National PTA® STEM +FAMILIES®

PTA.org/STEM

STEM AT HOME ACTIVITY GUIDE:
Roller Coaster Challenge

spark. inspire. engage.

BAYER · MATHNASIUM The Math Learning Center · Huntington Ingalls Industries · National PTA every child. our voice.

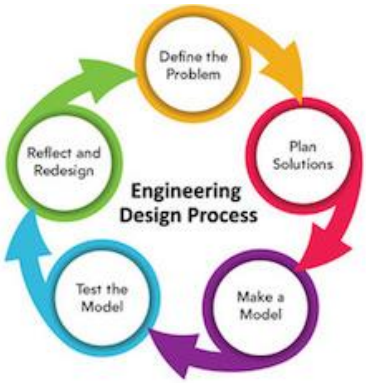
PTA.org/STEM

STEM AT HOME GUIDE: Roller Coaster Challenge

Aim: Design and create a roller coaster track made from various simple machines designed from household items that transport a marble successfully.

Problem & Career Focus: Who doesn't love roller coasters? As an amusement park favorite ride, roller coasters are made combining several simple machines. Using the engineering design process, your task is to work with your team of mathematicians, mechanical engineers, and computer systems analyst to design, model, and prototype a working roller coaster track using several simple machines.

Educational Standards Correlations: Engineering Design, Motion, Energy, Simple Machines, Physics, Mathematics



Engineering Design Process: STEM professionals use the engineering design process as steps to help solve real-world problems. With your team: define the problem, discuss solutions, design, build, test, and improve a prototype of your solution. One of the most important steps of the engineering design process is reflect and redesign- if your team notices your playground equipment prototypes aren't working then improve the design. Use the engineering design process steps to guide your exploration during the Roller Coaster Challenge.

Investigating Questions

- What materials will be used to support the roller coaster track?
- How will your team design your roller coaster track using simple machines from household materials?
- How can your team use what you learned about physics and momentum in your designs?

Materials

- No Legos!
- Empty toilet paper rolls
- Empty paper towel rolls
- Paper plates
- Ping pong ball or Marble
- Cardboard
- Construction paper
- Tape
- Scissors

***Other recyclable household materials

STEM AT HOME GUIDE: Roller Coaster Challenge

Background Knowledge

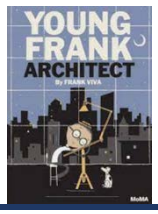
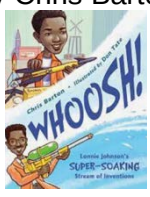
Vocabulary:

Simple Machines: mechanical devices that help people do work; there are 6 simple machines (wedge, lever, pulley, inclined plane, screw, and wheel and axle).
Acceleration: how quickly an object speeds up, slows down, or changes direction.
Force: a push or a pull.
Gravity: A force that draws any two objects towards one another.
Speed: How fast an object moves. The distance that the object travels is divided by the time it takes.
Velocity: A combination of speed and the direction in which an object travel.

STEM Career Connections:

Mathematician	Mechanical Engineer	Computer Systems Analyst
Are professionals that use math to solve real-world problems.	Are professionals that design and fix machine systems.	Are professionals that analyze data processing problems to improve computer systems.
They: use mathematical theories, computational techniques, algorithms, and the latest computer technology to solve economic, engineering, and business needs.	**They**: are typically involved with the generation, distribution, and use of energy for machines and solutions in environmental problems	**They**: need to have knowledge of mathematics, technology, analytical skills, attention to detail, and much more!

Literacy Connections:

Young Frank, Architect	Whoosh! Lonnie Johnson's Super-Soaking Stream of Inventions	Building A Roller Coaster
by Frank Viva	by Chris Barton	by Karen L. Kenney
		

STEM AT HOME GUIDE: Roller Coaster Challenge

Background Knowledge

Real World Applications

Modern day roller coasters are similar to the first known roller coasters- they all use simple machines and physics to thrill riders. Take a trip to your nearest amusement park to research and see for yourself or watch the video links provided to see engineering in action.

Engineering New Ideas in Entertainment: Roller Coasters!

The two main simple machines of roller coasters are wheel and axles and inclined planes, although you can see many more! Notice the structures that hold up the roller coaster tracks- they are created with combined triangles. There is a lot of math and science used in building and maintaining a roller coaster!

The first hill of a roller coaster is always the highest point of the roller coaster because friction and drag immediately begin robbing the car of energy. At the top of the first hill, a car's energy is almost entirely gravitational potential energy (because its velocity is zero or almost zero). This is the maximum energy that the car will ever have during the ride. That energy can become kinetic energy (which it does at the bottom of hills when the car is moving fast) or a combination of potential and kinetic energy (like at the top of smaller hills), but the total energy of the car cannot be more than it was at the top of the first hill. If a taller hill were placed in the middle of the roller coaster, it would represent more gravitational potential energy than the first hill, so a car would not be able to ascend the top of the taller hill.

Everyday Science: Roller Coasters!

Amusement park guests enjoy the thrills of a roller coaster all over the world! Currently, over 2,400 roller coasters exist in the world today! Just in the United States, there are 760 roller coasters.

Roller Coaster Fun Facts!

- One of the earliest roller coasters in American carried coal before it carried thrill seekers.
- In the 15th century, Russia created one of the first known roller coasters- covered in ice.
- Roller coaster loops are never circular.
- The tallest roller coaster in the world, right now, is in New Jersey.
- The longest roller coaster in the world is in Japan.

Check out these video links!

