TECHNOLOGY

Structures

Hoërskool Gerrit Maritz

District D15

2009

Grade 8

Learner ______________________________

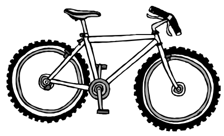
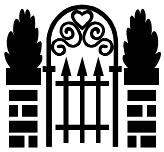
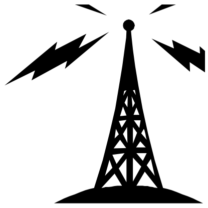
Teacher ____ ___________________________

Grade 8 Technology STRUCTURES

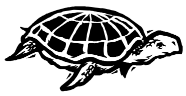
Types of Structures

Natural and Manmade structures
Structures are all around us, some are natural like eggshells, spider-webs, caves and trees and others are man-made like bridges, towers, houses, shopping bags and cups. Structures are further divided into three other groups namely frame, shell and mass structures:

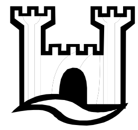
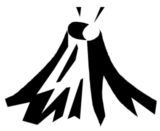
Frame Structures
A frame structure is a structure made up of many rigid parts joined together to form a 'framework'.
These different parts are called members.

Shell Structures
A shell structure is more enclosing than a frame structure - it surrounds and encloses something.

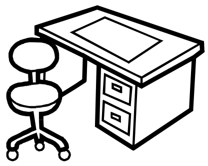
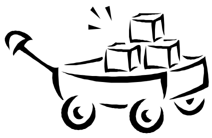


Solid/mass Structures
Solid structures rely heavily on solid construction such as masonry to support loads and to transfer these loads safely to the ground.
Advantages of solid structures are that they are held in place by their own weight, losing small parts often has little effect on the overall strength of the structure
- Mountains, caves and coral reefs are natural mass structures
- Sand castles, dams and brick walls are manufactured mass structures

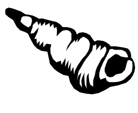
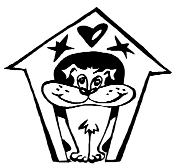
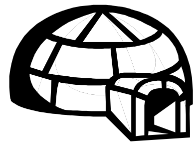
Functions of structures

Supporting a load
A structure must be able to support its own weight and the load it has to carry. A load can be a person, an object or a force. A moving load is known as a dynamic load. A stationary load is known as a static load.

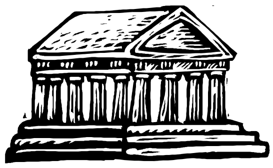
Spanning a gap
The most common structure fulfilling this function is a bridge. Bridges fulfills another function - supporting a load - they have to carry their own weight and the weight of whatever travels over them.


Enclosing people, animals or objects
All containers fulfill this function, as well as most buildings. Natural objects include shells, caves, hollow tree trunks etc.

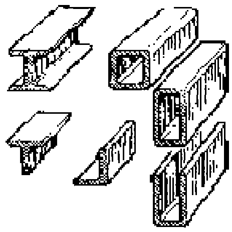




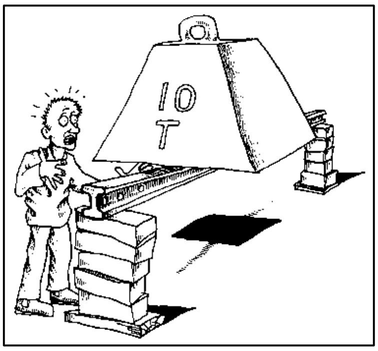
Structural members

Columns are vertical structural members.

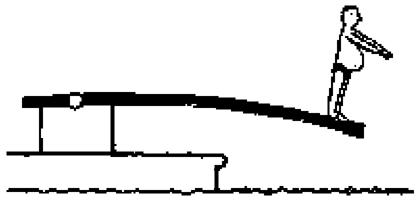


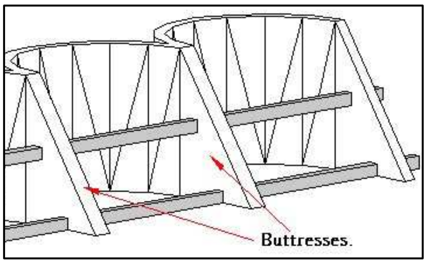
Beams are horizontal structural members. Beams often spread a load across two or more columns. How well the beam works depends the material it is made from and its shape. Beams used in larger structures take many different forms, some are simply solid, some are hollow, and others have special cross-sections to provide strength and rigidity.





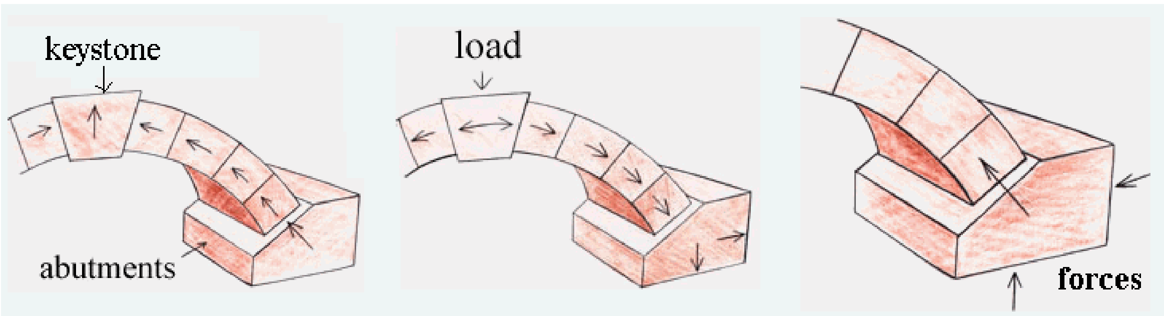
A **cantilever** is a structural member which sticks out like an arm form the main structure. A cantilever is a beam which is supported at one end only.





