FIRST® at Home
Marble Roller Coaster

ACTIVITY SUMMARY

Students use the engineering design process to create a roller coaster using the given materials that will safely transport the marble from start to finish.

Age Range & Grade Level: *Ages 9+, Grade 4+*

Program Connection: *FIRST*® LEGO® League Challenge

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ACTIVITY OUTCOMES

Participants will:

1. Design a roller coaster that will have loops, hills and drops.
2. Build a roller coaster that will safely transport the marble from start to finish.
3. Analyze the results to see if their design would fit the given problem.

RELEVANCE MATRIX – Subject Area Crosswalks and Core Values Addressed

Science	Math	Literacy	Social Studies	Computer Science
Forces and motion, energy	Estimation and problem solving	Writing and sentence usage	Historical perspectives	Logical Thinking
Discovery	Innovation	Impact	Inclusion	Teamwork

FUN! Our last Core Value should always be used when doing any *FIRST* activities.

KEY VOCABULARY

Forces	Motion	Design
Engineering design process	Engineer	Solution

MATERIALS & SUPPLIES NEEDED FOR THIS ACTIVITY

Marble Roller Coaster Design Brief, (for constructing the track - paper, cardstock, insulation tubing cut in half), tape, rulers, marble, chairs or other objects to support the structure.

GUIDANCE & SET-UP

Description – Action – Guidance	Notes
Provide students with the design brief	
Review the problem statement and criteria/constraints with the students. Remind students they will be using the engineering design process to work towards a solution.	Review the age appropriate engineering design process with your students.
Determine how students will complete the activity, what their length of time will be, how to collaborate virtually and how to share their solutions. Have students work on their solutions.	Solutions can be built and designed using materials around the house. Students could submit pictures or videos of their designs.
Review *Evidence of Achievement* rubric (on next page) and create assessments if needed.	Sample rubric provided.
Explore the *Go Further!* opportunities	See below
Wrap up – Have students complete their *Core Values Self-Reflection* and review.	*Core Values Self-Reflection* is found in the student design brief document.

STUDENT OR TEAM ACTIONS

1. Review the Marble Roller Coaster Design Brief and problem statement.
2. Research the questions and discuss.
3. Brainstorm ideas.
4. Generate a rough sketch of your marble roller coaster.
5. Create a marble roller coaster solution to solve the challenge presented in the problem statement.
   (If students are completing at home, they could recruit a sibling, parent or guardian to do activity with them.)
6. Determine your testing and observation methods. Analyze your results after testing.
7. Iterate on your design and make improvements. Test again.
8. Generate a sketch that shows the final roller coaster that you created.
9. Share your solution and reflect on your learning.
10. Explore the Go Further! opportunities.
11. Complete your Core Values Self-Reflection.

GO FURTHER!

- Go online to https://www.learner.org/series/interactive-amusement-park-physics/. Build a roller coaster and evaluate your design. Click “Your Safety Inspection” to analyze your design.
  - Why did your design work? Why did it fail? Describe below how each step was successful or a failure.

EVIDENCE OF ACHIEVEMENT

Evaluation Rubric			
Category	**3 points**	**2 points**	**1 point**
Requirements	All requirements on the design brief were met.	Some of the requirements on the design brief were met.	Only a few requirements on the design brief were met.
Design	Clearly showed how the solution solved the challenge.	Showed how the solution would solve the challenge.	Not clear how the solution would solve the challenge.
Collaboration	Demonstrated collaboration by sharing information or working with team members.	Shared some information or with team members.	Respect and inclusion being developed.
Knowledge Gained	All the questions are answered completely.	All the questions are answered but could have more detail.	The questions are not answered.

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Design Brief

PROBLEM STATEMENT

You are president of an engineering firm that designs and builds roller coasters. Six Flags has just commissioned you and your team of highly trained and specialized engineers to design their new roller coaster. This is to be the premier roller coaster in the world. It is to be faster and more thrilling than any other coaster that exists today.

CRITERIA & CONSTRAINTS

- The roller coaster must change levels at least 7 times.
- The roller coaster must have a minimum of two loops.
- A marble will be used as the vehicle for your marble roller coaster.
- The marble will begin at the top of the coaster and end at the bottom level of the coaster.
- The Marble does not have to return to the starting point.
- After you assemble your roller coaster, test it and record your observations, analyze the results.

ENGINEERING DESIGN PROCESS & *FIRST* CORE VALUES

FIRST Engineering Design Process | Explore *FIRST* Core Values

BUILDING THE BACKGROUND

Reflect, research, and answer the questions below.

What forces act on a roller coaster?

