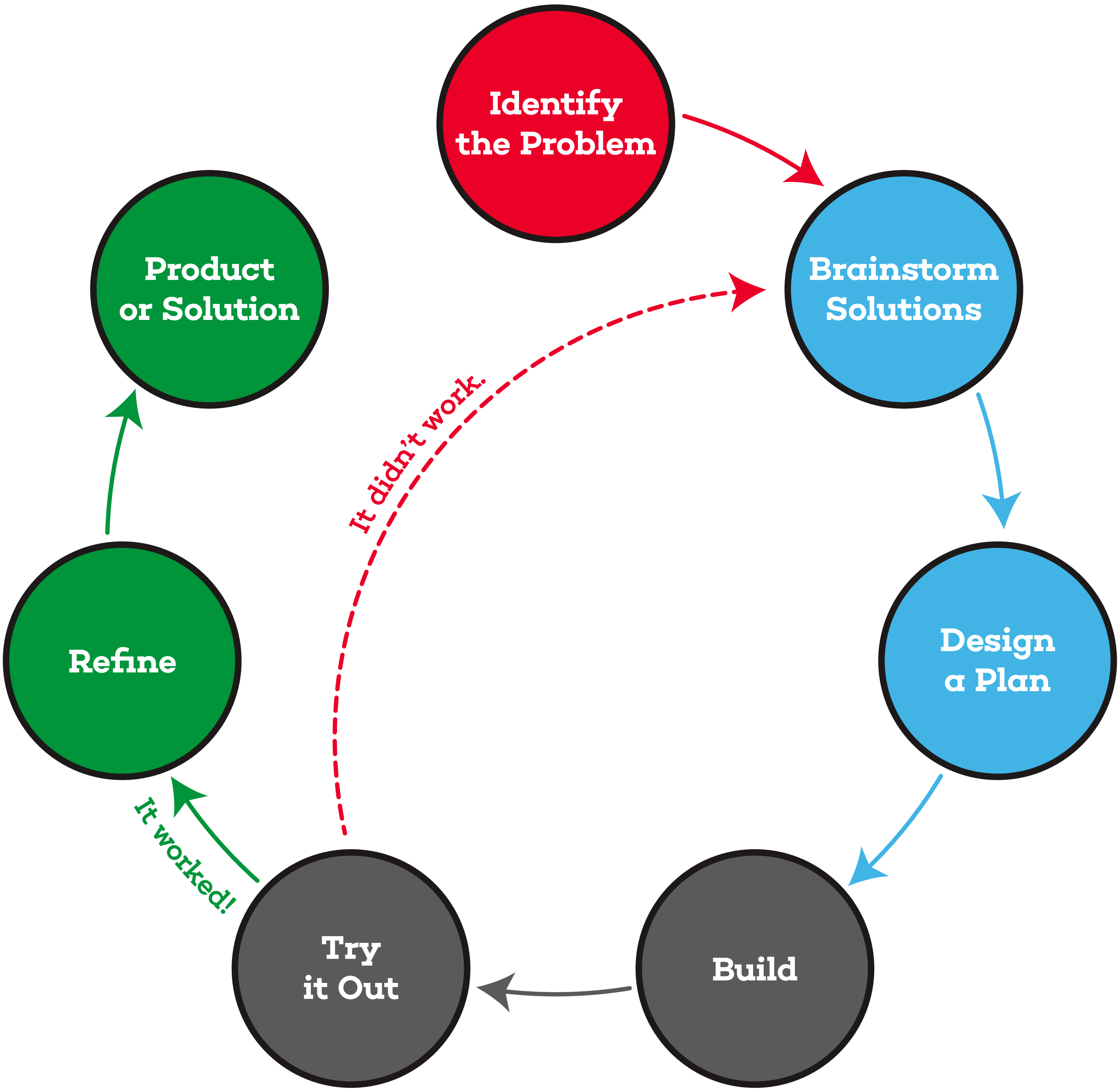
# An Engineer's Approach

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# Roller Coasters
## Getting Loopy

### Time
1–2 sessions

### Before You Start
Download and install the trial version of NoLimits Roller Coaster Simulation (Mac/PC) software, which features five roller coaster rides. (Use of the free trial version is limited to 15 days.)

http://www.nolimitscoaster.com/download.php

You will need nine 6-ft lengths of foam pipe insulation (for 3/4-in. diameter pipes). Pipe insulation comes with a slit running along its length. Use the slit as a guide for cutting the tube in half lengthwise. Alternately, have the tubes pre-cut at the hardware store.