A **buttress** is a structure built against or projecting from a wall which serves to support or reinforce the wall.

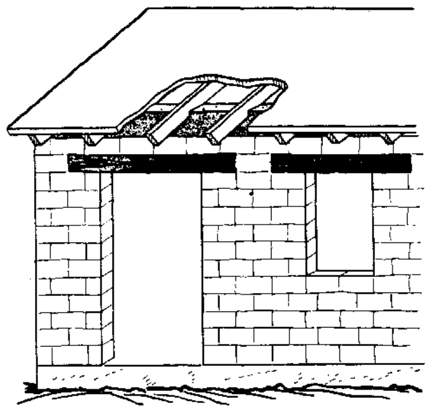
Arches



The load at the top of the key stone makes each stone on the arch of the bridge press on the one next to it. This happens until the push is applied to the end supports or *abutments,* which are enbedded in the ground.

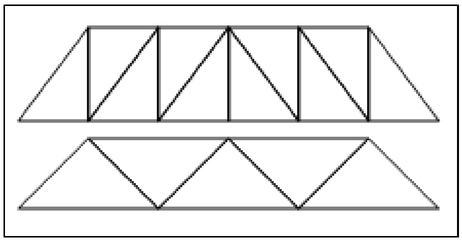
The ground around the abutments is squeezed and pushes back on the abutments.

For every action there is an equal and opposite reaction. The ground which pushes back on the *abutments* creates a *resistance* which is passed from stone to stone, until it is eventually pushing on the key stone which is supporting the load.



Lintels are beams made of concrete and reinforced with steel bars. They spread the weight of the structure above the opening of doors and windows to the structure beside them.

A **truss** is a structure made up of triangles.



PROPERTIES OF STRUCTURES

Strength - the capacity to withstand forces that tend to break an object or change its shape; it is an object's ability to hold its shape without collapsing.

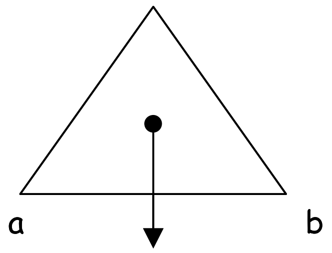
Rigidity - the ability not to buckle or distort.

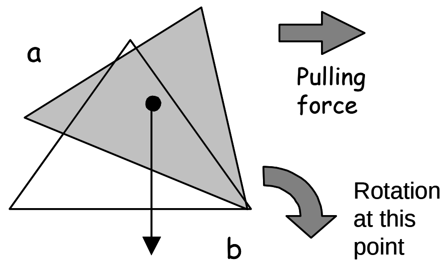
Stability - the capacity of an object to maintain or return to

its original position; the state of being balanced in a fixed position.
Why are some structures more stable than others?
We say that a structure has high stability if, when it is loaded, it tends to return to, or remain in, the same position. The degree of stability depends on the relationship between the base, the height and the weight of the structure.
The weight of an object is due to the force of gravity pulling down vertically on the mass of the object. The invisible position of the mass through which the force of gravity pulls is called the centre of gravity. If the position of the centre of gravity is low and lies well inside a large base area, the object is said to be very stable. If the centre of gravity lies to one side of the base area, the object is much less stable. If the centre of gravity is outside the base area, the object is very unstable and may require further support. A tall object tends to be unstable because its centre of gravity is in a very high position. Because of this, it can be more easily moved outside the base area by the application of external loads. A structure is said to be stable when it will not topple over easily when acted upon by a force.

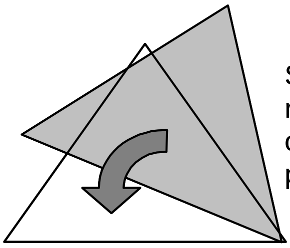
The relation between stability and centre of gravity

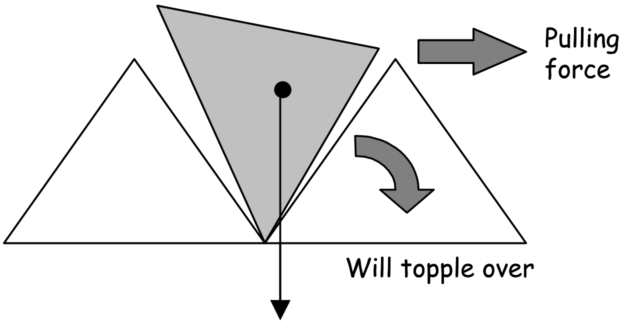
The stability of a structure is related to the position of the centre of gravity for that structure. As indicated in the diagram below, as the structure is tilted, its centre of gravity rises. It is rotated about point b, caused by the pulling force.

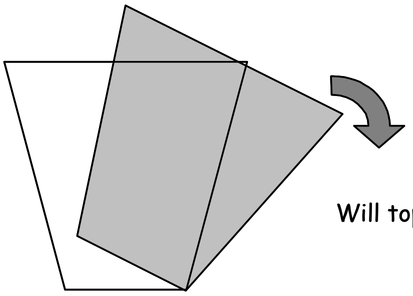




If the structure is stable, on release of the pulling force the structure will return to its original position.





