TECHNOLOGY

Structures

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District D15

2009

Grade 9

Learner _____

Teacher _____

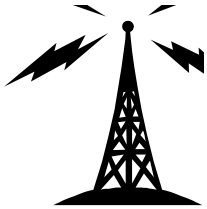
Grade 9 Technology STRUCTURES

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

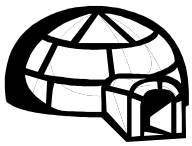

Functions of structures

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.

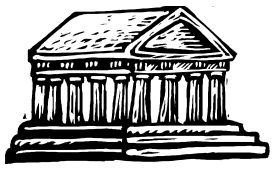

Spanning a gap
The most common structure fulfilling this function is a bridge. Bridges fulfills another function - supporting a load - they have to carry their own weight and the weight of whatever travels over them.


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



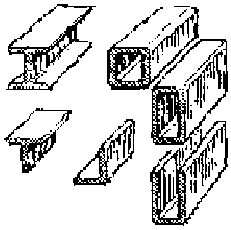


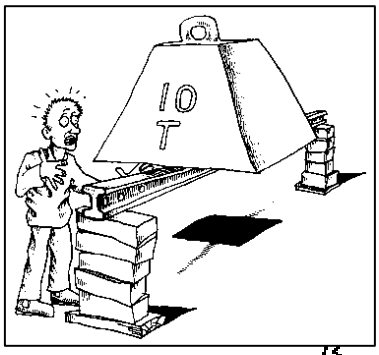
Structural members



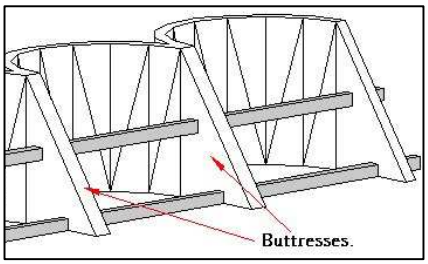
Columns are vertical structural members.

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.

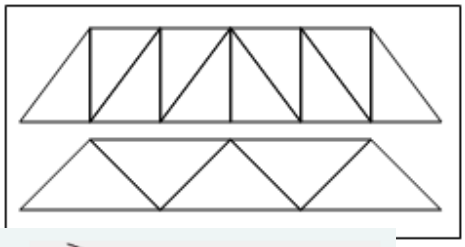




A **cantilever** is a structural member which sticks out like an arm form the main structure. A cantilever is a beam which is supported at one end only.

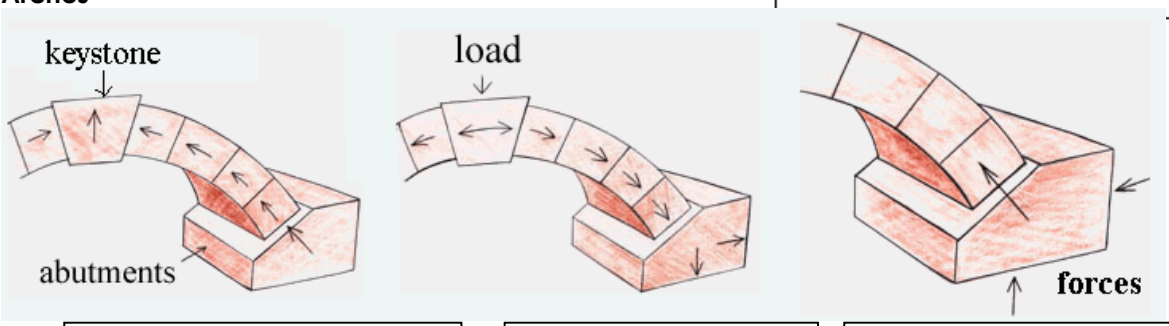


A **buttress** is a structure built against or projecting from a wall which serves to support or reinforce the wall.



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

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.

