DOCUMENT RESUME

ED 480 799 SE 068 040

AUTHOR	Rushton, Erik; Ryan, Emily; Swift, Charles
TITLE	The Squeeze is On. Grades 6-8.
INSTITUTION	Tufts Univ., Medford, MA.
PUB DATE	2001-00-00
NOTE	12p.; Produced by the Office for Technology and Industry Collaboration. For other activities in series, see SE 068 011-041.
AVAILABLE FROM	Web site: www.prek-12engineering.org/activities/ .
PUB TYPE	Guides - Classroom - Teacher (052)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Critical Thinking; *Design; Engineering; *Experiential Learning; Hands on Science; Middle Schools; Science Activities; Science Education; Science Instruction; Science Process Skills; *Scientific Concepts

ABSTRACT

When asked to list some strong materials, people think of steel, concrete, and wood. In this activity, students learn about the force of compression and how it acts on structural components through a hands-on group problem. Using everyday products such as paper, toothpicks, and tape, students construct a structure that will support the weight of a cylinder block for 30 seconds. This activity requires a 75-minute time period over three days for completion. (Author/SOE)

Activity: **The Squeeze is On**

GRADE LEVELS: 6-8

SUMMARY:

If you were asked to list some strong materials you might think of steal, concrete, and wood. Would you believe that a piece of paper used correctly would support the full weight of a cinder block? Students will learn about the force of compression and how it acts on structural components through a hands-on group problem. Using everyday products such as paper, toothpicks, and tape they will construct a structure that will support the weight of a cinder block for 30 sec.

LEVEL OF DIFFICULTY [1 = Least Difficult: 5 = Most Difficult]

3- average

TIME REQUIRED

2 class periods (50 min each) 1/2 - 1 for discussion & background information. 1-1 1/2 for construction & testing of structures

COST

cinder blocks: $2-$3 each

student materials: $2 per class

STANDARDS:

Mass. Science & Technology / Engineering Grades 6-8 / Construction Technologies & Engineering Design

5.3 Explain how the forces of tension, compression, torsion, bending and shear affect the performance of bridges.

2.2 Demonstrate methods of representing solutions to a design problem, e.g., sketches, orthographic projections, multiview drawings.

2.4 Identify appropriate materials, tools, and machines needed to construct a prototype of a given engineering design.

2.5 Explain how such design features as size, shape, weight, function and cost limitations (i.e., ergonomics) would affect the construction of a given prototype.

WHAT WILL THE STUDENTS LEARN?

The students will gain insight into structural supports to withstand compression. They will develop construction skills. They will learn about the fundamental loads.

BACKGROUND INFORMATION:

See Fairly Fundamental Facts about Forces.

MATERIALS:

Cinder blocks, can substitute text books

Per Group:

Piece of wood (smooth flat object to put the cinder blocks on)

(4) 3"x 5" index cards

(1) 8 1/2" x 11" copy paper

(1) 8 1/2" x 11" plastic transparency

12" masking tape

(15) Tooth picks (optional)

(2) Drinking straws (optional)

1 ruler

1 pair of scissors

3-4 pairs of safety glasses

PREPARATION:

Do the "Introduction to Loads on Structures" activity, to help increase what the students will be able to understand from doing the activity. Gather materials-setup a safe test area.

DIRECTIONS:

Problem Statement:

Using the material provided, teams of 3-4 will design and build a structure or structures to hold a concrete cinder block at a height of 3" above the floor for 30 seconds. More cinder blocks will then be added until their structure fails.

Students will have 10 minutes to brainstorm, during which time the students need to sketch their design ideas. When the time is up they will receive the materials. The maximum amount of time allowed to build the structure will be 15 minutes.

Testing will take place in the test area where all students are required to wear safety glasses. Each team will place their structure (s) on the floor and position the board onto their structure. Once in place two team members will slowly and carefully lower the block onto the board. Advise the students that they should be mindful of placing the cinderblock as flat as possible on the board to limit any twisting forces on their structure. Have the students, not placing the block; carefully watch their structure to see where and how it fails. After 30 seconds the solution will be deemed successful and more weight can be added until failure is achieved.

