611-1130 (35-145) Breaking Board Demonstration

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

Our **Breaking Board Apparatus** consists of a set of 10 wooden boards and a sheet of Newsprint. Any sheet of a normal sized newspaper will work the same. One board is laid out on a table, overhanging the edge. It is covered by a single sheet of paper. When the slab is struck, it breaks, rather than rotating away. Because of the large surface area, the inertia of air is equivalent to over 6000kg holding the board down.

How to Teach with the Breaking Board Demonstration:

Concepts Taught: Inertia, Weight of Air

Curriculum Fit: Physics Sequence; Force and Motion. **Grades 6-8 and up.**

How to use the Breaking Board Demonstration

1) **Make sure the demonstrator and bystanders are wearing Ansi Z87.1 or better impact safety goggles.**
2) **Set up the demonstration by laying a board on a table with 2/3 on the table and 1/3 off the table.**
3) **Crumple up a sheet of paper and place on the end of the board that is on the table.**
4) **Using a quick motion, swat the board on the side that is off the table. The paper will fly up into the air.**
5) **Now, set the board as before, but this time setting the sheet of Newsprint or Newspaper on top of the board which is resting on the table.**
6) **Using a quick motion, swat the board on the side that is protruding from the table.**

What Happened? The board broke in two.

Why did this happen? Newton's Second Law shows that Force= Mass times Acceleration

Force (F) is **mass (*m*)** times **acceleration (a)** $F = m \cdot a$. **Momentum (p)** is **mass** times **velocity (v)**: $p = m \cdot v$. Since acceleration measures change in velocity over time (t) (put another way, acceleration is the derivative of velocity with respect to time), force is the derivative of momentum with respect to time. Equivalently, force times time equals change in momentum, or **impulse** (Δp): $\Delta p = F \cdot t$. This is significant because momentum is a conserved quantity. It can be neither created nor destroyed, but is passed from one object (the hand) to another (the board). The reason for this conservation is Newton's third law of motion, which states that if an object exerts a force on another object for a given time, the second object exerts a force equal in magnitude but opposite in direction (force being a vector quantity) on the first object for the same amount of time so the second object gains exactly the amount of momentum the first object loses. Momentum is thus transferred. With Δp a fixed quantity, F and t are necessarily inversely proportional. One can deliver a given amount of momentum by transferring a large force for a short time or by transferring small amounts of force continuously for a longer time.

In order to break a board (or any kind of material), you must cause a shearing moment in the board that is larger than the critical moment for wood. When you try to break the board, the board itself is supported on one side by atmospheric pressure pushing down on the board. The Force on the other side of the board comes from the impulse you have created. The edge of the table becomes the pivot point (or fulcrum). When the force meets the board, the top of the board will be in a state of tension and the bottom will be in compression. This will produce a torque on an axis through the middle of the board. If the torque is great enough the board will break.

Experiment Suggestions:

1) **Try different objects with varying weights and dimensions. See which ones allow the board to break.**
2) **Try two boards on top of one another. Do they still break with the same effort?**
3) **Does a person's overall body mass effect this demonstation?**

Benchmarks and Standards

This investigation provides support for the *Benchmarks for Science Literacy* and *National Science Education Standards* shown in the table below.

Benchmarks for Science Literacy				*National Science Education Standard*
			Grades 5 – 8 **Physical Science Content Standard B.1** – Motions and Forces	"The motion of an object can be described by its position, direction of motion and speed. The motion can be measured and represented on a graph." (p. 154)
Grades 3 – 5 **The Physical Setting**	**4B.1**	"Changes in speed or direction of motion are caused by forces. The greater the force is the greater the change in motion will be."	Grades 5 – 8 **Physical Science Content Standard B.2** – Motions and Forces	"An object that is not being subjected to a force will continue to move at a constant speed and in a straight line." (p. 154)
Grades 6 – 8 **The Physical Setting**	**4B.3**	"An unbalanced force acting on an object changes its speed or direction of motion, or both.	Grades 5 -8 **Physical Science Content Standard B.3** – Motions and Forces	"If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in speed or direction of an object's motion." (p. 154)
Grades 9 – 12 **The Physical Setting**	**4B.1**	"The change in motion of an object is proportional to the applied force and inversely proportional to the mass."	Grades 9-12 **Physical Science Content Standard B.1** – Motions and Forces	"Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts a force on another, a force equal in magnitude and opposite in direction is exerted on the first object." (p. 180)