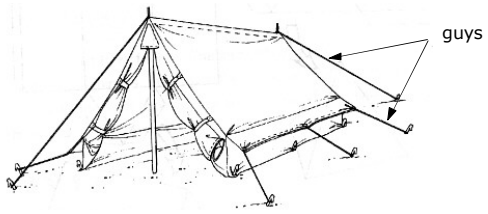
PROPERTIES OF STRUCTURES

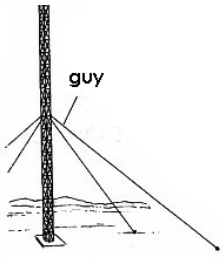
Strength - the capacity to withstand forces that tend to break an object or change its shape; it is an object's ability to hold its shape without collapsing.
Rigidity - the ability not to buckle or distort.
Stability - the capacity of an object to maintain or return to its original position; the state 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.

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.

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.



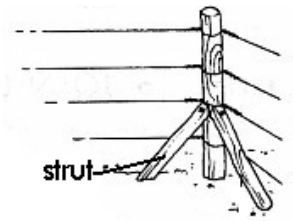


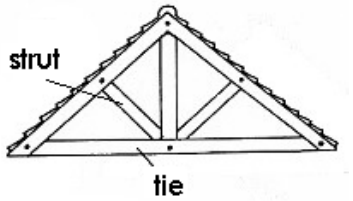
GUYS

Structures like high towers and 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.



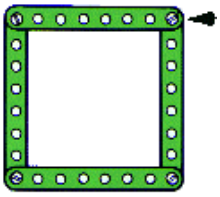


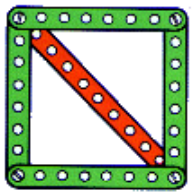
A tie (usually inflexible) holds other members in place by pulling on them. Many frame structures have members called struts (always inflexible). Struts hold members in position by pushing against them. Struts are made of materials like wood or steel which do not bend.

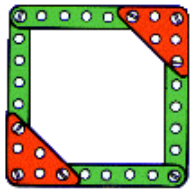
THE DESIGN OF FRAME STRUCTURES

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



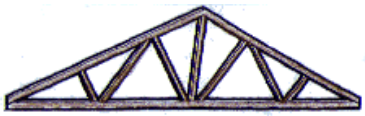


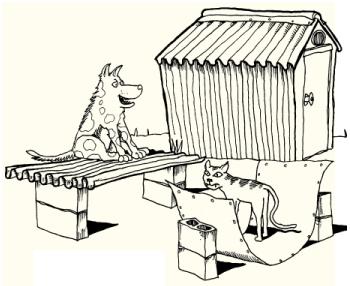


When forces are applied to a simple four-sided structure it can be forced out of shape quite easily. A structure which behaves in this way is said to be non-rigid.

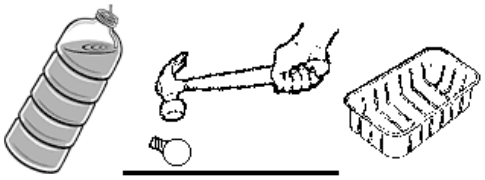
By adding an extra bar or member (usually a strut) corners A and B are prevented from moving apart. The structure then cannot be be forced out of shape, and is said to be rigid. Notice that the additional member has formed two triangles in the structure.

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.



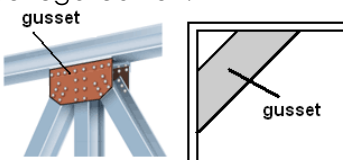


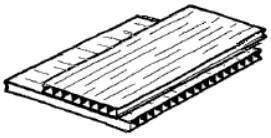
Framed structures achieve most of their strength and rigidity from the way they are assembled. Most frameworks are built using a combination of struts and ties to make triangles. Triangles make very strong and rigid structures. Using triangles in this way is called **triangulation**.



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 strips of 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 wood are glued together at an angle of 90°. A beam is also stronger when it is used in an upright position rather than flat.

Forces

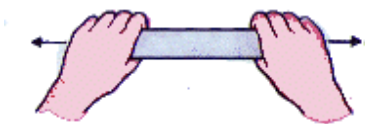
Forces can be either **static (stationary)** or **dynamic (moving)**.

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

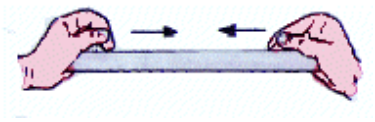
Dynamic forces are caused by things such as wind, waves, people, and vehicles. Dynamic forces are usually much greater than static forces and are very difficult to predict. These are the most common reason for structural failures.

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.