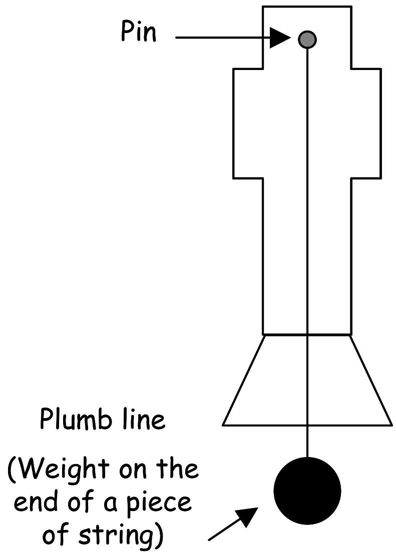


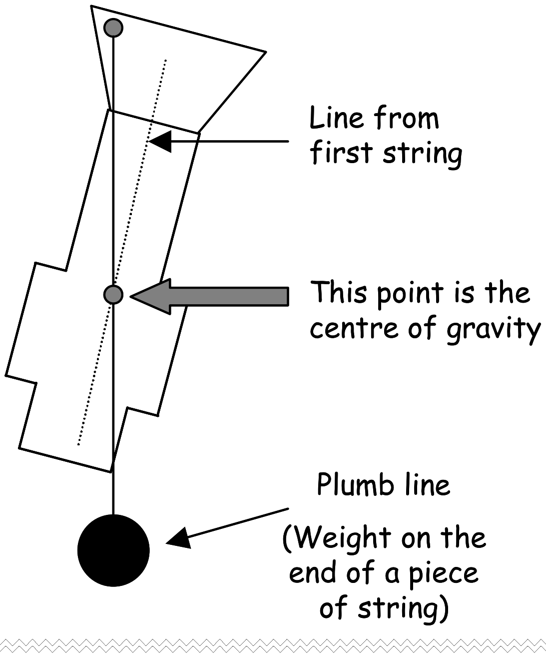
However, it must be noted that this will only be the case if the centre of gravity remains inside the base of the structure. When the structure is tilted to such a degree that its centre of gravity is outside its base, then the structure will become unstable as gravity acts on it and causes it to topple over.
If an unstable object is rotated as shown, when the pulling force is removed the structure will continue to rotate and will eventually topple over.

LET'S TRY IT !

Accurately determining the centre of gravity.

Use a piece of thick card and cut out an irregular shape as shown opposite. Hang a plumb line from a pin as shown. Hold onto the pin and mark the position of the plumb line with a pencil.



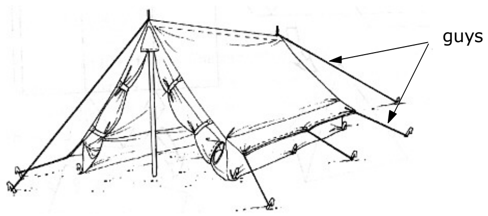


Repeat the process again twice, but each time place the pin at a different location, and mark the position of the plumb line string. Where the three pencil lines cross is the centre of gravity of the shape.

Some rules for stability:

- **A low centre of gravity.**
- A **wide base** is generally more stable than a structure with narrow base.
- The **weight at the top** of the structure should by less that the weight at the bottom.
- using struts, guys and stays to hold it
- using a foundation

It is not always possible to design structures that comply with these rules, and therefore sometimes special measures should be taken to make a structure stable. The tower crane is a long slender structure with a very thin base, and a very wide top. It has a large load to carry at the top at one end of the arm as indicated in the previous picture. A counter weight is placed on the opposite side of the crane arm to that of the. This system works by balancing the load with that of the counter weight.

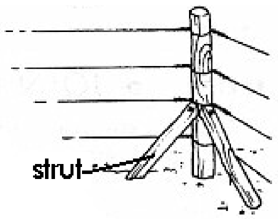


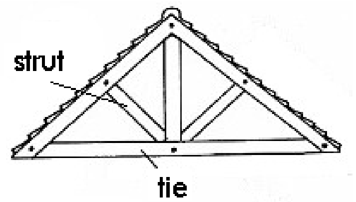
GUYS

Structures like tents can also be made stable by anchoring it to the ground with guys. **Guys** are ropes, cables or chains (flexible members) that hold a structure firmly in place by pulling on it.

STRUTS and TIES

All structures have forces acting on them. Ties, guys and struts are structural members used to make structures stable. The part of the structure that has a tensile force acting on it is called a TIE and the part that has a compressive force acting on it is called a STRUT.

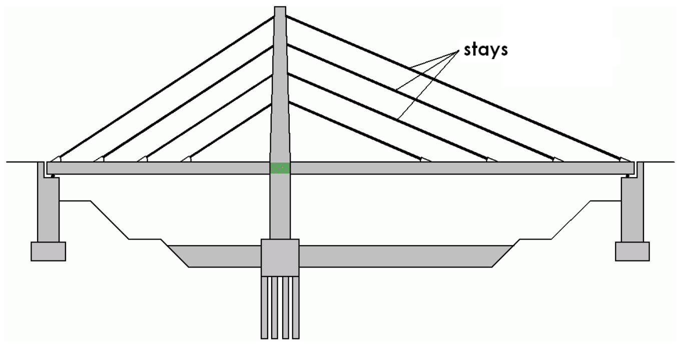


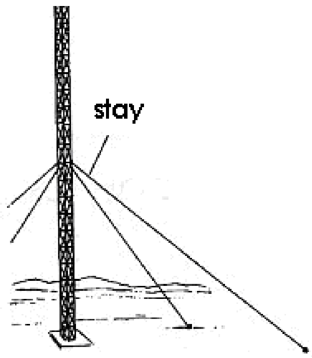


A tie (usually inflexible) holds other members in place by pulling on them. Many frame structures have members called struts (always inflexible). Struts hold members in position by pushing against them. Struts are made of materials like wood or steel which do not bend.