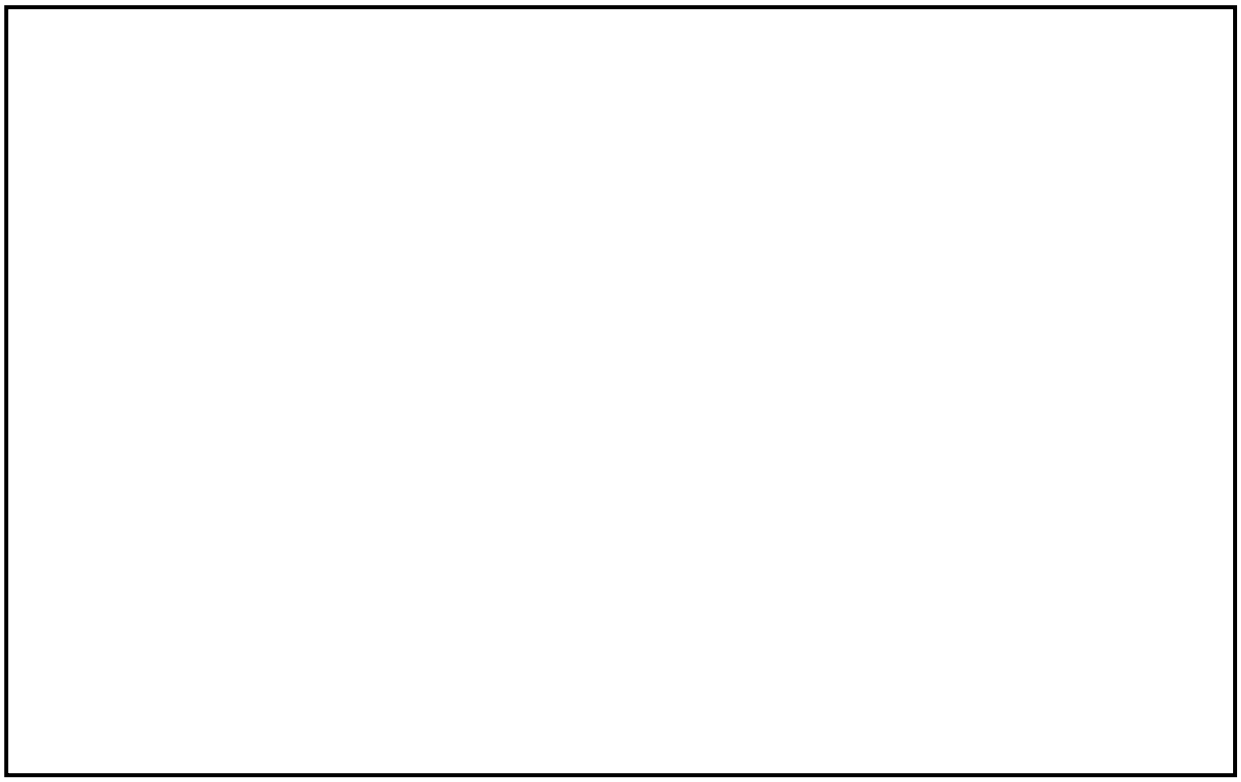
What different materials are used to build roller coasters?

What technological advances and innovative designs have there been in roller coasters?

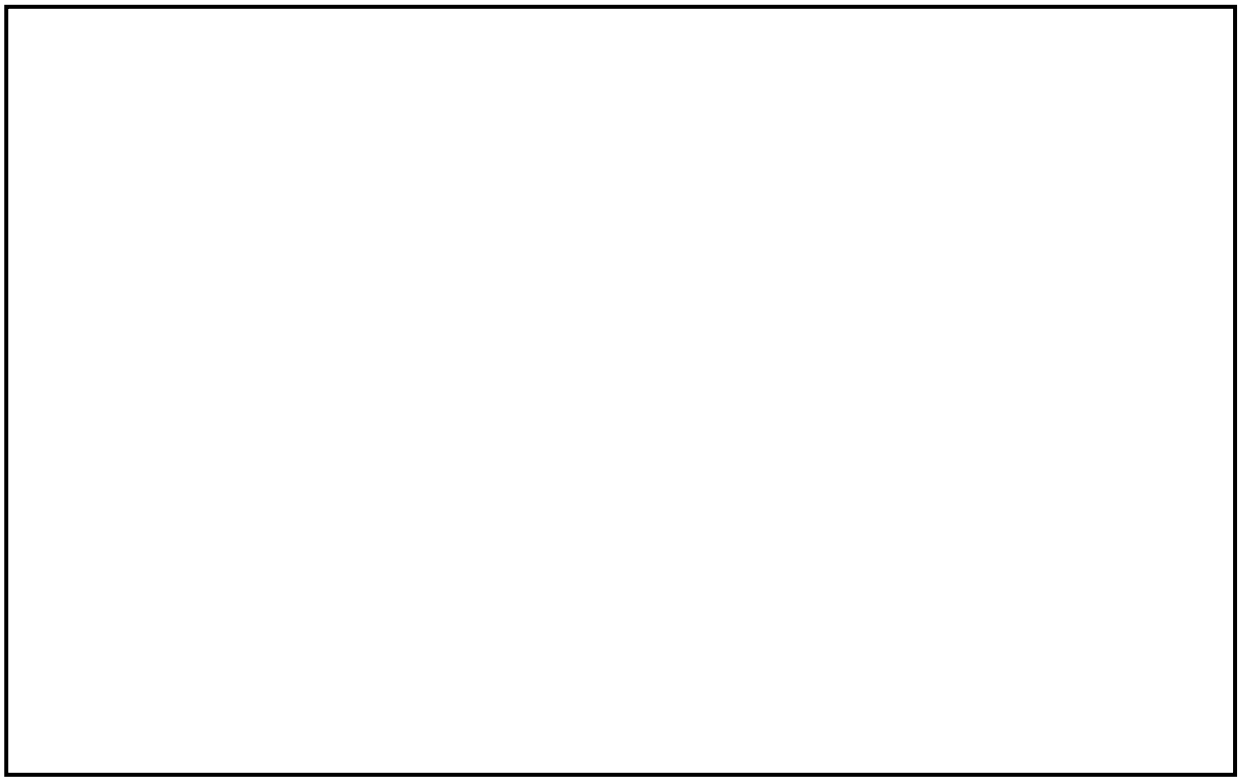
What is the history of roller coasters?