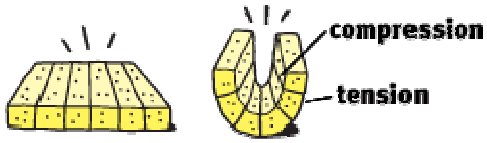
Tension : Is a force which tries to pull something apart. A structural member in tension is called a tie. A tie resists tensile stress.

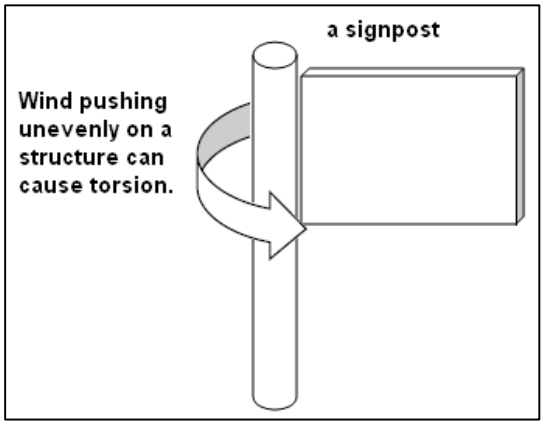


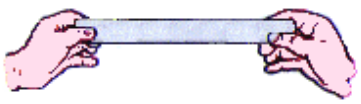
Compression : Is a force which tries to squash something together. A structural member in compression is called a strut. A strut resists compressive stress.

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.

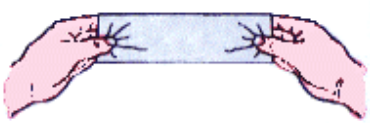
Bending: A combination of forces that causes one part of a material to be in compression and another part to be in tension. In this picture a sponge with lines drawn on it is bent. You can clearly see how the lines at the top are moved closer together (in compression) and the lines at the bottom is pulled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

MATERIALS USED IN STRUCTURES

The properties of materials determine their function in structures

Tensile strength: ability of a material to withstand pulling or tension forces
Compressive strength: ability of materials to withstand pushing or compressive forces
Torsional strength: ability of material to withstand being twisted or placed under torsion
Stiffness: how little distortion or deflection occurs when a material is placed under pressure
Hardness: Ability to withstand being scratched cut or dented
Brittleness: When material fractures with little or no deformation
Toughness: Resistance to impact
Ductility: Allows a material to be elongated or stretched without breaking
Elasticity: When a material can be stretched out of shape, but it will go back to its old shape when you remove the force.
Flexibility: If a material bends easily and does not crack.
Plasticity: When a material changes shape when you press or squash it, it will not go back to its old shape when you remove the force.
Absorbent: Materials that suck up water easily.
Waterproof: Materials that seems to push water away, it just runs of the material
Corrosion resistant: rust of UV-rays of the sun
Heat resistant: will not burn or act as insulator against heat

METALS

All metals fall into two categories. They can either be pure metals or alloys. A pure metal consists of a single element, which means that it is a metal only having one type of atom in it. The most commonly used pure metals are aluminium, copper, iron, lead, zinc, tin, silver and gold.
An alloy is a mixture of two or more pure elements. Pure metals sometimes lack certain required properties. To create these properties a number of these pure metals are combined together.
Pure aluminium is rarely used because it is too soft. It is normally mixed with other metals, which produce aluminium alloys that are even stronger than mild steel, are resistant to corrosion but still retain the lightness of aluminium.

FERROUS METALS

Ferrous metals are metals, which are mainly made of iron with small amounts of other metals or elements added in order to give the correct properties. Almost all ferrous metals are magnetic and can be picked up with a magnet. These metals rust or oxidise if not treated as they contain iron.
Type: Mild Steel, Cast Steel, Stainless steel, Cast Iron, Wrought iron

NON-FERROUS METALS

Non-Ferrous metals are those metals, which do not contain iron. These metals are not magnetic and cannot be attracted by a magnet. Examples of these are aluminium, copper, lead, zinc and tin. These metals do not oxidise as they do not contain iron.
Types: Silver, aluminium, copper, zinc, lead, tin, brass, bronze, titanium, magnesium

COMPOSITE MATERIALS:

fibreglass, tyres, mud bricks, concrete

WOOD

There are two types of sawn wood.
The terms hardwood and softwood do not refer to the wood, but to the leaves of the trees: Softwoods come from trees with needle-like leaves; the most common types are pine, spruce and larch. Hardwoods come from broad-leaved trees such as mahogany and meranti. Not all hardwoods are hard - balsa is very soft.