STAYS

A stay is a cable used to secure a mast (to keep a mast in place). Cable stayed bridges make use of stays as well as some pylons or high towers.

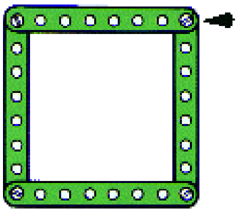




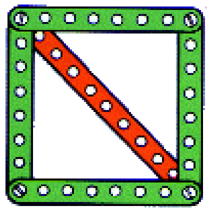
THE DESIGN OF FRAME STRUCTURES

If you look at some pictures of familiar frame structures like cranes, electricity pylons or roof supports you may notice that triangulation is used to make them rigid.

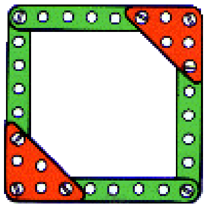
Making Structures Rigid



When forces are applied to a simple four-sided structure it can be forced out of shape quite easily. A structure which behaves in this way is said to be non-rigid.

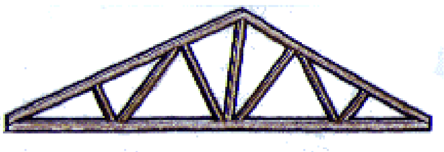


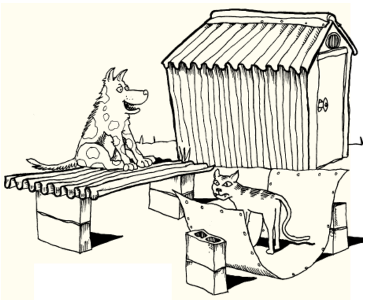
By adding an extra bar or member (usually a strut) corners A and B are prevented from moving apart. The structure then cannot be be forced out of shape, and is said to be rigid. Notice that the additional member has formed two triangles in the structure.



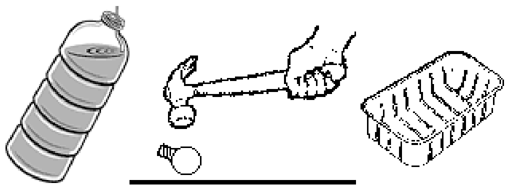
An alternative to triangulation is to use a gusset plate. A gusset is simply a piece of material used to brace and join the members in a structure. A triangular gusset plate has been used here but they can be made in a variety of shapes.

You will now do Resource Task 1 on page 12



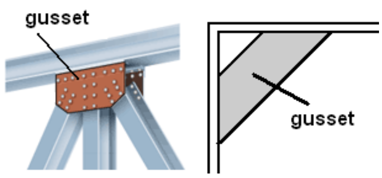


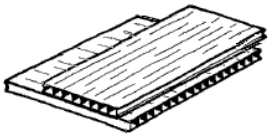
Framed structures achieve most of their strength and rigidity from the way they are assembled. Most frameworks are built using a combination of struts and ties to make triangles. Triangles make very strong and rigid structures. Using triangles in this way is called **triangulation**.



Most shell structures achieve their strength and rigidity from the way they are shaped. Shell structures very rarely have large flat surfaces they tend to be designed and made with ribs to act as stiffeners. Egg and light bulbs containers are good examples. Both eggs and light bulbs can withstand considerable static forces if they are applied carefully. The same principle is used for corrugated iron.

Gussets are made of rigid materials such as wood or metal and is used to brace or hold frame members together.





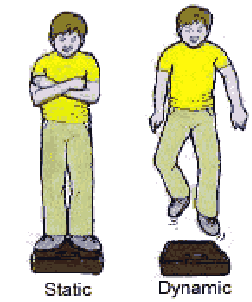
Materials which are used to make structures, can be reinforced by using it in a different position. If two stripsof are stuck to each other at a 90° angle, the cardboard will be stronger. The same happens to wood when it is laminated. The strips of the wood is glued together at an angle of 90°. A beam is also stronger when it is used in an upright position rather than flat.

FORCES

Forces can be either **static (stationary**) or **dynamic (moving**).

Static forces are usually forces caused by the weight of the structure and anything which is permanently attached to it.

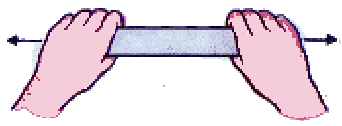
Dynamic forces are caused by things such as wind, waves, people, and vehicles. Dynamic forces are usually much greater than static forces and are very difficult to predict. These are the most common reason for structural failures.



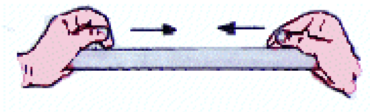
An **external force** is a force placed on the structure from outside, by the wind perhaps or perhaps by someone sitting or standing on it.
Internal forces are the forces which the structure must provide within itself to resist the external forces placed upon it. If the external forces are greater than the internal forces, a structure will collapse.

Forces acting on and within Structures

External forces or loads cause internal stresses to be set up in a structure. Not all forces or loads act in the same way. Forces can bend, pull, press, or twist. Each of these types of force are given special names.



