MAKEngineering Kit Facilitation Guide: Paper Rollercoaster

ENGINEERING TASK

A local amusement park has asked you to design their next roller coaster. You decide to design a prototype suitable for a marble to travel from the start to the finish. You will use the prototype during your presentation to the local amusement park.

MATERIALS IN KIT

- Multiple strips of cardstock paper
- Scissors
- Tape
- Marble
- Other household objects

DID YOU KNOW?

Engineers design and work on a team to build theme park rides and attractions that are safe, yet fun for guests like you. Engineers at Walt Disney World in Orlando, Florida make between $67,000 and $110,000 a year.

About how many Micky Mouse hats ($30) could you buy if you made $67,000 a year?

DID YOU KNOW?—EXTENSION

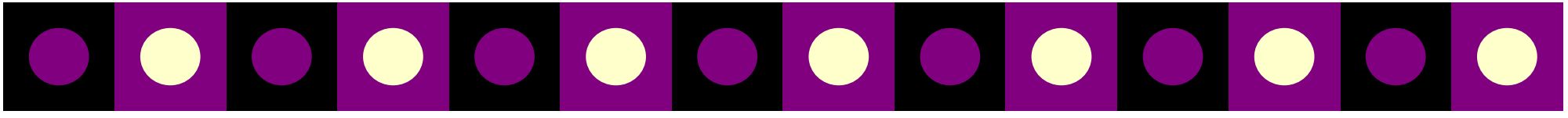
If there is interest, check out these videos...

https://youtu.be/Ny1zPqt8LVE

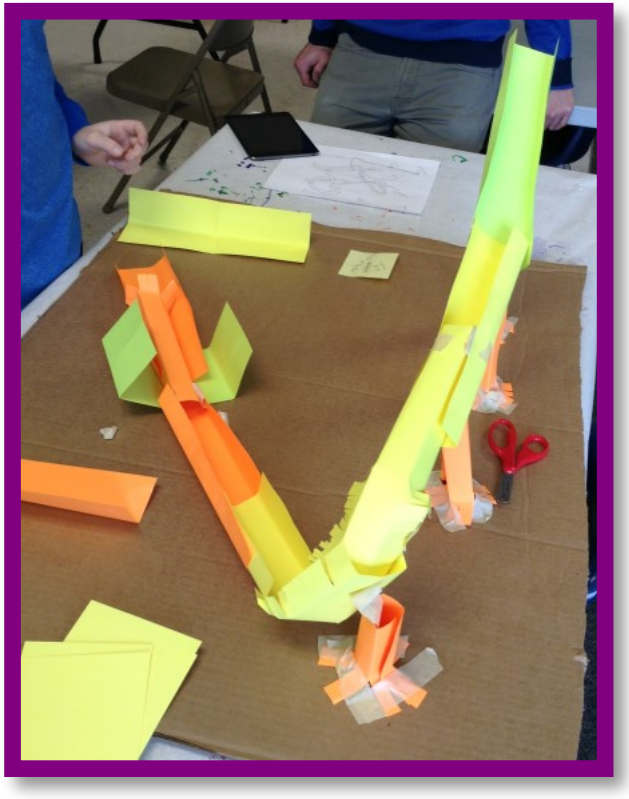
https://youtu.be/7O_W5ayuSk8

...and ask a few questions. Here are a few options:

- What is the most interesting thing you learned?
- What do you still wonder about and want to continue exploring?
- How would you explain a theme park engineer to one of your friends?



STEP 1—RESEARCH



We encourage you to research roller coasters for inspiration. Most have a theme—Space Mountain and the Incredible Hulk are two examples. Write down things you notice during your research.

A good place to start is “List of Roller Coaster Rankings” on Wikipedia.