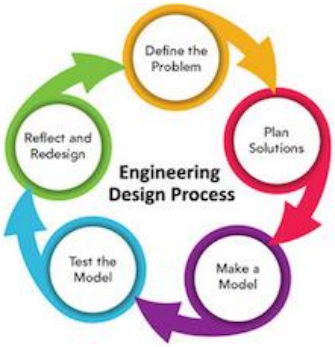
Cool Facts About Roller Coasters
https://www.youtube.com/watch?v=Wkp0-iGtfyI

World's Best Roller Coasters
https://www.youtube.com/watch?v=OjoyjbEu2oM

A Brief History of Roller Coasters
https://www.youtube.com/watch?v=nLP1z6-nhZw

STEM AT HOME GUIDE: Roller Coaster Challenge
Activity Directions

Aim: Design and create a roller coaster track made from various simple machines designed from household items that transport a marble successfully.



Investigating Questions

- What materials will be used to support the roller coaster track?
- How will your team design your roller coaster track using simple machines from household materials?
- How can your team use what you learned about physics and momentum in your designs?

Materials

No Legos!	Empty toilet paper rolls	Empty paper towel rolls
Paper plates	Ping pong ball or Marble	Cardboard
Construction paper	Tape	Scissors

***Other recyclable household materials

Criteria & Constraints:

Engineering design challenges (EDCs) are great opportunities for open-ended activities to grow critical thinking and problem-solving skills. EDCs do not use a list of directions to build a specific design, rather suggest a framework of designing a solution based on the problem and goal. How your team chooses to address the problem and goal is entirely up to you.

- Discuss as a family how simple machines make work easier. Take two jugs of water (one closed with a screw lid; and another closed with a pop-top lid). In this challenge you are designing your own roller coaster track including a special feature (loop, tunnel, multiple hills, etc.) and ending the track with your ball landing in a cup! Research and brainstorm the designs of rollercoasters: the geometric design of supports, tracks, gravity, and momentum) (*Define the Problem*)

- Lay out all materials and items available for the challenge. Plan to give time for your team to discuss the problem relating to your background knowledge. How will you use the materials provided and information you learned in your research of roller coasters to make your roller coaster track based on what you've learned from the video links and background information? (*Define the Problem*)

- Discuss, sketch, and determine what order you will use the materials to build your roller coaster supports and track (*Plan Solutions*).

- Using your sketches and discussions, begin creating the supports for the first roller coaster hill/track from your model from materials available. Family adults: allow your child(ren) to experiment with the materials and help them build problem-solving skills (*Make a Model*).

- As you are building your model, test out the prototype to make sure they can move/work. The track needs to start higher, as a hill- practice using the marble or ping pong ball to test your construction ALOT! Continue to build your supports as you add more to your track. Keep testing!

- Add your special feature portion of your track when ready. Continue to test that your marble or ping pong ball can make it through your design. (*Test the Model*)

- With your team, continue to discuss and work through problems with your designed models along the way. As you build, modify your design as needed. You may discover you are using too much tape, or the supporting columns are not secure. Redesign! What adjustments can your team make to improve your design? If you were to make a new roller coaster track with different household items, what materials would you use or how would your model be different? (*Reflect and Redesign*)

Ideas to Increase Difficulty:

-Add additional special features to your track.

-Limit the number of materials that will be used!

PTA.org/STEM

STEM AT HOME GUIDE: Roller Coaster Challenge

Sample Ideas

Photo's courtesy of: Kristen Wright, Santa Maria Valley Discovery Museum

spark. inspire. engage.

PTA.org/STEM

STEM AT HOME GUIDE: Roller Coaster Challenge
Extension Activity

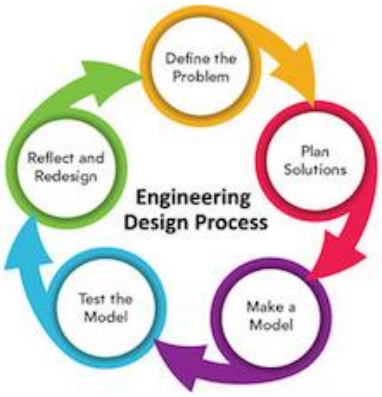
Pinball Machine Challenge

Materials:

Cardboard box	Duct tape	Construction paper
Glue	3 Marbles (or small balls)	Spring
Rubber bands	Mini cups	Straw
Plastic bottles	Scissors	Popsicle sticks
Cardboard	Rule	*Other household items

Criteria & Constraints:

Engineering design challenges (EDCs) are great opportunities for open-ended activities to grow critical thinking and problem-solving skills. EDCs do not use a list of directions to build a specific design, rather suggest a framework of designing a solution based on the problem and goal. How your team chooses to address the problem and goal is entirely up to you.



-In this challenge you are designing a homemade pinball machine that contains properly functioning parts: flippers, drain, holes, bumpers, and plunger. In your pinball machine, a spring inside the plunger launches your pinball (marble or small ball) into the machine where the goal is to keep the ball moving within the obstacles (holes, flippers, and bumpers) before it falls into the drain (access point to retrieve your ball).

- Research and brainstorm designs of a pinball machine and obstacles. How do they work? (*Define the Problem*)
- Sketch your prototype and design of key aspects of your pinball machine (*Plan Solutions*).
- Use research and the sketches to start brainstorming your prototype (*Plan Solutions and Make a Model*)
- Using your household materials, use the cardboard box and create your obstacles to place inside the box. Use your sketches as a guide. *(Make a Model)*
- The spring part inside the plunger of the machine will need adjustments. Does the spring when pushed from the plunger give the marble or small ball enough speed to make it through into the main portion of the pinball machine? Re-design your model, if needed. *(Make a Model)*

- Test your design! Will you have to modify your design? Talk with your team about ways you could improve the design of your model (*Reflect and Redesign*).