GSK Science in the Summer™

Be a Structural Engineer

This summer, your child is invited to play the role of a scientist—a structural engineer—to explore basic concepts of engineering and solve a real-world problem.

Welcome to *GSK Science in the Summer*, brought to you in partnership between GSK and The Franklin Institute.

This free summer science program aims to inspire the next generation of scientists and engineers by inviting children to experience real science careers by practicing science skills and using real science tools—all while having fun!

This at-home science activity is supported by a series of online resources, including videos and a live, interactive virtual experience. Here is the recommended sequence for your *GSK Science in the Summer* Be an Engineer experience:

1. Start by watching **short introductory videos** to help your child set up their lab and learn about their engineering project.
2. Do your **at-home experiments**, using the guide in this booklet and the provided science materials. Remember to follow the safety guidelines during all activities.
3. Join a live **Structural Engineer Team Meeting** to share the results of your research with other *GSK Science in the Summer* participants.

Find all the videos, resources, and event registration information at scienceinthesummer.fi.edu/be-an-engineer.

Are you ready to be an engineer? It's time to set up your lab and get started on your research!

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THE FRANKLIN INSTITUTE

Structural Engineer

You work for a company that designs bridges for parks, roads, and highways. A nature center wants to build a bridge on one of their hiking trails to help people cross a river. The trail planners want to use a new, lightweight building material for this bridge. The new material is expensive, so they don't want to use too much of it.

Your job is to find the best way to use this new material to create a sturdy bridge, using as little of the material as possible.

MATERIALS

- 8 ½" x 11" copy paper
- Cardboard
- Small cup
- Round metal washers
- Masking tape
- Lab notebook
- Pencil
- Ruler

ADDITIONAL MATERIALS:

- Two thick books or blocks, 2.5–5 centimeters (1–2 inches) thick and at least 10 cm (4 in) wide for supporting the bridge
- Scissors
- (Optional) markers or crayons

LAB SET-UP AND SAFETY

1. Gather your supplies. Make sure you have all your science tools and materials from the list above in one place.
2. Find a flat, hard surface like a table or desk to use as your lab bench. You'll need plenty of space for building your designs and storing your materials.
3. Cut several sheets of copy paper in half (to make short, wide halves). These half-sheets will be your model for the lightweight building material.
4. Cut a piece of cardboard into a square about two inches on each side, or about as big as the palm of your hand.
5. Use one of the paper half-sheets to create a model river. Use crayons or markers to color it like a river or write the word "river" on it to label it.
6. Set up your model river. The books or blocks are the river-banks that your bridge will stand on. Place the two books on a flat surface with your paper river model in between them. They should be lined up against the long edges of the paper.

Part 1: Research

Use your model building material to find out which bridge shapes make the sturdiest bridges.

1. Start by thinking about the requirements of your bridge. Make some notes on page 16 of your lab notebook.
   - *What should it be able to do when it is working correctly?*
   - *What does it need for people to use it safely?*
   - *What other limits does it have? For example, how long does it have to be?*
   - *What are the limits about the kind and amount of material you can use?*

2. Next, use your paper building material to test some different bridge shapes and find out which shapes will hold the most weight. Start with the three shapes listed in steps 5–7 below, and then test your own ideas!

3. To test how much weight each bridge can hold (its **maximum load**), place the cardboard square on the center of the bridge with the small cup on top of it. Add metal washers one at a time until the bridge is just about to collapse. Use page 17 in your notebook to write down how many washers each bridge could hold before collapsing.

4. Each test should also follow these rules:
   - The bridge cannot be taped or attached to the riverbanks (the books or blocks)
   - The bridge cannot touch the river anywhere
   - The bridge cannot use more than two paper half-sheets

5. **Test a flat bridge shape:** Lay one sheet of paper flat from one riverbank to the other. Test how many washers it can hold. Try stacking two sheets on top of each other or folding one sheet in half (the long way) to make two layers. Do those arrangements change its maximum load?