STEP 2—PLAN

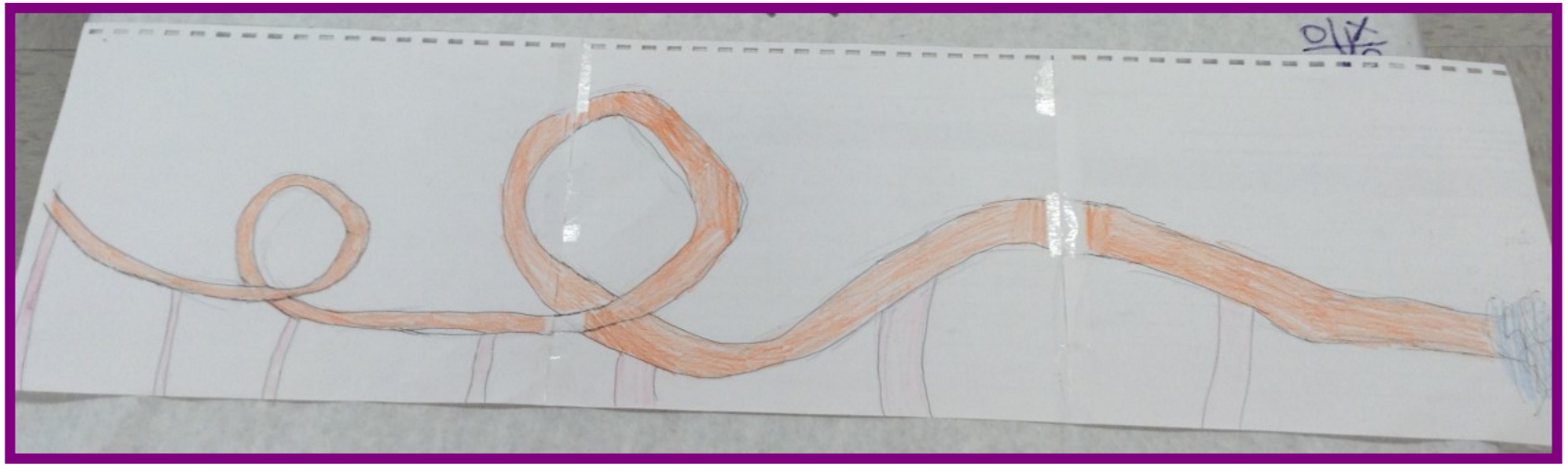
Let's think through the following for your design. Don't forget to take notes.

1. What is the theme of your roller coaster? Why? What artistic element might you add?
2. How tall? How long?
3. How many turns, curves, and/or loops, if any?
4. How will you support the structure?

STEP 2—PLAN

Now that you have some general design features written down, draw a sketch.

Describe your process for creating your prototype. What is the first step?



COMMUNICATE

Have a conversation around the planning process. The camera can be focused on the written plans or sketch.

1. Explain your roller coaster design. What did you find out in your research that you used in your design?
2. What was your inspiration for the theme?
3. Predict where in your design you think the marble will stop or fall off the track in your prototype. Why do you think this? Should we change the design now or wait until we test the prototype?

STEP 3

CREATE roller coaster tracks and BUILD on a flat surface!

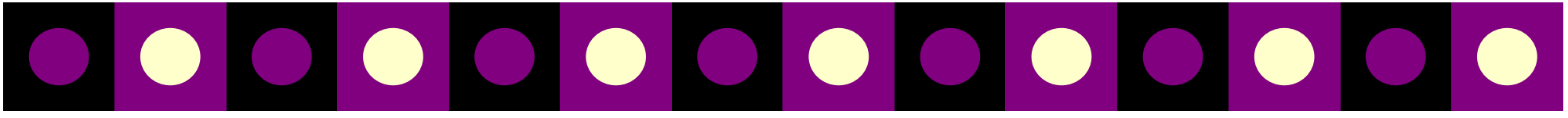
SEE DIFFERENT FOLDING TECHNIQUES ON THE FOLLOWING PAGES

To emphasize the testing and redesign stages of the engineering design process (Step 4 here), we suggest keeping the marble stored away until Step 4.

