Take a Stand!

Grade Level: 5	Total Time Required: 3 – 50 minute sessions or 5 – 50 minute sessions with optional lessons

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Lesson Objectives:

In this lesson, students will be able to:

1. Learn about structural engineering.
2. Identify the various forces acting on a structure as a load is applied (tension, compression, torsion/torque).
3. Learn about engineering design and redesign.
4. Identify the application of adhesives and their purpose in construction.
5. Create a prototype using given constraints to achieve a desired outcome.

Indiana Standards:

3-5.E.1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Next Generation Science Standards

Discipline Core Ideas

3-5.ETS1-1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Science/Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence

Crosscutting Concepts

2. Cause and effect: Mechanism and explanation.

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Concepts and Vocabulary

Term	*Defined by a scientist or engineer*	*Defined by a student*
Adhesive	A substance used for sticking objects or materials together.	Glue, tape
Compression	A force that squeezes a material together.	Pushing force
Load	A mass or weight supported by something.	Weight
Tension	A force that stretches a material apart.	Pulling force
Torsion	An action that twists a material.	?
Torque	The tendency of a force to rotate an object about an axis, fulcrum, or pivot.	?

Equipment, Materials, and Tools

Materials		
Popsicle sticks (20/ team)	Wax paper	Paper towels
Paper clips	Newspaper	Binder clips
Variety of glues	Variety of different balls (e.g., baseball, softball, shot put)	Small post-it notes

Tools		
Rulers	Scissors	

Safety Guidelines:

It is not recommended to use Super Glue or Crazy Glue adhesive, rubber cement, or other hazardous adhesives!

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Synopsis of Engineering Design Activity

Synopsis of the Design Activity:

Problem:	Your 5th grade class has been chosen to design displays for vintage baseballs, softballs, and shot puts for a new display case to celebrate a 100 years in High School Sports. Display stands must be designed to hold these various size balls.
Goal:	Design and test a structure to hold a shot put at least two inches above a surface.
Who is the client:	Your high school administration (i.e., principal, athletic director).
End-User:	School
What is the design:	Design and test a structure to hold a shot put at least two inches above a surface.
Criteria:	• Use 20 or less popsicle sticks • Use only one type of glue chosen from your investigation results. • Hold the balls two inches above the surface of a desk for 20 seconds. • Be an attractive design for the display case.
Constraints:	• Allotted time for construction in the classroom.

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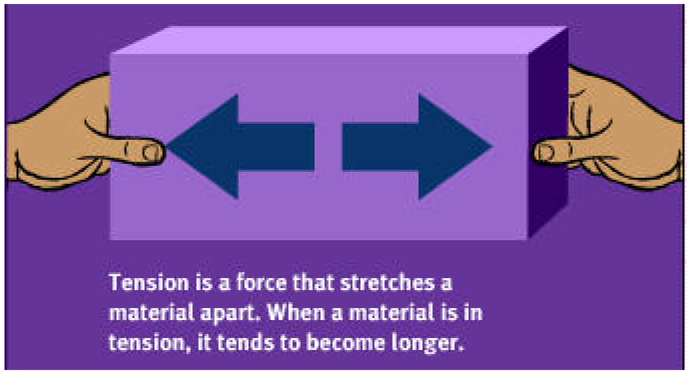
Science Content – Basics

Tension:

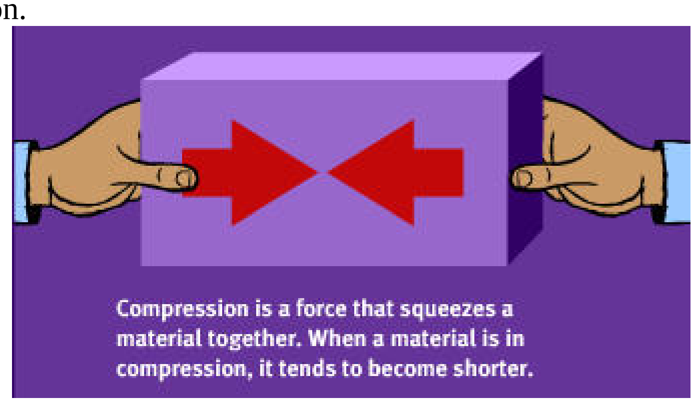
In physics, tension is the magnitude of the *pulling force* exerted on another object. It is the opposite of compression.



