

## Activity #3 (Part 1 of 3)

### Paper Structures

Can you support the weight of a book on top of a flimsy piece of paper? You can if you reshape that piece of paper by folding, rolling or bending it. Humans have always taken simple materials and reshaped or combined them to form tools, artwork, machines and other objects to fulfill a need. Engineers know that a material's strength varies with its shape and structure. Some shapes and structures can support more weight than others. In this activity you will work in a team and build a portable structure out of paper and tape that will support the weight of a book. You will learn that you can create new objects from everyday ordinary materials. Have fun!

#### Objectives:

After completing this activity, students will understand:

- Simple materials can be reshaped or combined to form tools or machines to fulfill a need.
- A material's strength varies with its shape and structure.
- Some shapes and structures can support more weight than others.

**Session Time:** 45 minutes (not including extensions)

#### Materials:

Each team will need the following:

- 30 sheets of 8 ½" X 11" Notebook or colored paper
- Roll of masking tape
- Books or weights

**Methods:** guided discussion, cooperative learning, interactive participation, spatial reasoning, geometric modeling

#### Procedure:

1. Divide students into teams of 4-5 people.
2. Review the "*Background Information For Paper Structures*".
3. Your challenge is to build a structure at least 1' (one foot) high which can support a book. You can build your structure anyway you like, but your structure must be portable! (This means you may not fasten or connect it to a table or other fixed structure.)
4. Build your structure. Use your imagination!
5. Test your structure. Place the book or weight on your structure. Can your structure support the book or weight?
6. Have teams try successively heavier books on their structures. How much weight can your structure hold?

**Math Extension:** If a sheet of paper costs \$1000 and an inch of tape costs \$100 (or a centimeter of tape costs \$40), how much does your team's structure cost? Which structure holds the most weight for the least amount of money?

### Activity #3 (Part 2 of 3)

## BACKGROUND INFORMATION FOR PAPER STRUCTURES



There are two general types of motion caused by forces acting on an object. The first, called "translational motion", is the kind of straight motion which is an example of the system falling downward under its weight if it were not balanced by upward forces. The second kind of motion that could result from these same forces is called "rotational motion."

Scientists and engineers often summarize the forces in a problem using the "center" of the force. The force is treated as if it acted through a single point.

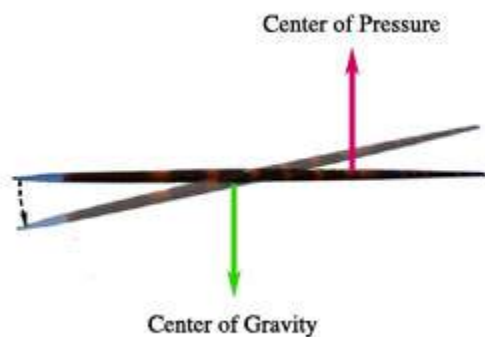
Pressure is a measure of force over an area ( $\text{Pressure} = \text{Force}/\text{Area}$ ), while the center of gravity refers to the force created by the weight of an object.

What exactly does "center of pressure" and "center of gravity" mean? To understand this concept, let's examine another device - the javelin.

Modern javelins land "point-down". Earlier javelins either traveled with the point up (which was dangerous) or horizontally. When the javelin landed horizontally in competitions it was difficult to determine the exact landing point. In 1984 the International Amateur Athletic Federation (IAAF) adopted new rules to make sure future javelins were designed to land point-down, so the "touch-down" point would be known exactly.

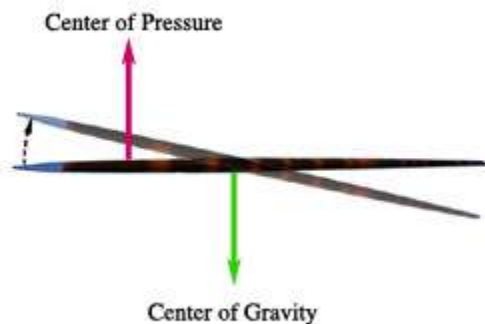
Every javelin designed for competition has the same "center of gravity" or balance point. However, the center of pressure on a javelin remains behind the center of gravity and the direction of the center of pressure is opposite that of the gravitational force. This keeps the javelin's point slanted toward the ground.

### Activity #3 (Part 3 of 3)



Center of Pressure Behind the Center of Gravity  
Javelin Tip Points Down

What would happen if the center of pressure was in front of the center of gravity on a javelin? The nose of the javelin would point up.



Center of Pressure In Front of the Center of Gravity  
Javelin Tip Points Up

The paper structures you create work in the same manner. The structures collapse when the forces acting on the structure are out of balance.