STEP 3—SUPPORT

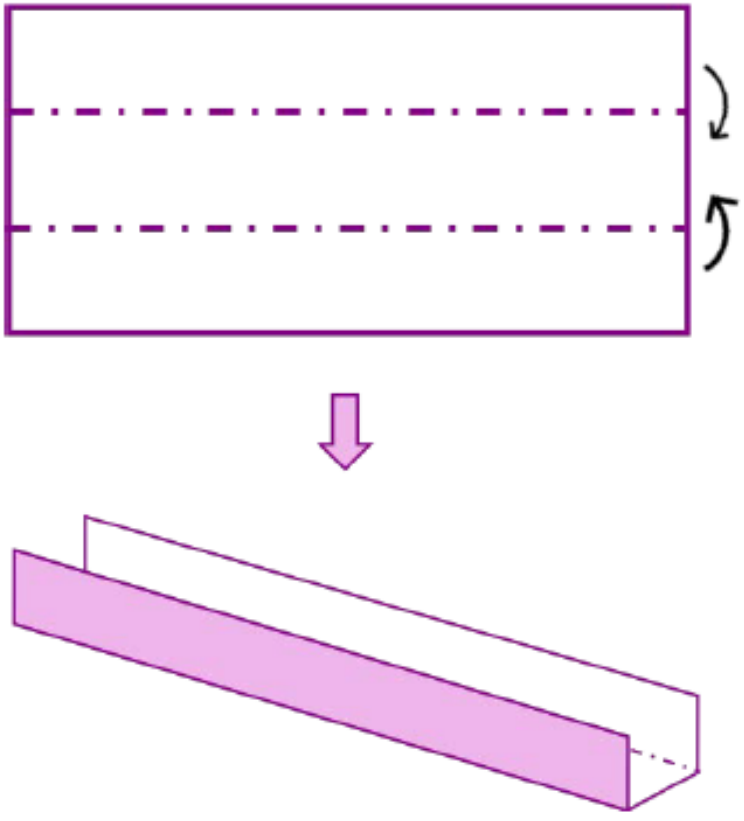
Optional questions to ask throughout this step:

- Show me where this track is in your sketch.
- It seems we need a taller support. What technique should we use to stack supports on top of one another? How can we make it stable?
- What if we _____ (e.g., added another track here)?
- I like the way you _____ (e.g., folded the track into thirds). Can you teach me?



STEP 3—CREATE & BUILD FOLDING TECHNIQUE—TRACK

Take 1 strip of paper and fold into thirds. To join tracks, overlap one end of a track to the end of another track. Use tape to attach the two tracks.