!!Warning!! Watch out for your fingers and feet during testing!

INVESTIGATING QUESTIONS:

What is compression and what effect does it have on structures (structural elements)?

Give examples of compression, and find real life examples of structural elements that are in compression.

How did your structure fail?

Did it twist or slide to one side as it collapsed? If so what do you think caused your structure to fail this way?

SAMPLE RUBRIC:

Rubric for Performance Assessment

Activity Title: The Squeeze is On

Grade Level: 6-8

Criteria	1 Beginning	2 Developing	3 Proficient	4 Advanced	Weight (X factor)	Subtotal
Design Sketch	Not complete, difficult to interpret.	Complete, clear, and easy to interpret.	Shows understanding of concepts complete, clear, and easy to interpret.	Shows understanding of concepts, complete, clear, easy to interpret, and shows creative thought.	1	
Structure Construction	Not 3" from the floor anywhere, rushed, sloppy, wasted time allotted.	3 or less sides not 3" from the floor, wasted time allotted.	3" from the floor everywhere, neatly constructed, utilized time allotted.	3" from the floor everywhere, reflects a lot of effort & care put into constructed, utilized time allotted.		
Structure Performance	Did not hold the weight of the board.	Holds weight of the board, but fails under weight of the cinderblock.	Holds board & cinderblock for 30 sec.	Holds more than the board & cinderblock.		

Teacher Comments:

5

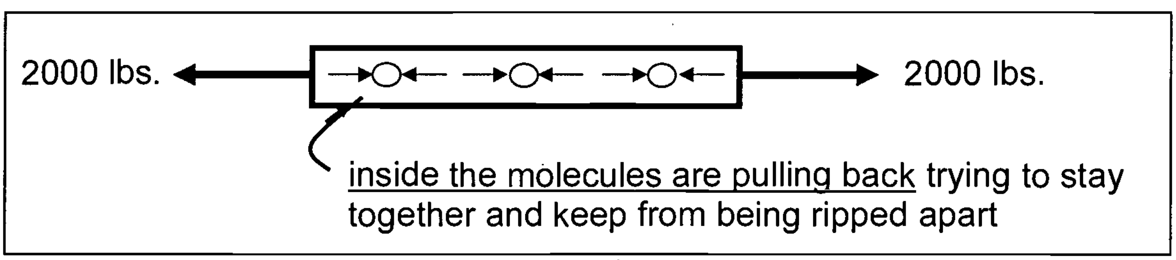
FAIRLY FUNDAMENTAL FACTS
ABOUT FORCES & STRUCTURES

by Douglas Prime
Tufts University
Center for Engineering Educational Outreach

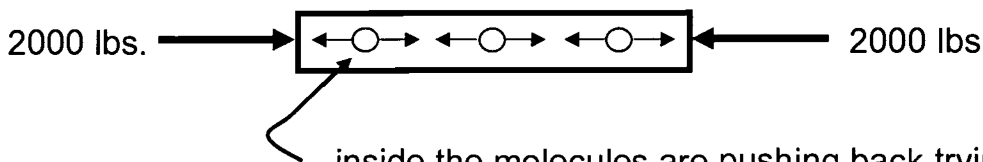
Everyone knows from experience that a **force** is a pushing or a pulling action which moves, or tries to move, an object. Engineers design **structures**, such as buildings, dams, planes and bicycle frames, to hold up weight and withstand forces that are placed on them. An engineer's job is to first determine the **loads** or external forces that are acting on a structure. Whenever external forces are applied to a structure, **internal stresses** (internal forces) develop inside the materials that resist the outside forces and fight to hold the structure together. Once an engineer knows what loads will be acting on a structure, they have to calculate the resulting internal stresses, and design each **structural member** (piece of the structure) so it is strong enough to carry the loads without breaking (or even coming close to breaking).