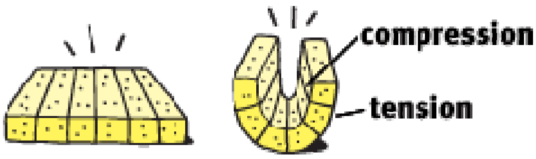
Tension : Is a force which tries to pull something apart. A structural member in tension is called a tie. A tie resists tensile stress.

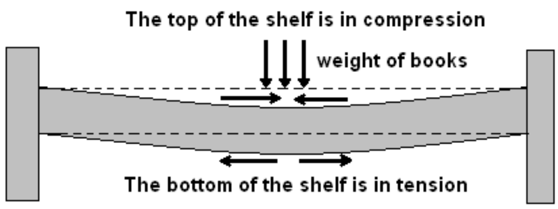


Compression : Is a force which tries to squash something together. A structural member in compression is called a strut. A strut resists compressive stress.

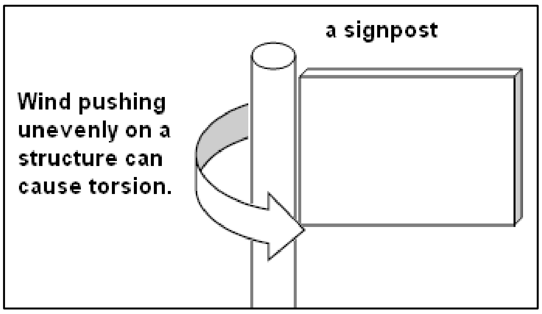
Bending : Bending is a word you will have met before. A structure which is subjected to bending is being stretched and squashed at the same time.

Bending: A combination of forces that causes one part of a material to be in compression and another part to be in tension. In this picture a sponge with lines drawn on it is bent. You can clearly see how the lines at the top are moved closer together (in compression) and the lines at the bottom is pulled apart (tension)





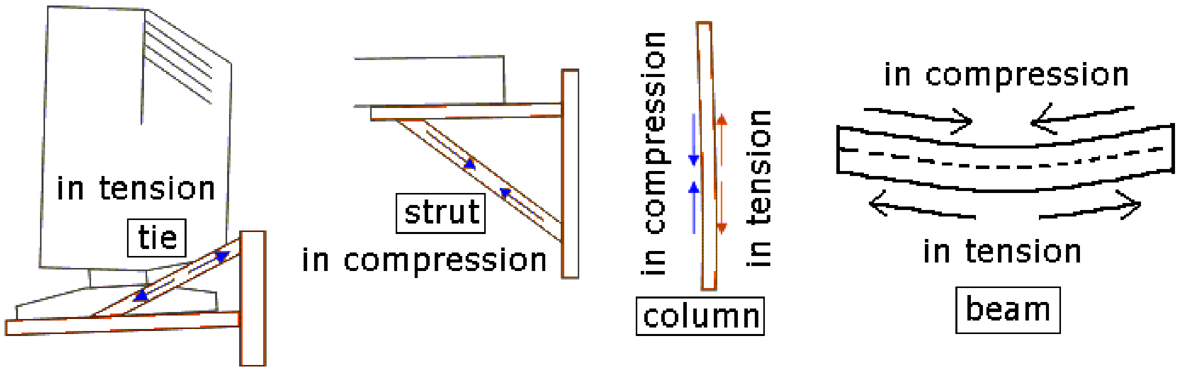
Torsion : Is the name given to a turning or a twisting force.



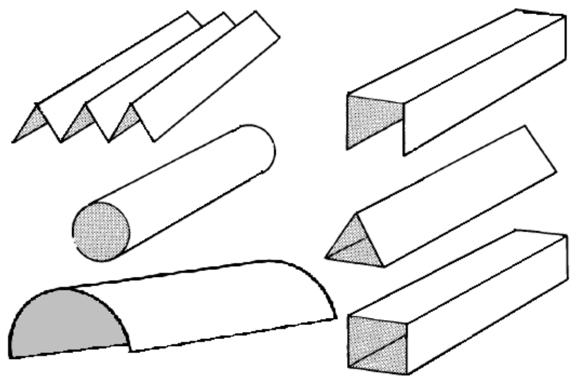
Shear : A shear force is created where two opposite forces try to cut tear or rip something in two

Identifying structural members

Under load, a **beam's** top surface is pushed down or **compressed** while the bottom edge is stretched or placed under **tension**, the same happens to a **column** - one side will be in **tension** and the other side in **compression**. **Struts** are always in **compression** and **ties** are always in **tension**.



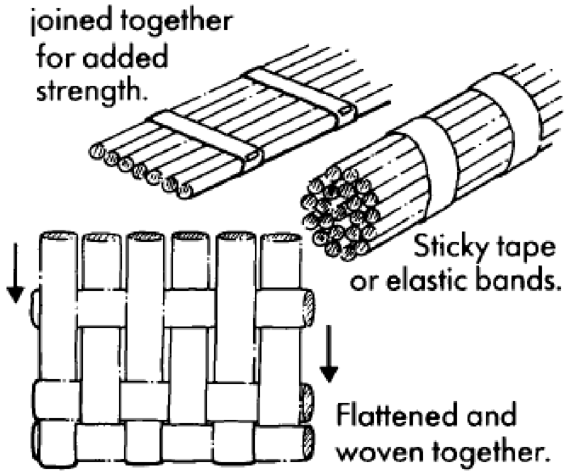
Paper Structures

What shapes are the strongest? Use paper and fold 3-D shapes as shown to the right. Determine which shapes will be the strongest. Use the shapes as beams and columns and see which can hold the biggest load. Try to make these shapes stronger, by reinforcing the paper and / or the structure.	

