



# Tensile Strength and Caliper Measurements

**Grade Level:** Science Grades 2, 4, 5

**Time:** 45 min

**Objectives:** Students will be able complete the tensile strength and caliper measurements tests in order to determine the thickness and strength of different types of paper so they can learn about the materiality of different types of paper.

**I Can Statements:** I can: (1) measure the caliper of different papers; (2) use balanced force, by pulling on both sides of the different papers to create a physical change in the paper, (3) measure the tensile strength of different papers; (4) use accurate vocabulary; (5) use tools safely and appropriately.

**Georgia Standards of Excellence:**

*Science*

S2P1.a

S4P3.a

S5P1.a

**Vocabulary:**

*caliper* — the thickness of a single sheet of paper

*micrometer* — a tool used to measure very small distances, such as the thickness of a sheet of paper. A screw amplifies the distance into a scale large enough to read.

*tensile Strength* — measurement of the force required to pull something to the point where it breaks

**Materials:**

Caliper Measurements - stacks of paper of each of the following three papers: facial tissue, newsprint, typing paper, as well as a ruler, sheet of paper to record and calculate information on.

Tensile Strength - sets of samples each of the following five papers facial tissue, napkin, notebook paper, paper towel, brown grocery sack (cut a 20cm by 25cm sheet from the sack)

**Preparations:** Prepare sets of paper samples in stacks that are pre-counted into an easily divided amount (like a multiple of 5) for the caliper measurements. Prepare sets of one of each of the five paper samples for groups for the tensile strength test.

**Essential Questions:** (1) How does the purpose of a paper item determine the need for its tensile strength? (2) How can balanced force on both sides of the paper during the tensile strength test create a physical change? (3) What kinds of paper have a high caliper, and which have a low; why?

## **Introduction:**

### *Caliper Measurements*

Caliper is the thickness of a single sheet of paper. Paper that is used in printing and writing should have uniform caliper. The caliper of each page of a book should be the same.

The caliper of each sheet in a package of writing paper should be the same as all the other sheets in the package.

In a paper mill laboratory, an instrument called a *micrometer* is used to measure caliper. It provides a more accurate measurement than a ruler. A micrometer and a ruler can be used to measure samples of different kinds of paper.

Instructors will demonstrate measuring a stack of paper and dividing the thickness by the number of sheets of paper to determine the caliper.

### *Tensile strength*

Papermakers use precise methods to test the strength of paper. They measure the *tensile strength* of paper by determining how much stress the paper can withstand before tearing apart. The intended use of a paper indicates the tensile strength it must have. For example, wrapping paper must have higher tensile strength than paper towels.

Instructors will demonstrate by tugging on one paper sample and recording observations and results regarding sound and strength. Instructor will also demonstrate how to rate strength of paper sample.

## **Procedures:**

### *Caliper Measurements:*

1. Students will measure the thickness of a stack of the paper with a ruler. Students will calculate the caliper by dividing the thickness of the stack by the number of sheets in the stack. For example. If there are 100 pieces of paper and the stack is .75 inches, divide .75 by 100, which means each sheet of paper is .0075 inches thick.
2. Students will place the first stack of paper on a flat, level surface.
3. Use the ruler to measure the thickness (height) of the paper stack. Student's eyes should be level with the top of the stack when they read the numbers on the ruler.
4. Students will record their measurements in the appropriate box on the data sheet.

5. Then, students will count the number of sheets in the stack and put total in the appropriate box on the data sheet.
6. Students will take similar measurements and record the data for the other paper samples.
7. Calculate the caliper for each kind of paper. To do this, divide the measurement of the stack thickness by the number of sheets you counted. Record results.
8. According to their calculations, students will determine which paper had the largest caliper and which the smallest.
9. Students will then compare results with other groups. Are their caliper values similar to the results from other groups?

### *Tensile Strength*

1. Students will hold the long side of one of the paper samples between their hands and gently tug on it, moving hands back and forth. Gradually students will pull harder and harder.
2. Repeat holding the sample by its short side.
3. Record observations and results.
4. Repeat the process for the other paper samples, recording data in the data sheet.

### **Wrap Up (can be used in discussion or written format)**

1. Which samples could be pulled apart?
2. For each sample tell which direction, length or width, pulled apart more easily.
3. Describe the sound each sample made. Do noise and the strength of the paper relate to each other?
4. Rank your samples from high to low according to tensile strength. When might low tensile strength be an important quality for a type of paper? When is high tensile strength important?
5. How can balanced force on both sides of the paper during the tensile strength test create a physical change?



## Tensile Strength and Caliper Measurements

### Caliper Test (stack thickness ÷ number of sheets = caliper)

Paper Type	Stack Thickness	Number of Sheets	Caliper
Tissue			
Newspaper			
Printer Paper			

### Strength Test

Paper Type	Can it be torn?	Does it tear more easily in one direction than another?	Describe the sound of tearing.	Other observations:
Tissue				
Napkin				
Paper Towel				
Paper Bag				