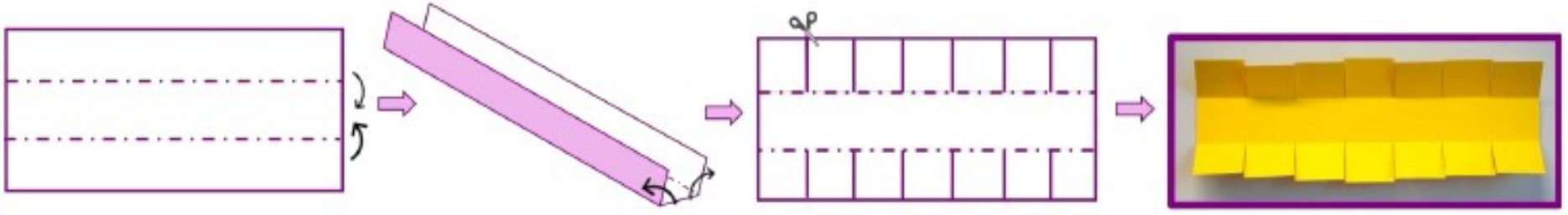


STEP 3—CREATE & BUILD FOLDING TECHNIQUE—LOOP, CURVE, HILL, AND MORE

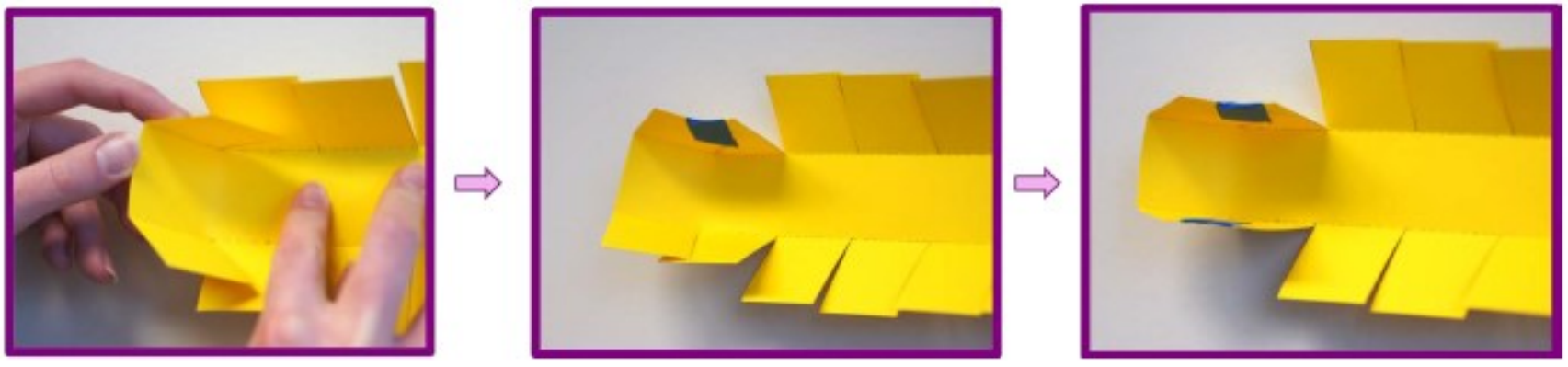
Take 1 strip of paper and fold into thirds. Cut slits of on both sides—not the track. The slits can be of any size, but should be similar or consistent. Fold as desired and use tape as needed.

SEE IMAGES ON THE FOLLOWING PAGES.