The 5 types of loads that can act on a structure are tension, compression, shear, bending and torsion

1) **tension**: two pulling forces, directly opposing each other, that stretch out an object and try to pull it apart (ex. pulling on a rope, a car towing another car with a chain – the rope and the chain are in tension or are "being subjected to a tensile load")



2) **compression**: two pushing forces, directly opposing each other, which squeeze an object and try to squash it (ex. standing on a soda can, squeezing a piece of wood in a vise – both the can and the wood are in compression or are "being subjected to a compressive load")

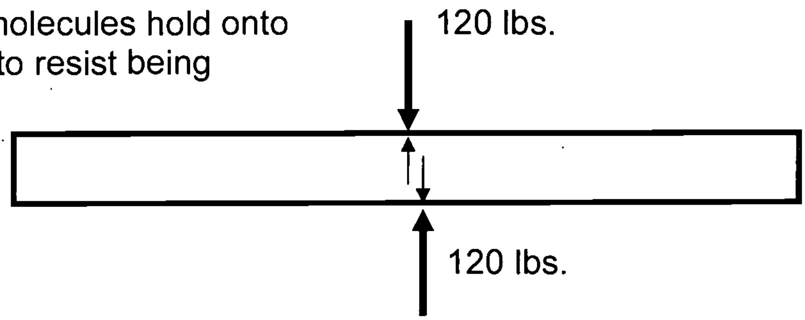


inside the molecules are pushing back trying to stay apart and not get crushed

3) **shear:** two pushing or pulling forces, acting close together but not directly opposing each other – a shearing load cuts or rips an object by **sliding its molecules apart sideways**

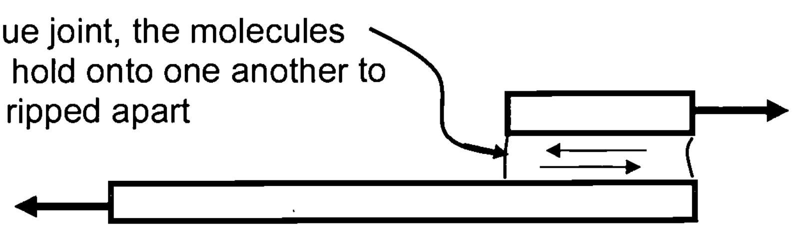
ex. pruning shears cutting through a branch
paper cutter cutting paper
(the branch and the paper are "subjected to a shear loading")

inside the molecules hold onto each other to resist being slid apart



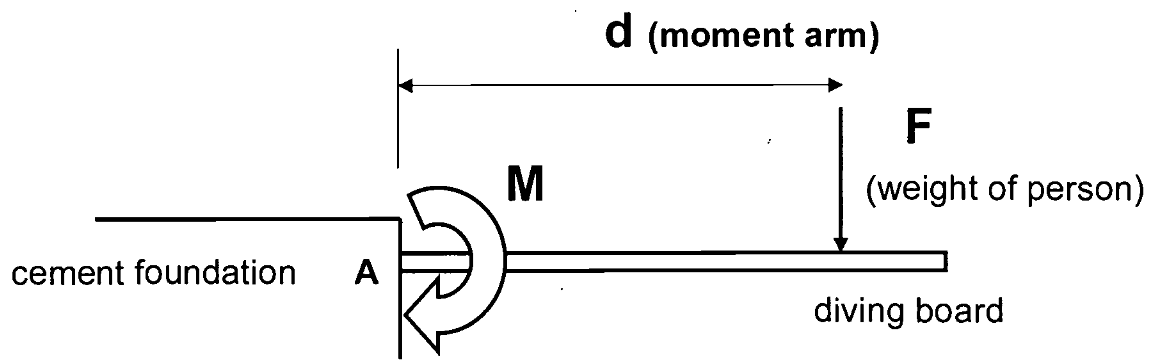
ex. pulling on two pieces of wood that have been glued together (the glue joint is "being subjected to a shear loading")

inside the glue joint, the molecules are trying to hold onto one another to resist being ripped apart



A Moment of A Force

Before you can understand the last two types of loads, you need to understand the idea of **a moment of a force**. A moment is a "turning force" caused by a force acting on an object at some distance from a fixed point. Consider the diving board shown below. The heavier the person, and the farther he walks out on the board, the greater the "turning force" which acts on the cement foundation.



the force (F) produces a moment or "turning force" (M) that tries to rotate the diving board around a fixed point (A) – in this case the moment bends the diving board

The stronger the force, and the greater the distance at which it acts, the larger the moment or "turning force" which it produces.