http://www.pbs.org/wgbh/buildingbig/lab/forces.html

Compression:

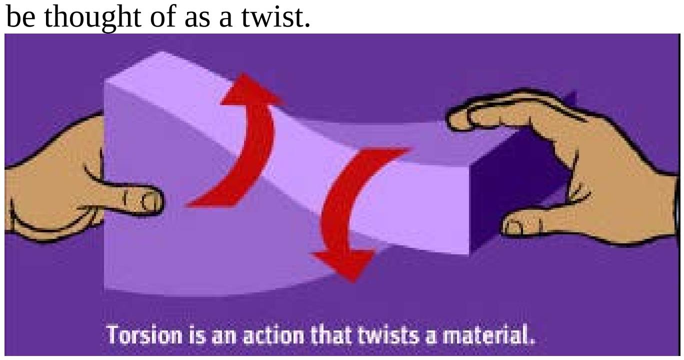
In physics, compression is the magnitude of the *pushing force* exerted on another object. It is the opposite of tension.



http://www.pbs.org/wgbh/buildingbig/lab/forces.html

Torsion:

In physics, torsion is the twisting of an object due to an applied *torque*. Torque is the tendency of a force to rotate an object about an axis, fulcrum, or pivot. Just as a force is a push or a pull, a torque can be thought of as a twist.



http://www.pbs.org/wgbh/buildingbig/lab/forces.html

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The Building Big website by PBS is an excellent resource and includes a forces lab to review the forces acting on a structure: **www.pbs.org/wgbh/buildingbig/lab/forces.html**

Simple Post and Beam

For a simple post and beam design, the horizontal wooden beam is in compression at the top of the beam and tension at the bottom. The vertical beams that support the horizontal beam are both in compression.

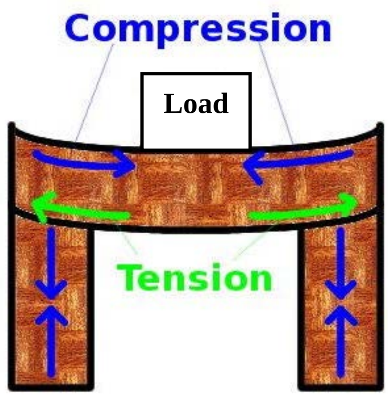
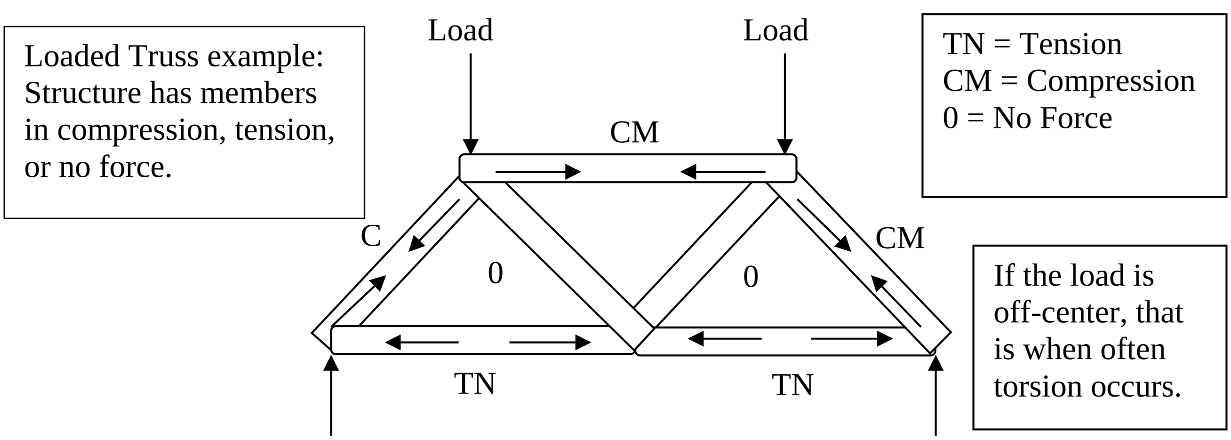