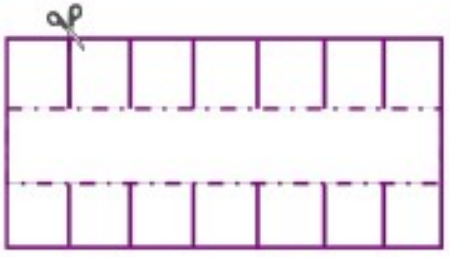
STEP 3—CREATE & BUILD FOLDING TECHNIQUE



Cut along the solid lines

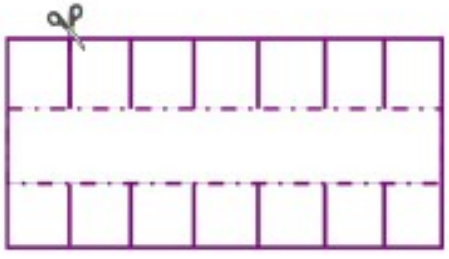


STEP 3—CREATE & BUILD FOLDING TECHNIQUE



Single loop

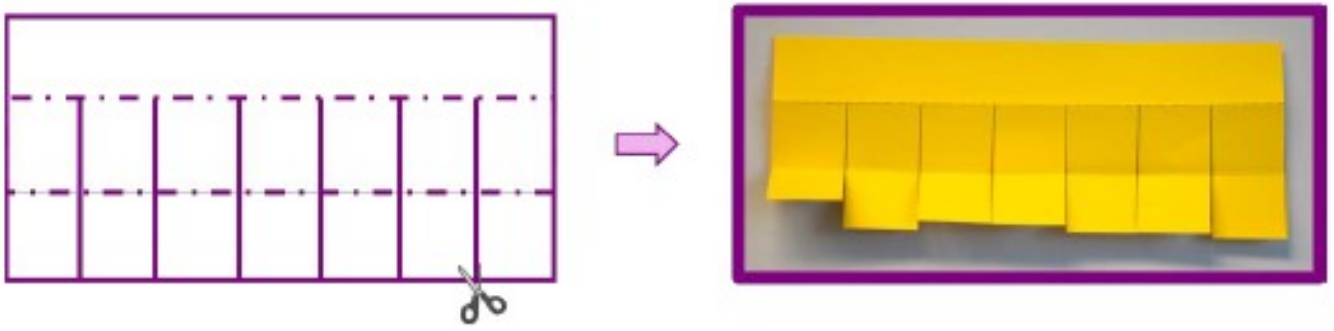
Double loop



Hill

Valley

STEP 3—CREATE & BUILD FOLDING TECHNIQUE



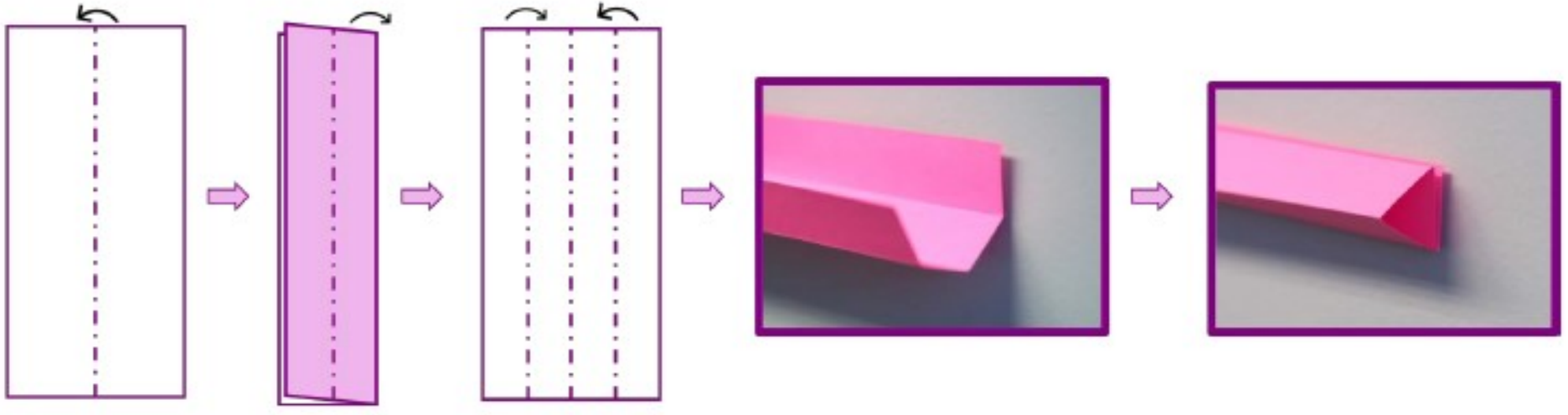
STEP 3—CREATE

DESIGN YOUR OWN FOLDING TECHNIQUE

Create your own folding technique or design to add to your roller coaster.

STEP 3—CREATE & BUILD
FOLDING TECHNIQUE—SUPPORT

Take 1 strip of paper and fold into fourths length-wise. Make a triangular prism by overlapping two of the fourths.