A moment or "turning force" (M) is calculated by multiplying a force (F) by its moment arm (d) – the moment arm is the distance at which the force is applied, taken from the fixed point:

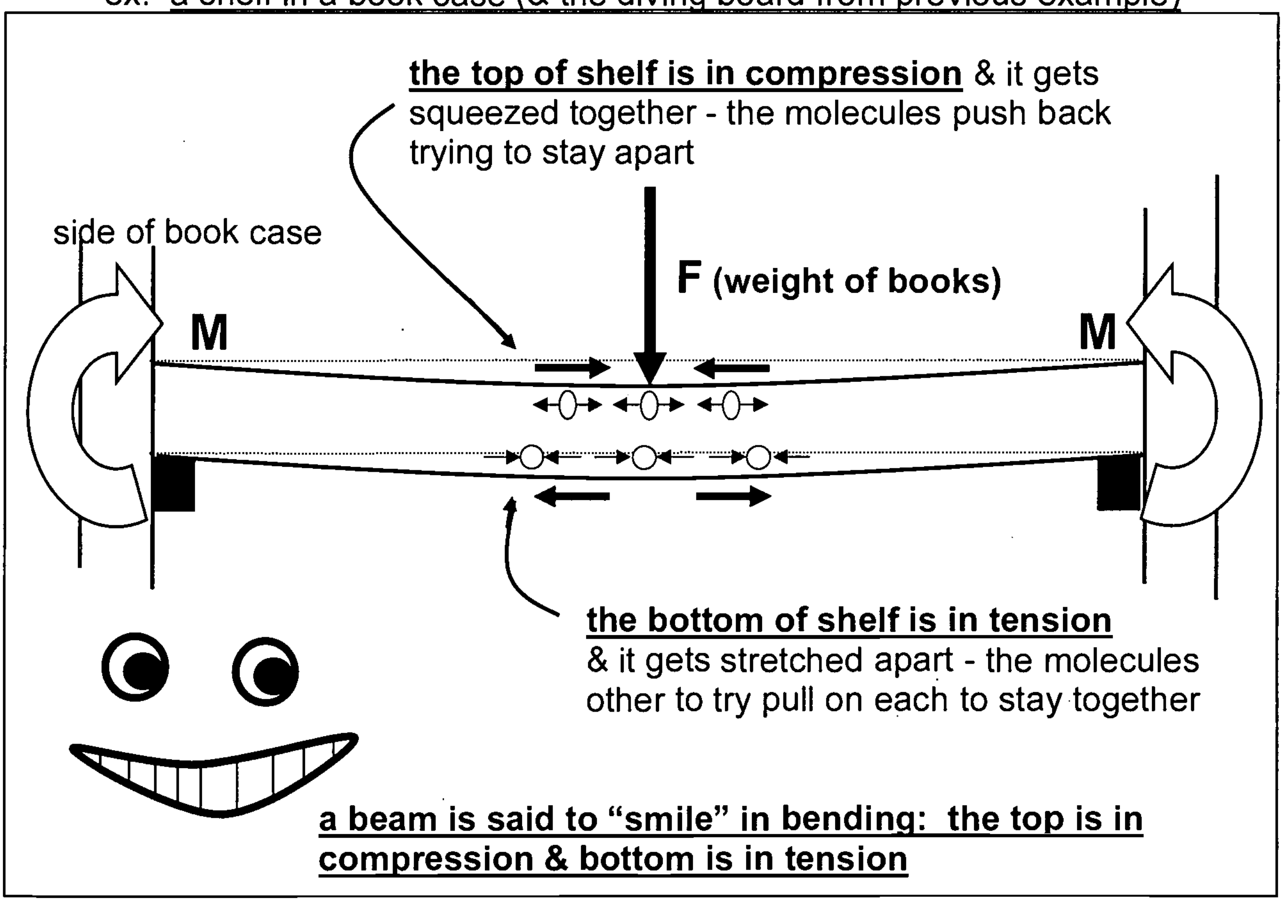
$$\boxed{M = F \bullet d}$$

(as long as the force acting on the object is perpendicular to the object)

