# Engineering Toilet Paper

In need of toilet paper? No problem! Make your own, one square at a time, with simple household items.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Concepts to Explore</th>
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<tbody>
<tr>
<td>● Container (ex. tupperware)</td>
<td>● Properties of water: Adhesion</td>
</tr>
<tr>
<td>● Water</td>
<td>● Properties of water: Cohesion</td>
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<tr>
<td>● Water-based glue or gelatin</td>
<td>● Engineering and Design</td>
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<tr>
<td>● Plastic Sandwich Bag</td>
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<tr>
<td>● Duct Tape (preferred)</td>
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<tr>
<td>● Sponge</td>
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<tr>
<td>● Cotton Balls (approximately 8)</td>
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<tr>
<td>● Teaspoon</td>
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## Activity Format

- As students work through the activity, you may choose to have students write down **detailed observations** and include **drawings when directed**.

- Students may answer the focus questions using the **Claim, Evidence, Reasoning** format:
  - Claim that answers the question
  - Evidence from students' data
  - Reasoning that involves a rule or scientific principle that describes why the evidence supports the claim

## Procedure

1. Place a sandwich bag on a table or countertop. Line all sides of the bag with duct tape, such that it creates a border around the bag.

2. Place a thin layer of water on the bag such that it completely covers the surface but does not spill past the duct tape border. *

3. Separate small, thin pieces of cotton from a cotton ball and place on the surface of the bag. Repeat this process until the entire bag is covered with thin, wet pieces of cotton (approximately 4-6 cotton balls are needed). You may need to add more water during this process.

4. Lightly press the cotton together and then gently place a damp sponge directly on the cotton/plastic bag. Press down on the sponge. Lift sponge away from the cotton and squeeze the sponge water into a container.

5. Repeat step 4 until most of the water is removed from the cotton paper. Let paper dry before use.

6. Create another sheet of paper by repeating steps 1-5, but add 1-2 teaspoons of glue or gelatin to the water before use.

* Picture references include an optional design, whereas, a wall of tape is built up around the bag to hold in more water. This is accomplished by adding additional tape to the border of the bag, and folding the tape in on itself, creating a “wall”. 

Focus Questions

Pre-K - 2:
1. What did you notice about the cotton when you placed it on the wet surface of the bag?
2. Which of the two types of paper you made would you use to draw on? Which might you use as toilet paper? Why?
3. Why do you think we used small pieces of cotton instead of whole cotton balls?
4. Why do you think we used a damp sponge instead of a dry sponge?

Elementary:
1. Describe how the thin cotton pieces interacted with each other when placed on the watery surface of the sandwich bag. Might you observe these characteristics in the pieces of cotton without the layer of water? What might this say about characteristics of water?
2. This activity is an investigation where you produced two sheets of paper using slightly different methods. Which sheet of paper is the more “successful” of the two? What characteristics of these paper sheets lead you to that answer?
3. What observations did you make about the paper making process and production? Were these observations measurable? If not, what type of measurable observations might you make about the paper?
4. This process produces one small paper sheet at a time. Develop a procedure that allows for either more sheets to be made at one time, or for making a stronger sheet of paper. Describe the process you engineered.

Middle School:
1. What characteristics determine whether a piece of paper is strong or weak? Analyze the two sheets of paper you made using these characteristics. Use evidence from this analysis to determine which paper is the strongest of the two.
2. Use the evidence from your answer to question #1 to design and test a method that produces a sheet of paper that is stronger than the two sheets produced in the activity.
3. Place one to two small strands of cotton in a cup of cold water, and one to two small strands of cotton in a cup of hot water. Observe the behavior of the cotton strands. Compare how the cotton interacts with the water in the two different temperatures. Draw a model to explain why there may be differences in these interactions.
4. How might evidence from your answer in question #3 be used to improve the process of making paper?

High School:
1. Place one small strand of cotton in a cup of cold water, and one small strand of cotton in a cup of hot water. Observe the behavior of the two pieces of cotton. Describe the interactions between cotton and water in terms of energy and with respect to these properties of water: adhesion and cohesion.
2. What is the purpose of adding water to the paper-making process? What is the purpose of removing the water?
3. Consider that cotton is made up of polymers that have negative and positive charges. Based on the interactions between water and cotton, what does this imply about water and charges? How might we test your assertion?
4. For the second sheet of paper, you added glue or gelatin to the process. What is the purpose of adding this material? What evidence leads you to this conclusion?

Optional Extension: Test other methods of engineering a sheet of paper, test other materials of use in the process.
<table>
<thead>
<tr>
<th>Photo References:</th>
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<tbody>
<tr>
<td>Taped borders, including wall</td>
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<tr>
<td>Thin piece of cotton</td>
</tr>
<tr>
<td>Place on wet surface of bag</td>
</tr>
<tr>
<td>Sheet of cotton paper</td>
</tr>
</tbody>
</table>