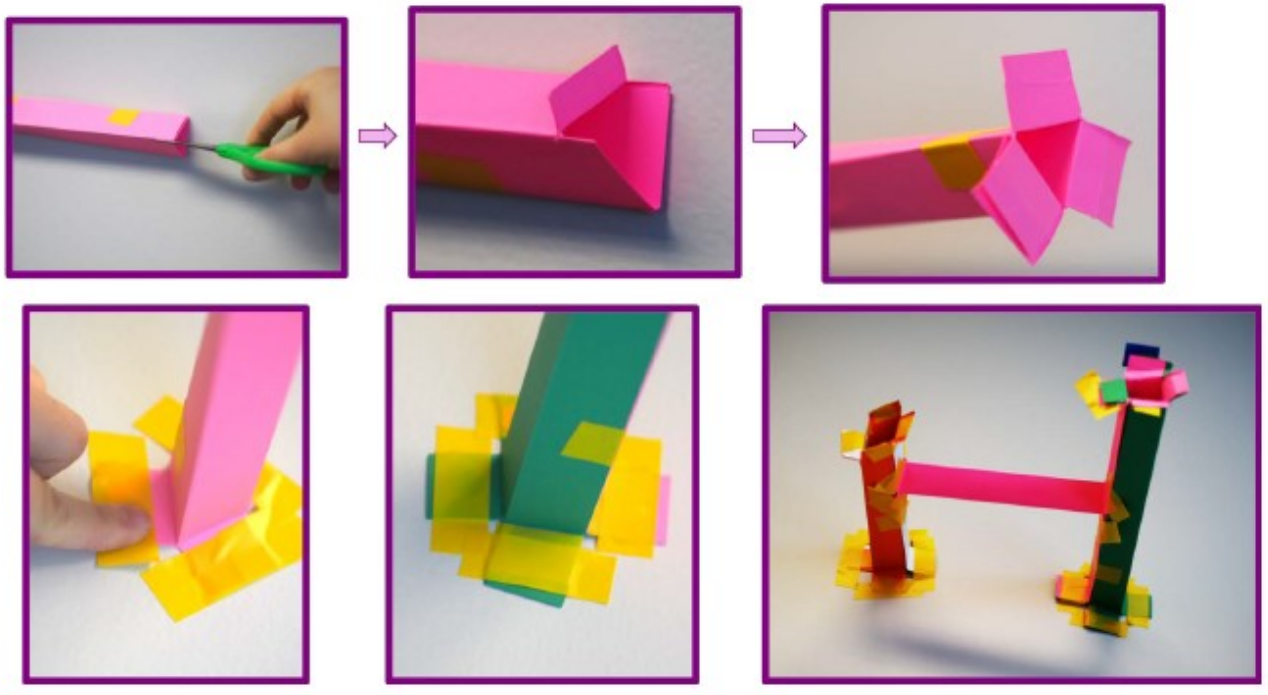


STEP 3—CREATE & BUILD
FOLDING TECHNIQUE—SUPPORT

You can also make a rectangular prism using 2 strips of paper and folding both into fourths. Which support—triangular prism or rectangular prism—will provide more stability? Why?

STEP 3—CREATE & BUILD
FOLDING TECHNIQUE—SUPPORT

What do you notice about securing the supports to a base (e.g., table, cardboard)? Why is this an important step?



COMMUNICATE

Have a conversation around creating the tracks and building the prototype. The camera can be focused on the roller coaster.

1. Explain your process.
2. How did you work together as a team of engineers?
3. Where did you make changes? Why? How are these changes different from your original plan?

STEP 4—TEST & IMPROVE

Pause! For each test or trial, write down what happened or ask a parent/caregiver to write this information down. What went well or not so well? What did you change based on your observations? Remember the marble is to travel from the beginning to the end multiple times.

STEP 4—SUPPORT

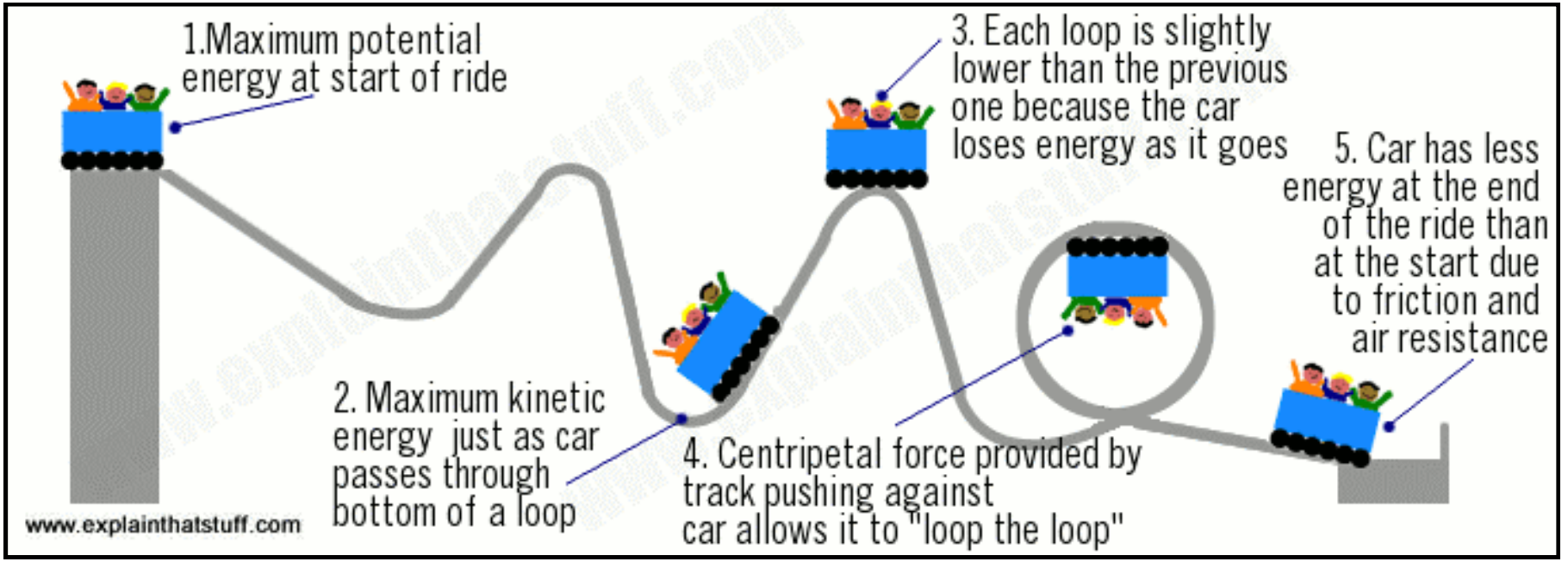
Here is one suggestion for organizing and documenting the tests. This will afford you an opportunity to discuss how mistakes and failures are okay and how engineers go through this process too.