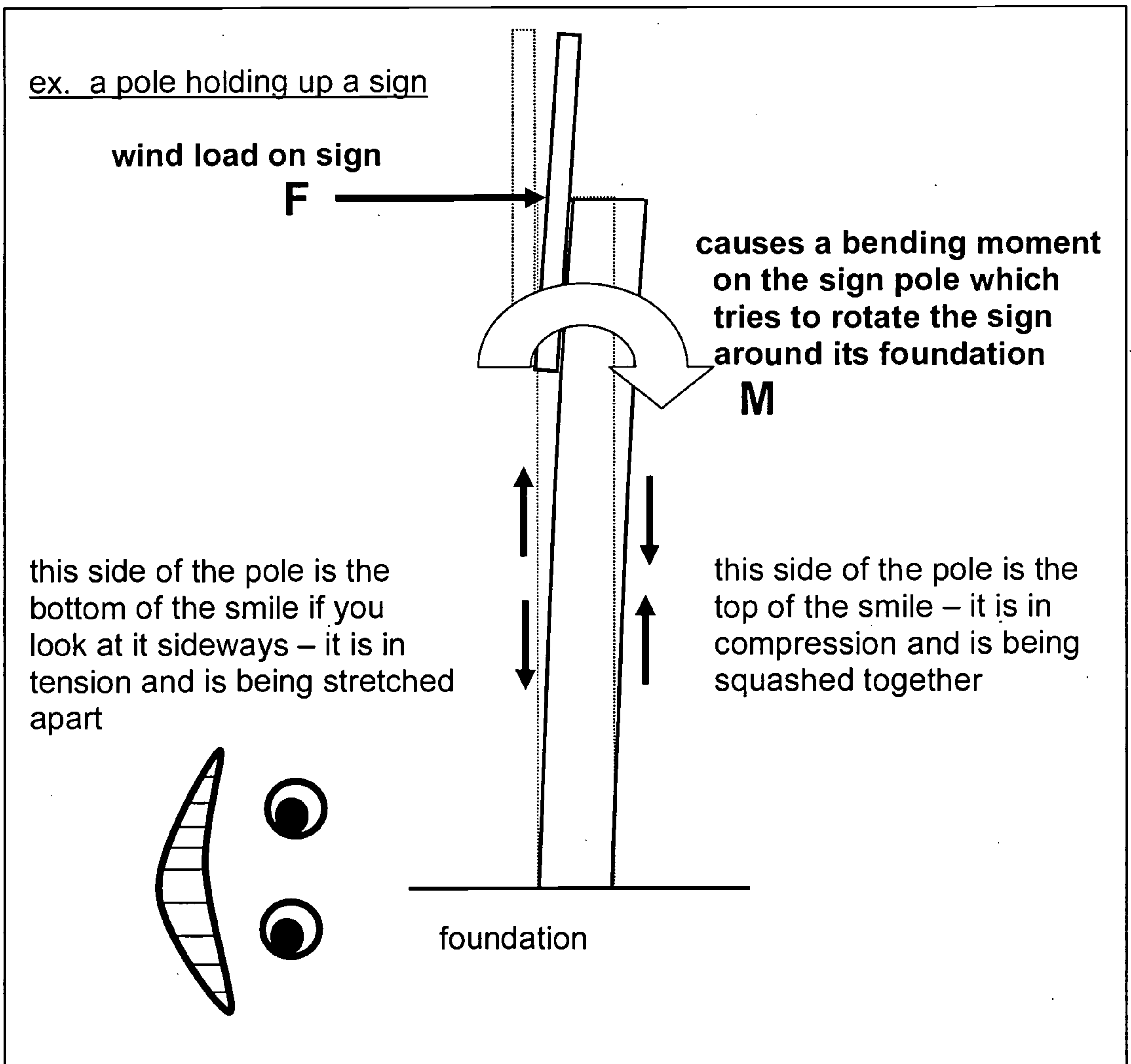
If you have a force measured in Newton multiplied by a distance in meters, then your units for the moment are N-m, read "Newton-meters". If your force is measured in pounds and you multiply it by a distance given in inches, then your units will be lb-in., read "pound-inches". The units for moments can be any force unit multiplied by any distance unit.