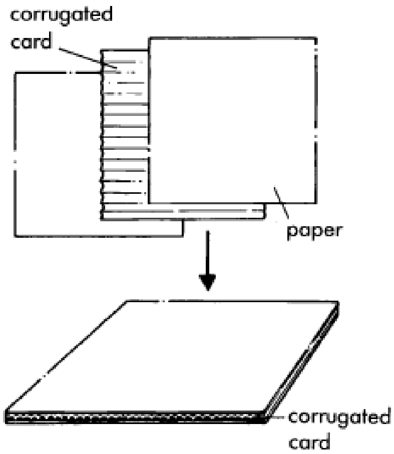
You will now do Resource Task 2 on page 13

Help with structure building

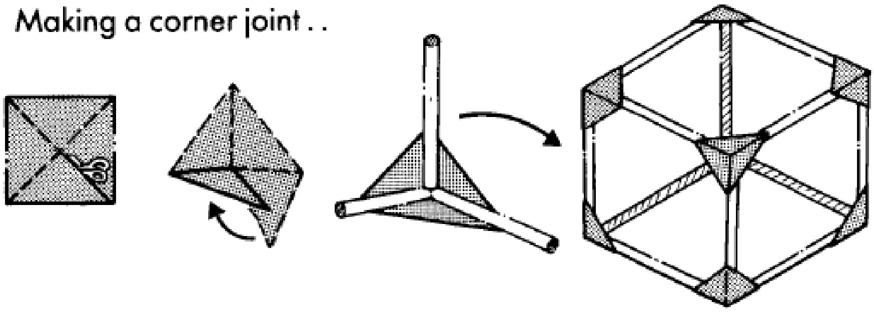
Strengthening



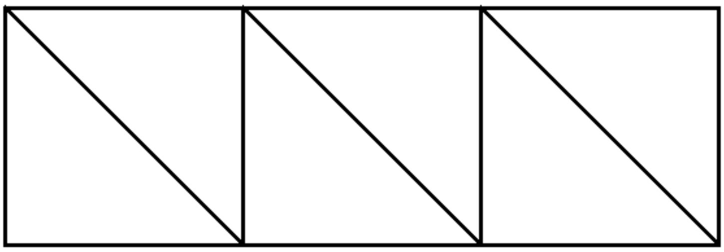
By laminating –
sandwiching stronger layers.

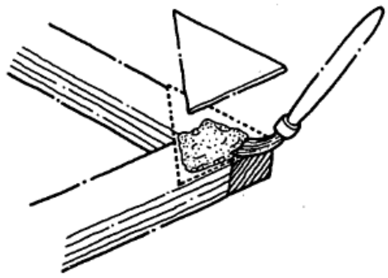


Making a corner joint . .