	Strength(s)?	Improvement(s)?	Change(s)?
Test 1			
Test 2			

STEP 4—EXTENSION

How might the failures during testing be based on physics?

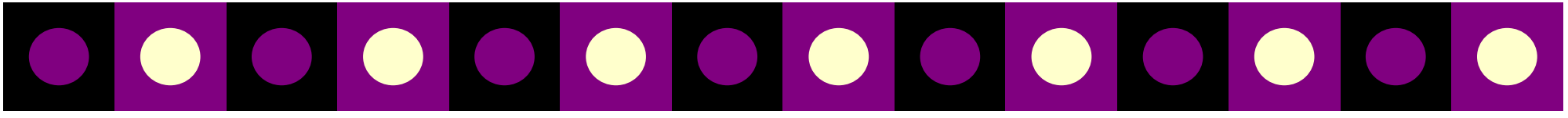
https://youtu.be/BunU6CTmhFw



STEP 4—EXTENSION SUPPORT

Optional questions to ask throughout this step:

- ◊ It seems the marble does not have enough energy to pass the loop. What can we do?
- ◊ What if we increase or decrease the curvature (or angle) of a hill or valley? What type of energy would we be changing? Explain.
- ◊ What can we do to prevent the marble from flying off of the track? Or getting stuck on the tracks?
- ◊ Should this (e.g., loop, hill) be higher or lower than the previous one? Why? Explain using the diagram.



COMMUNICATE

Are you ready for your presentation to the local amusement park? How will you grab their attention and build interest and excitement about your roller coasters?

- Talk about your theme and what makes it unique.
- Talk about changes you made when the marble did not travel from the beginning to the end.
- Show how the roller coaster works.
- End with something that will make you and your prototype unforgettable.

DID YOU KNOW…

The first roller coaster in America opened at Coney Island in Brooklyn, New York on June 16, 1884. It traveled approximately six miles per hour and cost a nickel to ride.

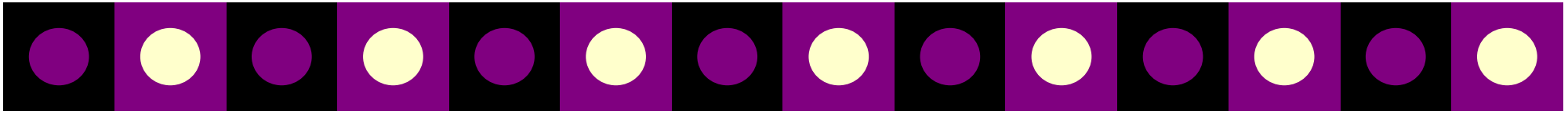
Kingda Ka is one of the world's tallest (456 feet) and fastest (128 miles per hour) roller coasters. Yet, it may be one of the shortest at 50.6 seconds.

The longest roller coaster is the Steel Dragon 2000 at 8,000 feet long. The duration of the ride is 4:00 minutes.

IF YOU ARE INTERESTED...

Do more research about roller coasters around the world.

1. What rollercoaster has the most loops? How many? What country is it located?
2. Are you more likely to get injured from falling off a bed or riding a roller coaster? Explain.
3. Where is the fastest rollercoaster in the world? How fast does it travel?
4. Why are there height restrictions on who can ride roller coasters?
5. True or False: Four men rode 74 rollercoasters in 10 theme parks in just one day.



WHAT TYPE OF ENGINEER ARE YOU?

Add a sticker to your Engineering Passport that identifies the type of engineer you were most like in the design of a roller coaster. Don't forget to write why you chose the type of engineer.

This engineering kit would not have been possible without funding and support from the National Science Foundation.