ACTIVITY STEPS

1. Brainstorm your ideas for your marble roller coaster solution.
2. Generate a rough sketch of your marble roller coaster. Include how the device will look, approximate dimensions (size), materials used and other important information about the design.



3. Create your solution.
4. Determine your testing and observation methods. Analyze your results after testing.
5. Iterate on your design and make improvements. Test again.
6. Generate a sketch that shows the final roller coaster that you created.



REFLECTION QUESTIONS

1. How does the starting position of the marble affect the speed of the marble at the end of the first hill?

2. What happens to the marble's energy as it goes up a hill and slows down?

3. Would a marble ever be able to get over a hill higher than its initial starting height? Why?

4. How would using a different sized marble affect its initial potential energy?

5. If a life-sized version of your roller coaster was built would you ride it? Why?

GO FURTHER!

- Go online to https://www.learner.org/series/interactive-amusement-park-physics/. Build a roller coaster and evaluate your design. Click “Your Safety Inspection” to analyze your design.
    - Why did your design work? Why did it fail? Describe below how each step was successful or a failure.

CORE VALUES SELF-REFLECTION

	Amazing Skill	Great Job	Making Progress	Could Be Better
Discover	I approached the tasks looking for all possible answers independently and used perseverance to discover the answer on my own.	I approached the tasks and asked questions from one other person but persevered to discover the answer on my own.	I approached tasks but needed assistance multiple times to reach a point of discovery.	I depended on others to make the discovery for me.
Innovation	I used creativity and perseverance to solve problems on my own, coming up with unique solutions for the tasks I was given.	I used creativity and perseverance to solve problems on my own coming up with different solutions for the tasks I was given.	I used creativity but struggled with perseverance to solve problems on my own.	I struggled with being creative and only used the information given and needed a lot of encouragement from others to complete the task.
Impact	I approached the tasks applying understanding of the information with the impact it can have on me and my future as well as how I could help others.	I approached the tasks knowing and applying the information with impact it can have on me and my future.	I understand the tasks but struggle to apply how it will help me in my future or to influence others.	I understand the tasks but did not approach it with understanding the impact it can have on my future or others.
Inclusion	I approached all tasks with inclusion of others' ideas, I showed tremendous kindness by including others' views in my projects and work. I approached my solution thinking how all people would interact with the solution.	I approached most with inclusion of others' ideas, I tried to understand others' views and include them in my projects and work. My solution mostly incorporates needs of others.	I approached some tasks with inclusion of others' ideas, I tried to understand others' views and include them in my projects and work. My solution meets only a few needs of others.	I did not approach tasks with inclusion of others' ideas, I tried to understand others' views and include them in my projects and work. My solution is not inclusive of different types of people.
Teamwork	I used collaboration, communication and project management to get all tasks accomplished for myself as well as the others.	I used collaboration, communication and project management to get most tasks accomplished for myself as well as the others.	I used collaboration, communication and project management to get some tasks accomplished for myself as well as the others.	I only sometimes used collaboration, communication and project management and accomplished a few tasks for myself as well as the others.
Fun	I kept a positive attitude throughout and found opportunities to have fun even through struggle. I looked for additional opportunities to have fun in my tasks.	I kept a positive attitude throughout and found opportunities to have fun even through struggle.	I saw the enjoyment and fun after the activity but struggled to see it during.	I only saw struggle in completing my tasks and did not look for times to have fun.