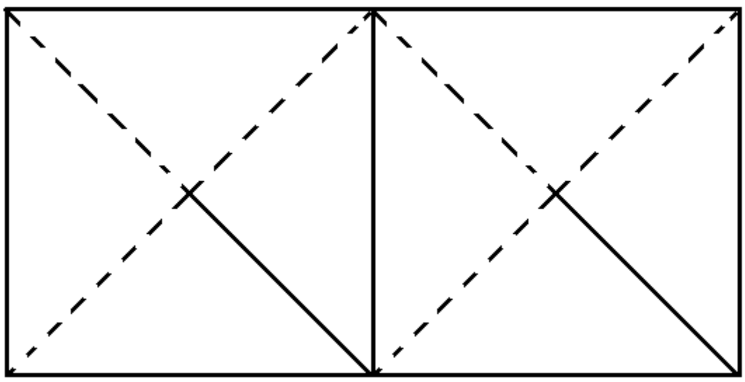


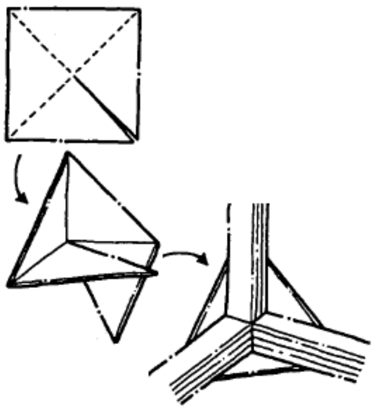
Reinforcing 2-D corner joints

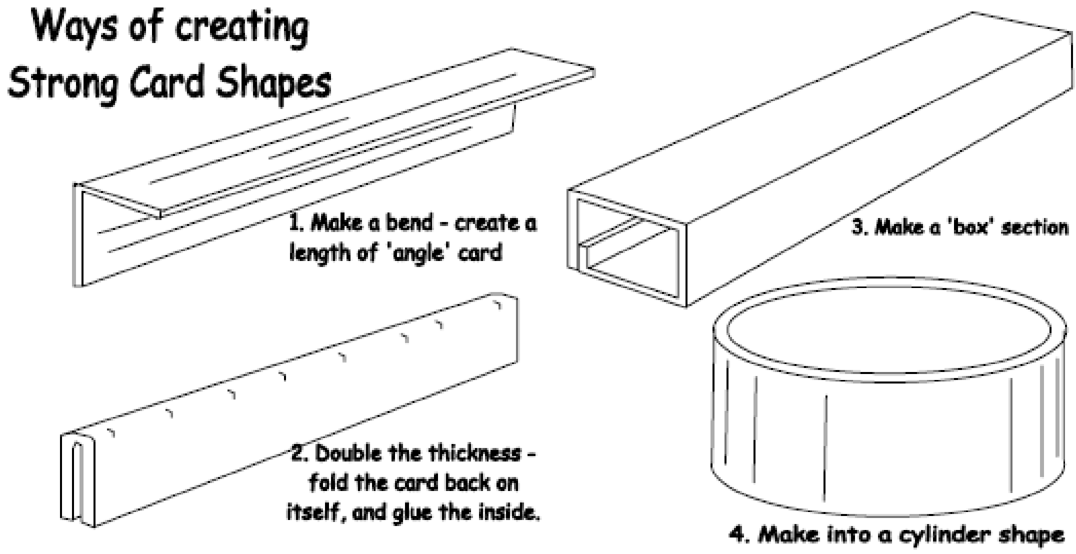


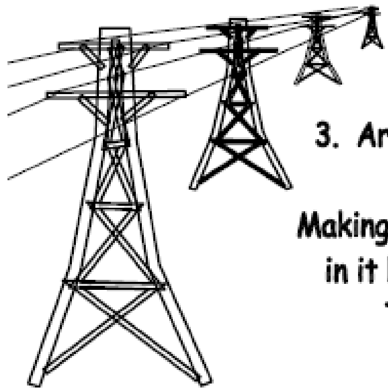


Reinforcing 3-D corner joints









3. Arrange the parts of the structure into 'strong shapes'.
Making a structure with triangular shapes in it help to make a rigid framework.
Think of an electricity pylon.

Capability Task

Your school received a rainwater tank from a sponsor and decides to make use of stored rainwater to water the school garden. Since you are learning about structures, your class is asked by the governing body to design and make models of water towers from which one will be chosen and handed over to building contractors to build the water tower.

Your facilitator will divide you into groups of 6. In your groups you have to decide together how you will solve the problem. Each group has to make one model for the water tower.

Given specifications

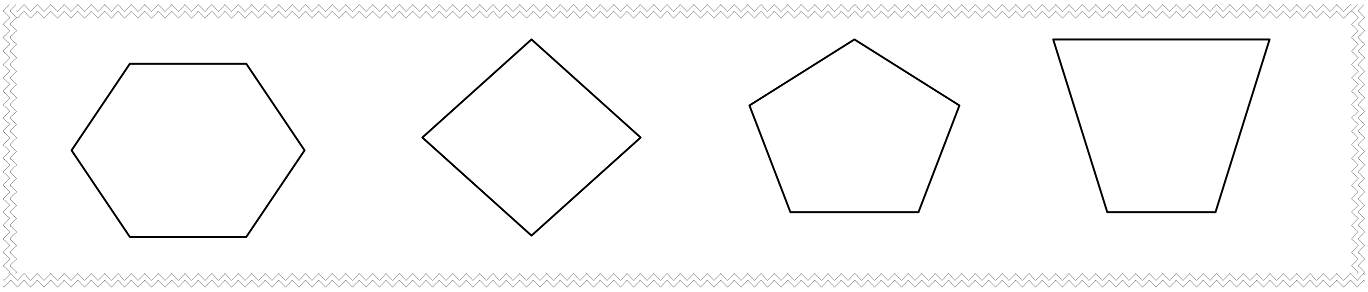
- The water tower must be a frame structure.
- The water tower must be stable, strong and rigid
- You may only use paper to make the structure
- The model must be 300 mm high
- You must use reinforcing techniques
- The model must be able to carry the weight of a 1 litre bottle of water

PORTFOLIO

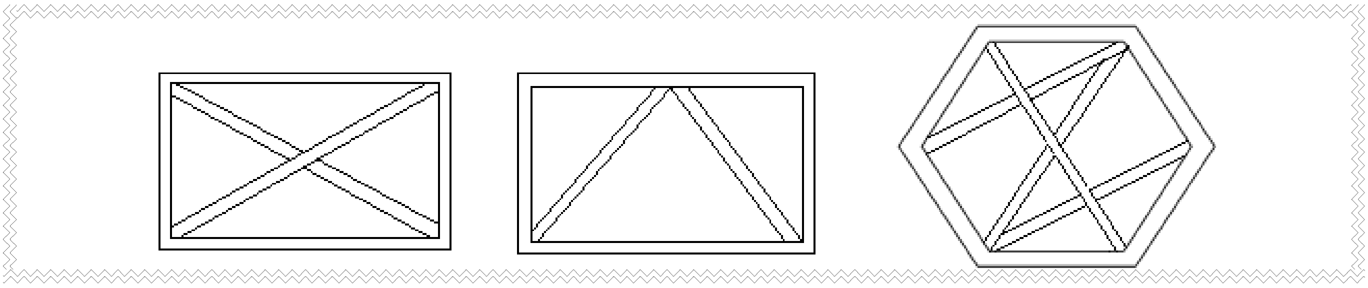
INVESTIGATION

Resource Task 1

Use strips of cardboard and make these shapes. Use more strips and reinforce the shapes. Draw lines in the shapes below to show what worked.



Some members of the following structures are redundant. Use strips of cardboard and make these shapes, then remove some members and see which ones are redundant. Colour the redundant ones with your pencil.



(15)

Resource Task 2

Can you make a sheet of newspaper hold up a book? Explain how to do this.