### You Need This Stuff
**Teacher Materials**
- 9 6-ft lengths of foam pipe insulation (for 3/4-in. diameter pipes)
- Computer with projector and Internet access
- Software: NoLimits Roller Coaster Simulation
- Videos: Roller Coasters, and World's Second Greatest Paper Roller Coaster/Marble Run
- Web page: Paper Roller Coaster

**Per Group of Students**
- 3 pre-cut, 6-ft lengths of foam pipe insulation (see "Before You Start," above)
- Marbles
- Masking tape
- Pair of scissors

**Per Student**
- 2 sheets of color copy paper (8.5-in. x 11-in.)
- Copy of "An Engineer's Approach" page

### What It's About
Mechanical engineers design and improve machinery and systems upon which we depend. One special kind of mechanical engineer designs roller coasters for amusement parks. Students may have ridden roller coasters, or seen them in movies and on the Internet. A roller coaster propels riders through exhilarating drops, turns, twists and loops that simulate the movements of an aerobatic plane.

All roller coasters go through an extensive design and testing process. To provide the most exciting, yet safe, ride possible, an engineer must have an excellent understanding of force, gravity, motion, momentum, and potential and kinetic energy.

The basic roller coaster shape (a series of progressively smaller hills) has been used since the roller coaster was created in the 1400s. Early modern-style roller coasters were built with wood

**Dragon Khan is a steel roller coaster in Catalonia, Spain. The train cars can be seen inverted on the highest loop of the coaster.**

Dragon Khan © Chris Hagerman. CC-BY-SA 3.0. (http://en.wikipedia.org/wiki/Dragon_Khan)

**Texas Giant wooden roller coaster at Six Flags Texas.**

supports and steel rails. But wooden roller coasters, which tend to feature hills and steep turns, can make for a rough ride. In 1959, Disneyland unveiled the first all-steel roller coaster, the Matterhorn Bobsled. Steel generally provides a smoother ride and allows more extreme maneuvers. That's why most roller coasters today use steel supports and tracks. Of course, loops, turns and gravity-defying spirals now are standard elements of roller coaster design.

## What's the Question?

What makes a good roller coaster design?

## What to Do: Part 1

1. Ask the class, *Have you ever ridden a roller coaster? Why do you think they're so much fun?* Lead students to think about how these rides safely simulate dangerous—but exciting—drops and turns.
2. Have each student draw a roller coaster on which he or she would like to ride. Then show the "ride of their life" coaster demonstrations from the NoLimits Roller Coaster Simulation software.

   http://www.nolimitscoaster.com/download.php

3. Have students rate each of the five rides. Ask, *What makes a great roller coaster ride?* Discuss their responses.
4. Ask, *Who do you think builds roller coasters?* Show the video, Roller Coasters, which introduces Chris Gray, a mechanical engineer and roller coaster designer. He discusses why he became an engineer and what his work is really like.

   http://www.youtube.com/watch?v=H_Xo9i9O-cXk

5. After watching the video, have students share what they learned about this engineer and his work.
6. Have students to think about the types of questions roller coaster designers must address when they begin a new project. Ask, *How much space do you have to build? How long should the ride last? What should the roller coaster do? How can you ensure its safety? How much fun can it be?*

## What to Do: Part 2

1. Divide the class into teams of four. Explain that they will work as mechanical engineers to design their own roller coasters. Students will build their roller coasters from foam insulation tubing, and will use marbles as the roller coaster cars.
2. Show students a sample section of foam half tube. Encourage them to investigate the tubing and ask questions about how it might work for a mini roller coaster.
3. Provide each team with three 6-foot lengths of pipe insulation tubing, cut in half lengthwise.