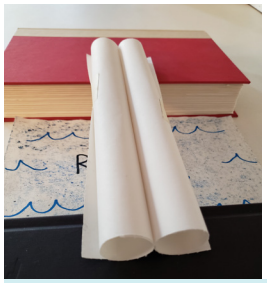
6. **Test a rolled bridge shape:** Roll a sheet into a long tube and use a small piece of tape to hold it closed. Test its maximum load. Try putting two rolled tubes side by side and test again. Does it matter how tightly you roll the tubes? Try rolling the tubes tighter or looser and notice how it affects the maximum load.

7. **Test an accordion bridge shape:** Fold a half-sheet into a fan or accordion shape. Test its maximum load. Does it matter how many times you fold it? Try two accordion shapes next to each other or stacked on top of each other. What is the maximum load of each of those structures? What do you notice about the accordion shape as the bridge starts to collapse? Can you think of any way to stabilize it? How does that change its behavior?

8. **Test other shapes:** What other shapes could you fold the paper into that might make a strong bridge? Try out your ideas and test their load using the cardboard, cup, and washers.

9. Look again at the requirements you wrote in your notebook. Is there anything you want to add to your list based on this research?

FLAT BRIDGE



ROLLED BRIDGE

ACCORDION BRIDGE

Part 2: Design

Create a plan for how to build a strong bridge for the hiking trail using as few sheets of material as possible.

1. Brainstorm different ways to create a bridge over your model river that uses as little paper as possible but is strong enough to hold as much weight as possible. Think about the shapes you tested during your research. On p. 17 of your notebook, write or draw as many different ideas as you can for building a strong, lightweight bridge.

2. Choose one idea that you think will work the best. Decide which materials you will use, and how you will place them or connect them together. Draw a new picture of your design or circle it in your notebook.

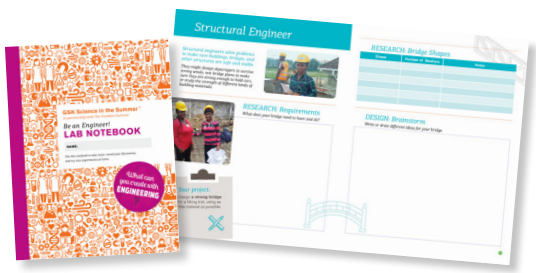
Part 3: Build, Test, Redesign

Try out your bridge design and improve it until it works as well as it can.

1. Build the bridge based on your plan. Test its maximum load with the washers.
   - *How well does it match the requirements you listed in your notebook?*
   - *Do you think you could make it hold more weight?*
   - *Could you make it using less paper or tape?*
2. Make changes to your bridge and test it again. Notice which parts of your design work well, and which parts you could improve to make it meet your requirements better. Use page 18 in your lab notebook to record your observations and ideas.
3. Keep changing, testing, and trying new ideas until your bridge is as close as possible to matching all the requirements you wrote in your notebook. (It might take a lot of tries! Engineers often test many ideas before finding the one that works best.)
4. Draw a picture or take a photo of your final, best design for a strong, lightweight bridge.

Part 4: Reflect

1. Think about the results of your research to design a strong, lightweight bridge for a hiking trail.
   - *What suggestions would you give to the nature center about how to use their lightweight building material to build the strongest bridge for their hiking trail?*
   - *Which parts of your design worked the best? What things did you try that didn't work? How did your design change from the beginning of the project to the end?*
2. Think about how you were like a structural engineer in this activity. Use page 19 in your lab notebook to draw or write about your ideas. Add some skill stickers from the sticker sheet to show some of the science skills you used in this activity. What did you do that might be like what a structural engineer does? What science skills did you use?
3. Find out more about being an engineer! Try out the three other engineer activities featured in your lab notebook using the other Be an Engineer videos and activities found at scienceinthesummer.fi.edu/be-an-engineer. Or check out some of the books and websites listed on the back of your lab notebook.



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Want even more science? The Franklin Institute has created Franklin@Home (fi.edu/franklin-at-home), a series of science videos, do-at-home experiments, and live virtual science experiences that allow you and your family to continue discovering, exploring, and experimenting at home all summer long!