Image retrieved August 2011 from www.explainthatstuff.com.

Truss Design

For a truss design, the forces acting on the structure are more complex. Trusses use triangulation (structures using triangles) so the compression and tension forces occur at different structure members. See image below.



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Lesson Plan #1
Guiding Question – Which glue provides the greatest strength?

Time: two 30-minute sessions

Procedure:

1. Select design teams by breaking the class into teams of 2-3 students, distribute materials to each group.

2. Present design briefs to the design teams. Explain that the challenge is to create a structure to hold various size sports balls including a shot put. The structure must hold the various balls 2” off a display case shelf. The design teams’ first task is to determine what adhesive is best to use for this structure.

3. Design teams will meet and develop a team plan for testing the strength of the chosen adhesive. Students must form a testable question about the adhesive and determine how the materials will be tested. The final plan will need to be recorded in their design journals indicating specific procedures for running the investigation. Testing several different types of glue should be encouraged.

4. Design teams next execute their investigation plans. Time will be needed for the glues to dry completely, 24 hours if time allows.

5. After the glue has completely dried, the design teams can execute their tests on the glue bonds. Each design team should evaluate their results and indicate which glue was most successful. Encourage students to use a Likert scale to summarize their results when testing multiple glues (such as 4 = most effective, 3 = good, 2 = fair. 1 = poor). The results of the investigation should be recorded in the design journals and the overall findings will be presented to the class.

6. For an extra challenge, have student design teams add the task of making their own glue (see Lesson Plan #2), and have the design teams decide whether their glue or factory-made glues work better, and why this might be so.

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Lesson Plan #2 (optional)
How can we make our own adhesive?

Time: 45-50 minute session

Procedure:

1. Instruct students to conduct three trials of their designs. Students record the amount of weight the bag held as well as score their designs on level of attractiveness.

For an optional activity, you may wish to have the design teams create their own glues to use on their structures. Some of these recipes would require the use of a stove or hot plate and would require adequate adult supervision and extra safety precautions.

Glue Recipe 1 (no heat source)

Mix 1/2 cup of flour with 1/4 cup of water.

Glue Recipe 2 (no heat source)

Mix 2 cups flour with one 1 cup of cold water and 1 cup of hot tap water

Glue Recipe 3 (requires heat source)

1. Mix in a saucepan: 1 cup flour, 1 cup sugar, 1 tsp. alum, 4 cups water
2. Cook until clear and thick. Add 30 drops oil of cloves or wintergreen (etc.) and store covered.

Glue Recipe 4 (requires heat source)

1. Mix 3/4 cup water, 3 tablespoons sugar, and 1 teaspoon white vinegar in small saucepan. Bring to a rolling boil.
2. In a separate bowl, mix 1/2 cup cornstarch or corn flour and 3/4 cup water, mix over a very low heat.
3. Add cornstarch mixture slowly to water/sugar/vinegar mixture. Stir continually for two minutes.
4. Take off heat and let cool completely before using as glue

Reference: http://www.tryengineering.com/lessons/stickyengineering.pdf

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Lesson Plan #3
Design Challenge – Designing a structure to hold a shot put

Time: two 45 minute (build time + drying time) and testing sessions

Procedure:

1. Return to their design teams and review their results of glue testing and the results of other teams' testing results. Select the best glue for the task.