Solid woods

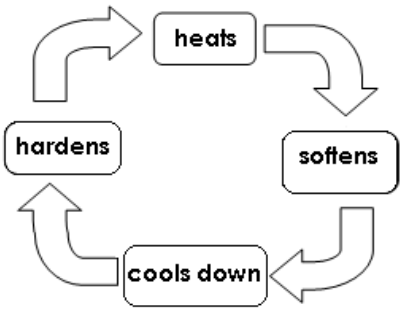
Hardwoods
Balsa Ebony Mahogany Teak Eucalyptus
Softwoods
Cedar, Pine

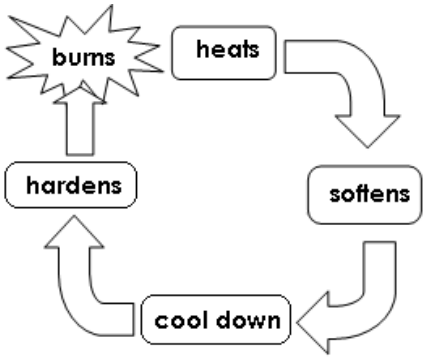
Manufactured boards
Plywood, laminated wood, chipboard, block board, hardboard, fibre board, soft board

PLASTICS

There are two main types of plastics and these are named Thermoplastics and Thermosetting Plastics.

Thermosetting Plastics are made up of lines of molecules which are heavily cross linked. It creates a rigid molecular structure. They may be heated the first time and shaped but they become permanently stiff and solid. They cannot be reshaped again.





Thermoplastics are made up of lines of molecules with few cross linkages. This allows them to soften when heated and to be bent into a variety of shapes and forms. They become stiff and solid again when cold. This process can be repeated many times. Examples of Thermoplastics are: PET, PE-HD, PVC, PE-LD, PP, PS-HD. This type of plastic is usually used for packaging. The fact that it can be reheated and reshaped is ideal for packaging and recycling.

Have you ever wondered about those little numbers inside a triangle of arrows on the bottom of plastic containers? They tell you the kind of plastic is used to manufacture the soft drink bottles, laundry detergent packages, milk jugs, and other plastic bottles that you purchase. The numbers and letters are intended as resin identification codes to facilitate the recycling process. Plastic containers with the codes 1 and 2 are the easiest to recycle.

Plastic identification codes

Plastic Identification Code	Type of plastic polymer	Properties	Common Packaging Applications
01 PET	Polyethylene Terephthalate (PET, PETE)	Clarity, strength, toughness, barrier to gas and moisture.	Soft drink, water and salad dressing bottles; peanut butter and jam jars
02 PE-HD	High Density Polyethylene (HDPE)	Stiffness, strength, toughness, resistance to moisture, permeability to gas	Milk, juice and water bottles; trash and retail bags.
03 PVC	Polyvinyl Chloride (V)	Versatility, clarity, ease of blending, strength, toughness	Juice bottles; cling films; PVC piping
04 PE-LD	Low Density Polyethylene (LDPE)	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Frozen food bags; squeezable bottles, e.g. honey, mustard; cling films; flexible container lids.
05 PP	Polypropylene (PP)	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture	Reusable microwaveable ware; kitchenware; yogurt containers; margarine tubs; microwaveable disposable take-away containers; disposable cups and plates.
06 PS	Polystyrene (PS)	Versatility, clarity, easily formed	Egg cartons; packing peanuts; "Styrofoam"; disposable cups, plates, trays and cutlery; disposable take-away containers;
07 O	Other (often polycarbonate or ABS)	Dependent on polymers or combination or polymers	Beverage bottles; baby milk bottles; electronic casing.

