Name ____ Period _______ Date _______

Structures Handout
Center Of Gravity

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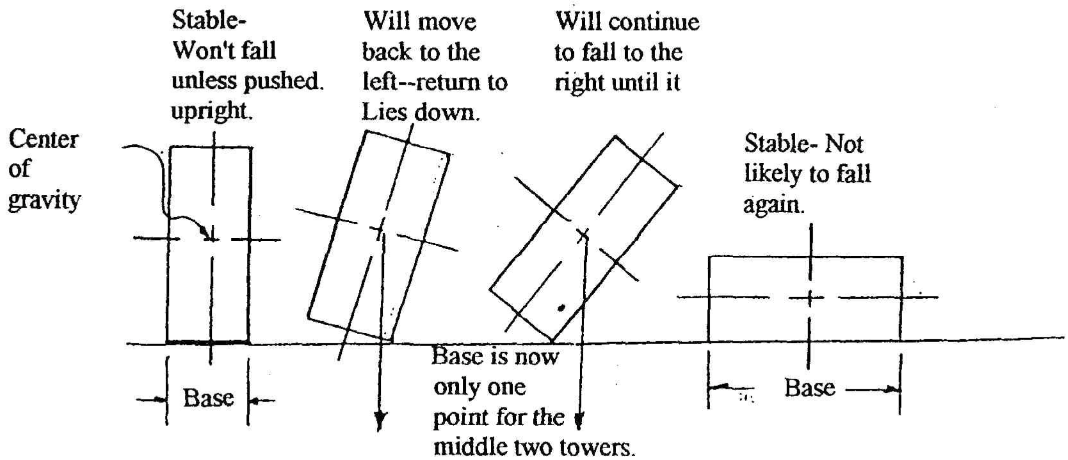

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Structures Handout

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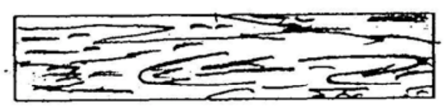
Structures Handout

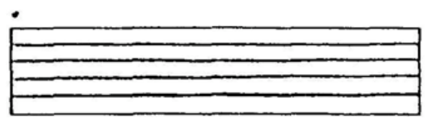
Orthotropic and Isotropic Material

The corrugated cardboard we will use is an orthotropic material. This means it is stronger, both in compression and tension, in one direction than in the other.

Many materials have "grain" or lines running through them, in one direction (orthotropic.) You can see this clearly in wood and in the wavy layer of corrugated cardboard. Most, but not all materials have this characteristic but tend to be more or less strong in opposing directions. Paper and steel have good strength in opposing directions but are definitely stronger in one direction that the other. Glass on the other hand is isotropic. It has no "grain." And is isotropic.



Wood



Corrugated Cardboard

Since material is strongest in compression and tension along its orthotropic lines it will be essential for you to cut your corrugated cardboard with this in mind.

Structures Handout

Strength

Strength in a material is its ability to withstand being deformed by an external force.

A) Tensile strength is the ability of a material to resist being stretched.

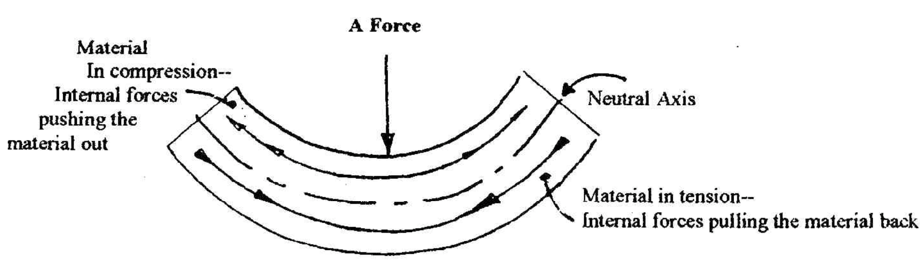
Different materials have different tensile strengths. This results from the molecular structure of each. For any material the **larger the cross-sectional area of a *solid* structural member, the greater its tensile strength will be.**

B) Compressive strength is the ability of a material to resist being made smaller by being pushed together from opposite ends.