4) **bending:** created when a moment or "turning force" is applied to a structural member (or piece of material) making it **deflect or sag (bend), moving it sideways away from its original position** - a moment which causes bending is called a **bending moment – bending actually produces tension and compression** inside a beam or a pole, causing it to "smile" – the molecules on the top of the smile get squeezed together, while the molecules on the bottom of the smile get stretched out – **a beam or pole in bending will fail in tension** (break on the side that is being pulled apart)

    ex. a shelf in a book case (& the diving board from previous example)

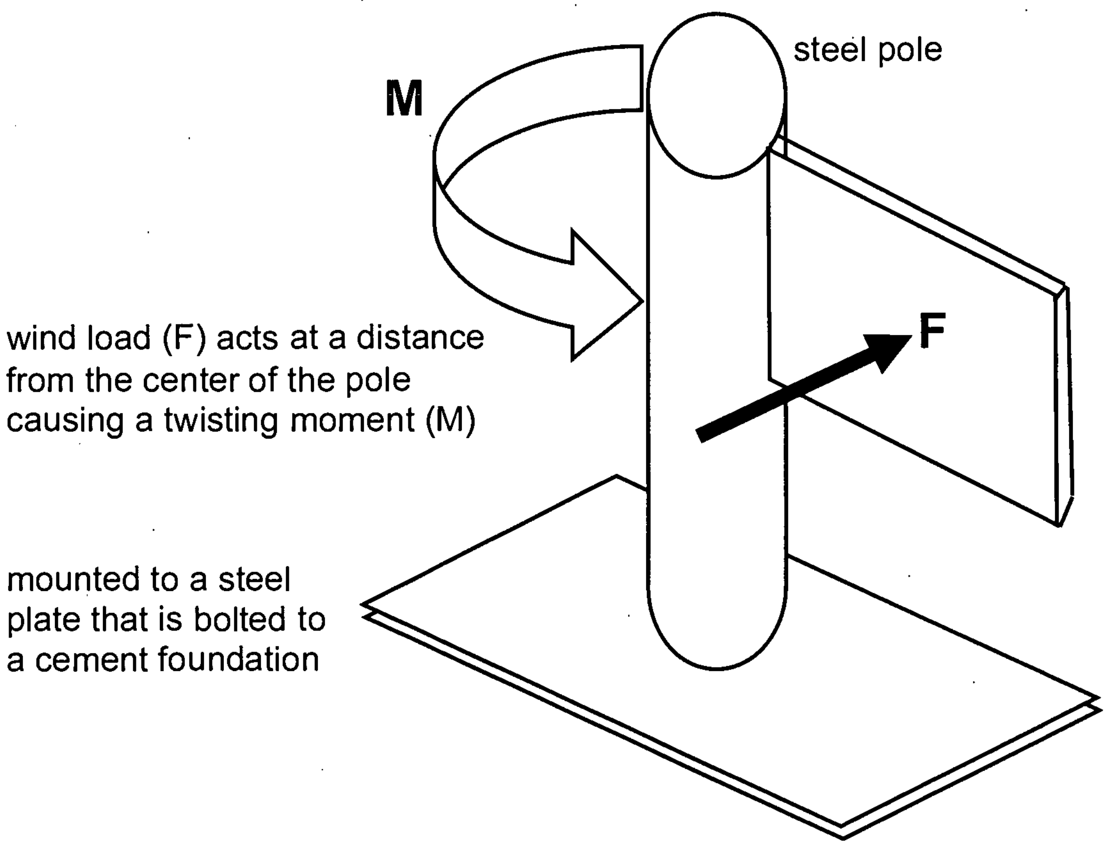


<u>Glue stick experiment to show tension and compression created by bending.</u> Take a glue stick used in a glue gun and use a ruler to mark four straight 4" lines which run down the length of the stick – the lines should be spaced 90 degrees apart: one on the top, one on the bottom, and one on each side of the glue stick. Hold the glue stick between a finger and your thumb, and apply a force to the middle. Notice how the lengths and shapes of the lines change. <u>What happens to the line on the top of the glue stick (side where your finger pushes)? What happens to the line on the bottom? What happens to the lines on the two sides of the glue stick?</u>



5) **torsion (twisting):** created when a moment or "turning force" is applied to a structural member (or piece of material) **making it deflect at an angle (twist)** - a moment which causes twisting is called a **twisting or torsional moment – torsion actually produces shear stresses inside the material - a beam in torsion will fail in shear** (the twisting action causes the molecules to be slid apart sideways)

ex. a pole with a sign hanging off one side



Glue stick experiment to show torsion. Again take a glue stick used in a glue gun and use a ruler to mark a series of straight lines along its length, similar to the experiment above. Hold one end of the glue stick, and get a partner to twist the other end as hard as possible. What happens to the lines on the glue stick? Imagine that each vertical line represents a line of glue molecules – **notice how they have been slid sideways out of position by the twisting moment – this is the sign of shear forces acting inside the material.**