Characteristics of plastic

	1 PET	2 PE-HD	3 PVC	4 PE-LD	5 PP	6 PS-HD	6 PS-LD
Cut with sharp knife	Easy and smooth	Easy and smooth	Easy and smooth	Easy and smooth	Easy and fairly smooth	Fairly hard	Crumbles
Hit with hammer	Very strong	Very strong	Fairly strong	Very strong	Very strong	Weak	Crumbles
Bend at Room Temp	Flexible	Fairly stiff	(plasticized) Flexible (Rigid) Stiff	Flexible	Stiff	Stiff, then breaks	Breaks
Placed in water	Sinks	Floats	Sinks	Floats	Floats	Sinks	Very buoyant
Scratch with finger nail	No	Yes	(Plasticized) Yes (Rigid) No	Yes	No	No	Yes
Softens in hot water	No Becomes harder and shrinks	Yes	Yes	Yes	Yes, if hot enough	Yes	No
Ignites	With difficulty	Easily	With difficulty	Easily	Easily	Easily	Easily
Flame Colour	Yellowish	Blue with yellow tip	Yellow	Blue with yellow tip	Yellow with blue base	Orange /yellow	Orange /yellow
Smoke	Little black	Little	White with lots of soot	Little	Little	Black with soot	Black with soot
Continues to burn	No	Yes	No	Yes	Yes	Yes	Yes
Smell	Little or none	Like candle wax	Like hydrochloric acid	Like candle wax	Like candle wax but not quite like 2 & 4	Sweet	Sweet

Capability Task

You and your fellow learners decided to have a party to celebrate your good Technology results. You have enough money to buy food and drinks and to hire a DJ. You have permission to use a large shed on a smallholding. Unfortunately you do not have enough money to rent tables and chairs. On the smallholding there are lots of empty plastic cold drink bottles which are waiting to be taken to a recycle plant.

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 piece of furniture (table or chair) for the party.

Given specifications

- The piece of furniture you make must be able to carry the weight of the heaviest person in your group.
- The table or chair must be safe for use (may not have sharp edges which can cut someone)
- If you are making a chair, the seat has to be at least 400 mm high.
- If you are making a table it has to be at least 500 mm high and the table top should be at least 800 mm across
- The seat of the chair and the top of the table should also be made from plastic bottles.

PORTFOLIO

INVESTIGATION

Resource Task 1

In order to make/build the following structures materials with specific properties are needed. Write down 6 of the most important properties next to each structure.

Cup						
Ladder						
Hot water bottle						
Bucket						
House						
Car tyre						
Suspension bridge						
Chair						
Toothpaste tube						
Lamp shade						
Garden hose						
School bag						

Write down 6 of the most important properties next to each material.

Plastic						
Stainless steel						
Wood						
Rubber						
Cardboard						
Ceramic						
Aluminium						
Textile						
Concrete						

Resource Task 2

Find at least 2 plastic containers which are made of different types of plastic and write the ***names of the products*** *next to each recycling code.*

Code and abbreviation	Products
1 = PET "Polyethylene Terephthalate"	
2 = PE-HD "High Density Polyethylene"	
3 = PVC "Polyvinyl Chloride"	
4 = PE-LD "Low Density Polyethylene"	
5 = PP "Polypropylene"	
6 = PS "Polystyrene"	

Case Study

Do research about the recycling of plastic. Briefly discuss the recycling process and name a few products which are made of recycled plastic. Find out where a plastic recycling plant close to Pretoria North is situated.

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Bibliography: _____

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DESIGN

Design brief

Specifications

Ideas

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

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

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Flow diagram

EVALUATION

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 piece of furniture

Changes and improvements you can make to your piece of furniture

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 (Resource Tasks 1 & 2)**	Tables completed. Information relevant. Obvious effort.	Tables completed. Information relevant. Minimal effort.	Tables completed. Information irrelevant.	Tables incomplete. Information totally irrelevant.	
3	**Investigation (Case Study)**	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**	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)**	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)**	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)***	Complies with at least 2 of the properties of structures. The properties of plastic which is to the advantage of the project are very well implemented and discussed in full.	Complies with one of the properties of structures. The properties of plastic which is to the advantage of the project are partly implemented and not properly discussed.	Does not comply well with the properties of structures. The properties of plastic which is to the advantage of the project are badly implemented and hardly discussed.	Complies with no properties of structures. The properties of plastic which is to the advantage of the project are not implemented or discussed at all.	
9	**Evaluation**	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	