Different materials have different compressive strengths. The compressive strength of a given material or structural member will increase as its cross-sectional area increases. Cross-sectional shape can also affect the compressive strength of a member. As the distance measured across a round, hollow column increases, its compressive strength decreases.

C) Strength Against Bending:

We are all familiar with the term bending. We see it, for example, when we overload a bookshelf as shown above. To understand why structural members bend we need to envision an imaginary line, known as the **neutral axis**, running through the length of the members. As a load is applied to the member, it bends. All the material on the inside curve of a bending member is in compression. All the material on the outside of the curve is in tension. An example a beam in bending is illustrated below.



If the material is strong enough in compression to resist being pushed together (compressed) and strong enough in tension to resist being stretched (by a tensile force) it will not bend.

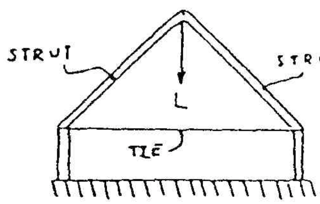
Structures Handout

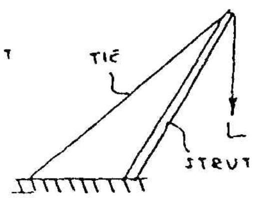
Structural Members:

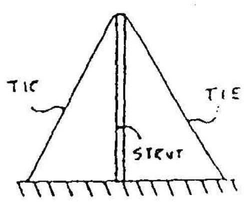
Struts and Ties:

A **strut** is structural member that is being pushed from opposite ends. It is said that a strut "resists compression."

A **tie** is a structural member that is being pulled from opposite ends. It is said that a tie "works in tension."







Columns are vertical, structural members of a structure.

Columns stand perpendicular to the ground. Since they are used to hold up the weight of a structure and to resist the external loads pushing down upon them **columns are always in compression**. A column is a special type of strut.

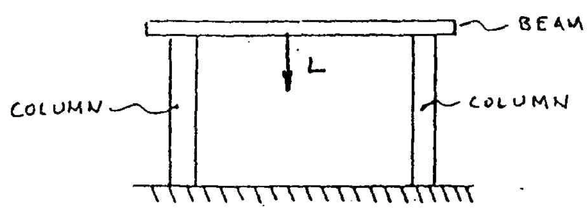
Beams are horizontal structural members that are used to carry a load.

(Horizontal members whose purpose is to keep columns apart are not beams.)

Beams are used to support loads placed between two columns. They transfer the load horizontally, across their length to the columns.

Beams must resist forces pushing perpendicular to them. These forces are also known as **"bending forces**." Thus, "**beams are always in bending**."

With the paper or cardboard structures we will build the columns may also work as ties. This is not generally true in structures made from more common building materials.

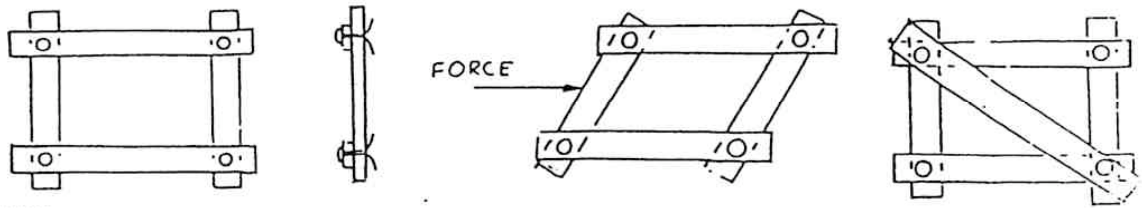


Structures Handout

Trusses and Buttresses, Triangles and Static Structures

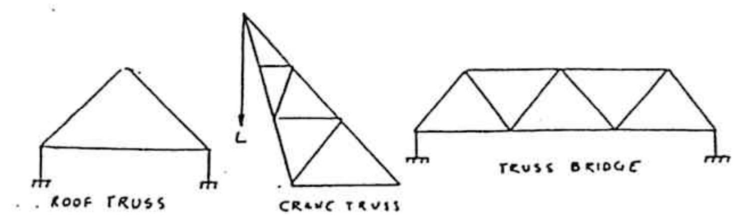
We will not be able to build static structures (i.e. structures that do not move or deform) unless we understand the important role of triangles in helping to create stability.