____

____

____

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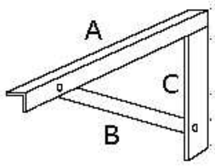
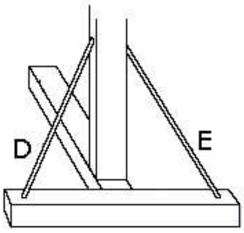
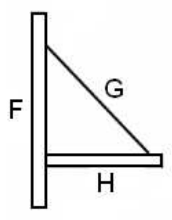
(5)

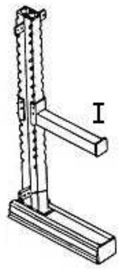
Resource Task 3

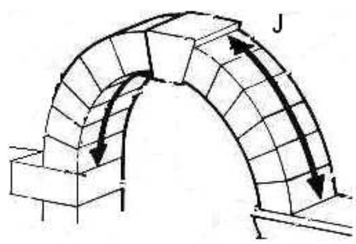
Identify the structural members and forces in the following drawings. (D and E are rigid and G is non-rigid)











Structural members:

A: ______________________ B: ______________________

C: ______________________ D: ______________________

E: ______________________ F: ______________________

G: ______________________ H: ______________________

I: ______________________ J: ______________________

Forces:

A: ______________________ B: ______________________

C: ______________________ D: ______________________

E: ______________________ G: ______________________

H: ______________________ J: ______________________

Explain in detail the forces experienced by

F: ____

____

____

I: ____

____

____

(20)

Case Study

Do research about one structure (building, bridge, tower etc. that failed. Give reasons why it failed and what was done / planned to be done to better the structure when it was rebuilt.

Bibliography:

(10)

DESIGN

Design brief

(5)

Specifications

(5)

Ideas (10)

Make a freehand 3-D representation of at leas 3 possible ideas for your product and briefly give the pros and cons for each.

Pros and Cons

Pros and Cons

Pros and Cons

Final Design (10)

Use one of the methods you were taught to make a 3-D drawing of your product.

Make a first angle projection of your product.

Further information about your product

MAKE

Tools and materials (5)

Flow diagram (5)

EVALUATION (10)

Write down the names of the members of your group in the table below. Give each member a mark out of 10 for cooperation

Name and surname	Mark out of 10	Name and surname	Mark out of 10

Weaknesses and strengths of your water tower

Changes and improvements you can make to your water tower

Assessment (The facilitator completes this)						
	Aspect	Level 7 (Mastered excellently)	Level 6 (Meritoriously mastered)	Level 4 (Adequately mastered)	Level 2 (Elementary mastered)	Assessment
			Level 5 (Substantially mastered)	Level 3 (Moderately mastered)	Level 1 (Not mastered)	
1	**Design Brief (What will be made)** ***(Marks: 5)***	Formulation of problem solving is clear and comprehensible.	Formulation of problem solving is reasonably clear	Formulation of problem solving is vague	Formulation of problem solving is incomplete and not relevant	
2	**Investigation (Res. Tasks 1 & 2) (Marks: 40 ÷ 4)**	Assignments completed and correct. Obvious effort.	Assignments completed and correct. Some effort.	Assignments completed haphazardly. Hardly any effort.	Assignments incomplete. No effort.	
3	**Investigation (Case Study) (Marks: 10)**	Various sources were used to obtain relevant information.	Few sources were used to obtain relevant information.	Some of the information obtained is relevant.	Information totally irrelevant.	
4	**Presentation (Specifications)** ***(Marks: 5)***	List of specifications complete and relevant.	Specifications complete	A few specifications were given	Specifications incomplete	
5	**Initial idea generation (Marks: 10)**	Ideas very neatly drawn, labels added. All pros and cons mentioned. Chosen idea very well motivated.	Ideas reasonably neatly drawn, labels added. Pros and cons mentioned. Chosen idea motivated.	Ideas not neatly drawn labels added. Few pros and cons mentioned. Chosen idea not clearly motivated.	Incomprehensible drawings of ideas. Pros and cons incomplete. Weak motivation of chosen idea.	
6	**Planning (Final 3-D drawing and working drawing) Marks: 10)**	Working drawing and 3-D drawing are neat and is labeled.	Working drawing and 3-D drawing is done and labeled.	Parts of the working drawing and 3-D drawing have been omitted.	Working drawing and 3-D drawing are incomplete.	
7	**Planning (List of tools and materials) (Flow diagram) (Marks: 10)**	List of tools and materials is detailed Flow diagram is logical and comprehensible.	List of tools and materials is complete Flow diagram is logical and but a bit sketchy.	List of tools and materials is not quite complete Flow diagram is not logical or comprehensible. .	List of tools and materials is incomplete Flow diagram is incomprehensible.	
8	**Product** ***(Marks: 30)***	The water tower is a frame structure. It is stable, strong and rigid. Only paper was used. It is 300 mm high More than 2 reinforcing techniques was used. It can carry the weight of a 1 litre bottle of water	The water tower is a frame structure. It is either stable, strong or rigid. Only paper was used. It is 300 mm high Only 2 reinforcing techniques was used. It can carry the weight of a 1 litre bottle of water	The water tower is a frame structure. It is not very stable, strong or rigid. Only paper was used. It is 300 mm high Only 1 reinforcing technique was used. It cannot carry the weight of a 1 litre bottle of water	The water tower is a frame structure. It is not stable, strong or rigid. Not only paper was used. It is not 300 mm high. No reinforcing techniques was used. It cannot carry the weight of a 1 litre bottle of water	
9	**Evaluation (Marks: 10)**	Relevant evaluation criteria. Useful ideas to improve product.	Reasonable evaluation criteria and ideas to improve product.	Evaluation criteria unclear. Ideas to improve product irrelevant.	No evaluation criteria. Ideas to improve product incomplete.	
					Marks: 100	