   *Not to scale.*

   Also, give each team one meter of masking tape to connect pieces of tubing, or to attach tubing to other objects (e.g., chairs or desks), if desired.
4. Like all engineers, the students will work within defined parameters. For this design, they may

Illustration by G.L. Vogt, EdD © Baylor College of Medicine. Texas Giant roller coaster © Brandon R. CC-BY-SA 3.0. (http://en.wikipedia.org/wiki/Roller_coaster#mediaviewer/File:Wooden_roller_coaster_txgi.jpg)

use furniture or classroom structures for support. Their roller coaster “car” must have a starting and ending point, must pass through at least one loop, and must complete the entire track without falling off.

5. Have students follow the engineering design process to create a roller coaster from the tubing and masking tape, using marbles as roller coaster cars.
6. After all teams seem to have produced successful roller coasters (or after a given period of time), have students rotate around the room to view the different designs. Ask them to identify similarities and differences in the roller coaster designs, and any original ideas they observed. Lead a class discussion about what worked—and didn’t work—in their roller coasters.
7. Have teams use what they have learned to improve their designs, and then make longer roller coasters. If possible, create a video of each team’s roller coaster.

## What to Do: Part 3

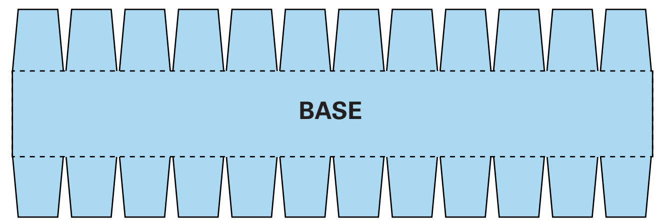
1. Challenge students to create more complex roller coasters using copy paper, sentence strips, scissors and tape. Information and animations on the Paper Roller Coaster web page explains the best method for creating a basic paper roller coaster. Review their information before starting, and use the site’s resources, as needed.

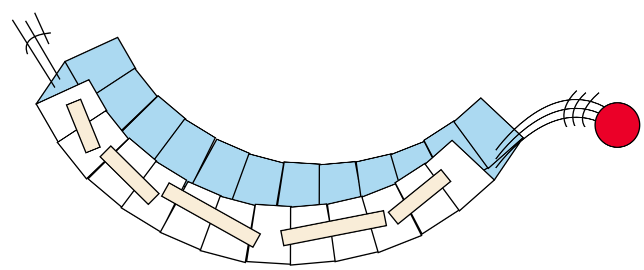
   http://www.mrwaynesclass.com/ProjectCoaster/Lab/index.html

2. It may be helpful to view the YouTube video, World’s Second Greatest Paper Roller Coaster/Marble Run. Discuss the video, with specific emphasis on how the roller coasters achieved various tricks.

   http://www.youtube.com/watch?v=CSdtMdj7k68

3. Demonstrate how to create a track by folding the edges of a sentence strip up on both sides, leaving about an inch in the center.
4. Fold a second sentence strip the same way. Make cuts in the outside sections to form trapezoids. Do not cut the center section (the base). Demonstrate the flexibility of the strips, showing how they can be bent up or down to create hills and valleys. Explain or demonstrate that several pieces of tape, placed on the cut sides of the track, can help to keep the desired shape of a curve.



5. To create supports for the roller coaster, roll 8.5-in. x 11-in. pieces of paper lengthwise into 11-in. tubes that are 1-in. in diameter. Tape the ends of each tube securely. The number of supports needed will depend on the design. Students can use tape to attach the roller coaster tracks to the support legs. If desired, build taller support columns by taping two tubes together. Shorter columns can be made by cutting them to a desired length.
6. Have students use a copy of “An Engineer’s Approach” page to brainstorm and build their roller coasters.
7. Allow students to present their roller coasters to the class.

## Wrapping Up

Have teams self-evaluate their roller coasters. Ask students, *Did the marble remain on the track and travel all the way to the end? Were there any unanticipated challenges? Any problems that teams could not solve? How fast did the marble roll? Is the ride safe?*

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