A rectangular structure is naturally unstable. If held together with a single connector such as a bolt, screw, rivet or nail in each corner, the rectangle can easily change its shape to a non-square parallelogram.



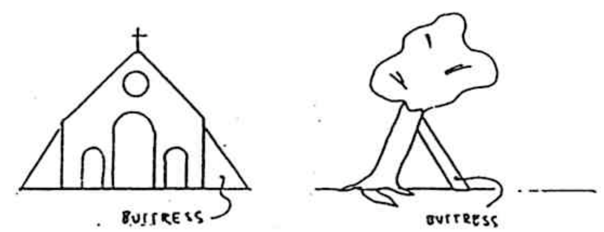
Trusses

A **truss** is a diagonal structural member. It is generally found **inside the structure.** Typically, a truss, when connected at its ends to two sides of a structure or a side and another truss, forms a triangle. Trusses **generally work in tension**. (They may also be subject to compressive forces.)



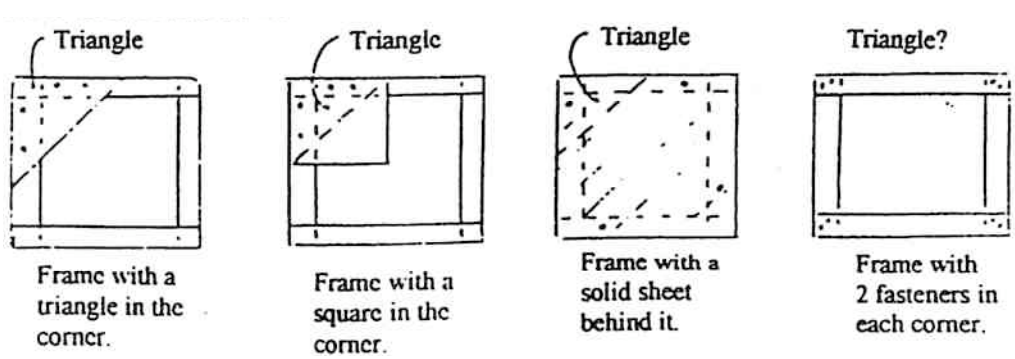
Butresses

A **buttress** is attached to the **outside of a structure**. It forms a triangle when attached to the outside wall. **A buttress is always in compression.** It may be formed by a solid piece or consist of a single member. Its purpose is to provide a force against the forces pushing a wall or a member out and away from the structure.



Hidden triangles?

Structural triangles may not always look like triangles. Sometimes this triangulation effect will be achieved by using solid sections as shown below.



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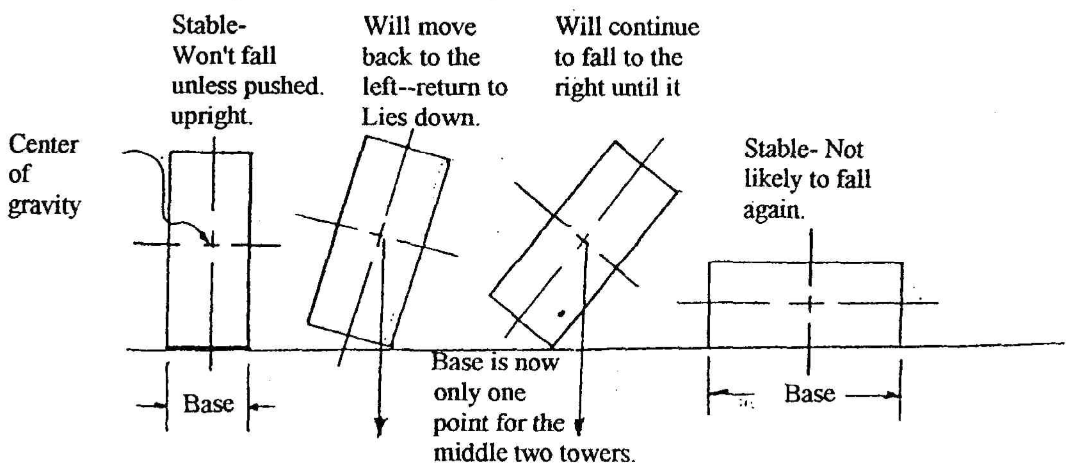

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