2. Review the design briefs with the class, highlighting the constraints of the design challenge. Have each team member design their own solution to the design challenge. After students have had time to create their own designs, have them share their plans with the team. The design teams should discuss and select the best design for implementation. All team members should create a final team design sketch in their design journal.

3. Gather materials and tools needed for construction of the structure. Remind students that they cannot use more than 20 popsicle sticks and only one type of glue. Newspaper or wax paper should be placed on the desks for keeping work surfaces clean. Various size binder clips make excellent clamps for holding pieces together. Gluing may need to take place in stages, allowing some parts of the structure to partially dry- this takes some managing.

4. Any modifications that have been made to their structure during the building phase should be noted in students design notebooks.

5. (Optional) Have the design teams use post-it notes with codes to indicate where they believe the load will apply forces in tension (TN), compression (CM), and torsion (TR) on the structure.

6. Have each design team present their prototypes to the class. Each team must identify where they think the forces will act on the structure and explain their rationale.

7. Begin testing each team's design. Allow one team member from each group to place the various balls on the display stand prototype beginning with the baseball, then a softball, and finally a shot put.

8. Each team will record their observations and final results of the prototype testing. Students should be encouraged to note specifically where structural failure occurred and possible reason for the failure.

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Lesson Plan #4
Design Challenge – *What feedback did you get on your design?*

Time: two 45 minute (build time + drying time) and testing sessions

Procedure:

1. Now that the students have tested their structures, how could they redesign it? Have student design teams look at their design journals and note their observations from the previous lesson. They should be looking at:
    a) What went well?
    b) What parts of the structure failed?
    c) What improvements can be made in a modification?

   These new redesign ideas should be noted and designed in the students' design journals.

2. If time permits, teachers should go back to Step #3 of Lesson Plan #3 and have student design teams build new structures based on their discussions and redesigns in their design journals.

Assessment

The following are possible sources of formative and summative assessment:

- Design notebooks (individual) – Note how students identify and clearly label their drawings; Identify the types of science vocabulary students use in their notebooks (tally the number of times each concept is used); Note how students record data from testing their prototypes and how well they explain their results (patterns in the data).

- Participation (group) – Note level of engagement; questions students asked; how well they worked in a group; how well each team met the goals of the task

- Other (individual) implement the pre and posttest that highlight key science vocabulary terms.

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Lesson Extensions and Resources

Activity Extensions:

Web Resources:

http://www.pbs.org/wgbh/buildingbig/index.html
http://www.pbs.org/wgbh/buildingbig/lab/forces.html
http://tryengineering.org/lesson-plans/popsicle-bridge
http://www.explainthatstuff.com/howbuildingswork.html

Other Resources:

Videos: Building Big: Bridges/Domes/Skyscrapers/Dams/Tunnels
http://www.amazon.com/Building-Big-Bridges-Skyscrapers-Tunnels/dp/B0002XVS92/ref=sr_1_1?s=movies-tv&ie=UTF8&qid=1316702894&sr=1-1

Books: Building Big by David Macaulay (2000) ISBN# 978-0395963319

The Art of Construction: Projects and Principles for Beginning Engineers & Architects by Mario Salvadori (2000) ISBN# 978-1556520808

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Design Activity

Student Resource

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Take a Stand!

Your High School has created a new display case to celebrate a 100 years in High School Sports.

Your 5th grade class has been chosen to design displays for vintage baseballs, softballs, and shot puts. Display stands must be designed to hold these various size balls. The stand must be strong and attractive. The best design will be used in the new display case and include a special plaque with the design team members names.

Can your design team create the winning design?

Your Task:
Design and test a structure to hold a shot put at least two inches above a surface.

Your structure should:

- Use 20 or less popsicle sticks
- Use only one type of glue chosen from your investigation results
- Hold the balls 2”(inches) above the surface of a desk for 20 seconds
- Be an attractive design for the display case
- Note: The tie breaker is the team that holds the shot put for the required time and uses the <u>least</u> amount of popsicle sticks.

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