PreK-12
ENGINEERING

Activity Evaluation Form

www.k12engineering.org

Activity Name:

Grade Level the Activity was implemented at:

Was this Activity effective at this grade level (if so, why, and if not, why not)?

What were the Activity's strong points?

What were its weak points?

Was the suggested Time Required sufficient (if not, which aspects of the Activity took shorter or longer than expected)?

Was the supposed Cost accurate (if not, what were some factors that contributed to either lower or higher costs)?

Do you think that the Activity sufficiently represented the listed MA Framework Standards (if not, do you have suggestions that might improve the Activity's relevance)?

Was the suggested Preparation sufficient in raising the students' initial familiarity with the Activity's topic (if not, do you have suggestions of steps that might be added here)?

If there were any attached Rubrics or Worksheets, were they effective (if not, do you have suggestions for their improvement)?

Please return to:

CEEO
105 Anderson Hall
Tufts University
Medford, MA 02155

SE068040

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

Reproduction Release
(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: PreK-12 Engineering Activities

1) Touch and Discover, Grades PreK-2
http://www.prek-12engineering.org/data/d2/Touchdiscover.pdf

2) Invent a Backscratcher from Everyday Materials, Grades PreK-2
http://www.prek-12engineering.org/data/d28/Backscratcher.pdf

3) Compare Human-Made Objects with Natural Objects, Grades PreK-5
http://www.prek-12engineering.org/data/d34/HumanvsNatural.pdf

4) Do Different Colors Absorb Heat Better?, Grades PreK-2
http://www.prek-12engineering.org/data/d37/Absorbheat.pdf

5) Which Roof is Tops?, Grades PreK-2
http://www.prek-12engineering.org/data/d44/RoofTops.pdf

6) Make Your Own Recycled Paper, Grades PreK-2
http://www.prek-12engineering.org/data/d56/Recycle.pdf

7) Build an Approximate Scale Model of an Object Using LEGOs, Grades 3-5
http://www.prek-12engineering.org/data/d3/LegoScaleModel.pdf

8) Design Weather Instruments using Lego Sensors, Grades 3-5
http://www.prek-12engineering.org/data/d4/LegoWeather.pdf

9) Space Shelter, Grades 3-5
http://www.prek-12engineering.org/data/d5/SpaceShelter.pdf

10) Build a Bird House, Grades 3-5
http://www.prek-12engineering.org/data/d6/BirdHouse.pdf

