# Be an Engineer!

**Estimated Time: 30 – 45 minutes**


**SUMMARY**

Some engineers design large structures like buildings and bridges. These are just the most visible things engineers create. The concepts of engineering can be applied to many things big or small, and engineers work with countless materials. In this activity, students will build bridges out of paper and, with engineering, get their bridges to hold a pretty impressive weight.


**WHAT YOU'LL LEARN**

- The engineering process of designing, testing, and redesigning.
- The definition of parameter and learning to work with constraints.

| Materials Used | |
|---|---|
| ● Four sheets of 8.5"x11" paper per student<br>● Masking tape<br>● Tables, chairs, or thick books | ● Small, heavy objects such as metal washers, nails, coins, etc.<br>● Small square (3"x3") of cardboard or plastic (optional) |

**WHAT TO DO**

1. Start by talking about what bridges are made of. Encourage students to list all the materials used to construct bridges such as stone, wood, bricks, metal, etc. Have they ever seen a bridge made of paper? Probably not, and if they can imagine it, they may not expect it to hold much weight.
2. Tell the students they will build a bridge out of paper and see how much weight it can hold. They will have to adhere to certain parameters for their design:
    a. You are limited to four pieces of printer paper and some masking tape.
    b. You need to cover a gap of eight and a half inches.
    c. The most successful design will be the one that holds the most weight without collapsing.
    d. You cannot tape the paper down.
3. Time to build! The gap for the bridges can be made by stacking books (as shown in the picture to the right), pushing two tables together, or pushing chairs near each other. Make the gap 8.5 inches for the first design challenge.
4. Time to Test! Some students may start by stretching their pieces of paper flat, but they will soon find that the paper buckles under the first weight added. Use this to talk about ways the bridges might be redesigned.

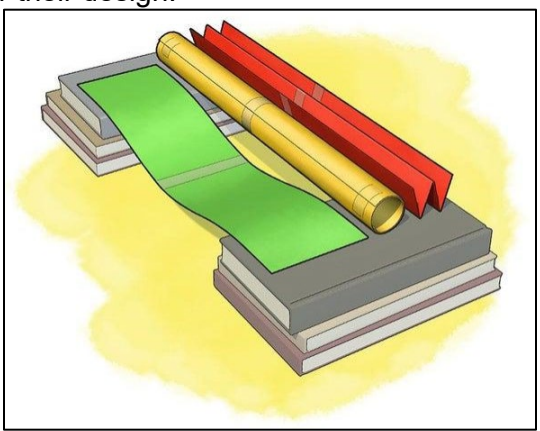

Image © Scientific American

    a. Paper has very little strength against forces applied to the flat surface of the paper, which you can tell by simply poking a piece of paper and watching it fold.
    b. Trying to pull a piece of paper apart, though, shows how strong it is against edge-on forces. How can we apply the weight to the paper's edge?
5. Time to Analyze! Each time the bridge collapses is a chance for discussion and analysis. Cheer each design's advantages and pick out the weaknesses that can be improved. During these analyses, you can ask the following questions.
    a. What worked? Where did the bridge hold up against the weight? What did you change from last time and how did it help? Is there a general rule you can make from your observations (e.g. "Triangles are strongest.")?
    b. What didn't work? How did the bridge perform worse than you had planned? What changes did you make that had no effect? Is there a general rule you can make from your observations (e.g. "Just a sheet of paper is not strong enough.")?
6. Repeat the "Build, Test, and Analyze" steps to continue redesigning the bridge. Redesigning bridges might take several trials, but with each failure, students learn more. The image above illustrates possible options: a rolled beam of paper and a folded accordion. Both of these designs put weight onto the edge of the paper where it is stronger and the triangles of the accordion will also spread the weight out over the triangles' base making it the strongest option.
7. After each redesign, add weights until the bridge collapses. Record the results and use each collapse as a lesson for what to change next time. You can use the data table below as an example of keeping track of changes. Take breaks frequently to discuss ideas.

| Student | Record | Notes |
|---|---|---|
| *Dajae* | *21 nails* | *Used accordion design, multiple layers* |
| *Chris* | *15 nails* | *Reinforced folds with tape, strengthened center of bridge.* |

**TIPS**

- An option for holding the weights to make it easier to balance on the bridges is to provide a square of cardboard or plastic to put the weights on. Make sure that all the squares are equal in size and shape to make fair comparisons between bridges.
- The best way to generate ideas with this activity is to have multiple teams working on their individual bridges. Students will have different ideas and try various approaches to share and discuss. Engineers often share ideas and compare notes to improve their work.
- If students are interested in exploring other STEM Careers, visit our "Sun" and "Space" week materials!