11) Ball Bounce Experiment, Grades 3-5
http://www.prek-12engineering.org/data/d6/BallBounce.pdf

12) Make an Alarm!, Grades 3-5
http://www.prek-12engineering.org/data/d11/MakeAlarm.pdf

13) Design Packing to Safely Mail Raw Spaghetti, Grades 3-5
http://www.prek-12engineering.org/data/d17/MailSpaghetti.pdf

14) Disassemble a Click Pen, Grades 3-5
http://www.prek-12engineering.org/data/d33/clickPen.pdf

15) Construct And Test Roofs for Different Climates, Grades 3-5
http://www.prek-12engineering.org/data/d35/ClimateRoof.pdf

16) Compare Fabric Materials, Grades 3-5
http://www.prek-12engineering.org/data/d36/Fabric.pdf

17) A House is a House for Me, Grades 3-5
http://www.prek-12engineering.org/data/d52/House.pdf

18) Water Filtration, Grades 3-5
http://www.prek-12engineering.org/data/d53/Water Filtration.pdf

19) What is the Best Insulator: Air, Styrofoam, Foil, or Cotton?, Grades 3-5
http://www.prek-12engineering.org/data/d54/BestInsulator.pdf

20) Design a Recycling Game!, Grades 3-5
http://www.prek-12engineering.org/data/d55/Recycling.pdf

21) Tower Investigation and the Egg, Grades 6-8
http://www.prek-12engineering.org/data/d7/TowerEgg.pdf

22) Wimpy Radar Antenna!, Grades 6-8
http://www.prek-12engineering.org/data/d10/WimpyAntenna.pdf

23) Portable Sundial, Grades 6-8
http://www.prek-12engineering.org/data/d30/PortableSundial.pdf

24) An Introduction To Loads Acting on Structures, Grades 6-8
http://www.prek-12engineering.org/data/d31/IntroLoads.pdf

25) Design Your Own Rube Goldberg Machine, Grades 6-8
http://www.prek-12engineering.org/data/d32/RubeGoldberg.pdf

26) Building Tetrahedral Kites, Grades 6-8
http://www.prek-12engineering.org/data/d38/tetrakites.pdf

27) Do as the Romans: Construct an Aqueduct!, Grades 6-8
http://www.prek-12engineering.org/data/d39/Aqueduct.pdf

28) Build an Earthquake City!!, Grades 6-8
http://www.prek-12engineering.org/data/d40/EarthquakeCity.pdf

29) Design a Parachute, Grades 6-8
http://www.prek-12engineering.org/data/d41/Parachute.pdf

30) The Squeeze is On, Grades 6-8
http://www.prek-12engineering.org/data/d42/Squeeze.pdf

31) Stop The Stretching, Grades 6-8
http://www.prek-12engineering.org/data/d43/StopStretching.pdf

32) Speaker Project, Grades 9-10
http://www.prek-12engineering.org/data/d13/Speaker.pdf

Author(s): Erik Rushton, Emily Ryan, Charles Swift

Corporate Source: Tufts University

Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, Resources in Education (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.
If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign in the indicated space following.

☒ Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g. electronic) and paper copy.

☐ Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only.

☐ Check here for Level 2B release, permitting reproduction and dissemination in ERIC archival collection microfiche only.

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.
I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche, or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Signature: Margaret E Newell

Printed Name/Position/Title: Margaret Newell, Associate Provost for Research

Organization/Address: Tufts University
136 Harrison Avenue, Suite 75K-401
Boston, MA 02111

Telephone: 617-636-6550
Fax: 617-636-2917
E-mail Address: peter.wong@tufts.edu

Date: 8/15/2003

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to:

ERIC Clearinghouse for Science, Mathematics, and Environmental Education
Acquisitions
1929 Kenny Road
Columbus, OH 43210-1080

Telephone: (614) 292-6717
Toll Free: (800) 276-0462
FAX: (614) 292-0263
e-mail: ericse@osu.edu
WWW: http://www.ericse.org

EFF-088 (Rev. 9/97)