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 on 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 from the main structure. A cantilever is a beam which is supported at one end only.

A **butress** 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 on 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 embedded 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 be less than 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 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)

Wind pushing unevenly on a structure can cause torsion.

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

**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 seem to push water away, it just runs off the material

**Corrosion resistant**: rust or 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

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

<table>
<thead>
<tr>
<th></th>
<th>1 PET</th>
<th>2 PE-HD</th>
<th>3 PVC</th>
<th>4 PE-LD</th>
<th>5 PP</th>
<th>6 PS-HD</th>
<th>8 PS-LD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut with sharp knife</td>
<td>Easy and smooth</td>
<td>Easy and smooth</td>
<td>Easy and smooth</td>
<td>Easy and smooth</td>
<td>Easy and fairly smooth</td>
<td>Fairly hard</td>
<td>Crumbles</td>
</tr>
<tr>
<td>Hit with hammer</td>
<td>Very strong</td>
<td>Very strong</td>
<td>Fairly strong</td>
<td>Very strong</td>
<td>Very strong</td>
<td>Weak</td>
<td>Crumbles</td>
</tr>
<tr>
<td>Bend at Room Temp</td>
<td>Flexible</td>
<td>Fairly stiff</td>
<td>(plasticized)</td>
<td>Flexible</td>
<td>Stiff</td>
<td>Stiff, then breaks</td>
<td>Breaks</td>
</tr>
<tr>
<td>Placed in water</td>
<td>Sinks</td>
<td>Floats</td>
<td>Sinks</td>
<td>Floats</td>
<td>Floats</td>
<td>Sinks</td>
<td>Very buoyant</td>
</tr>
<tr>
<td>Scratch with finger nail</td>
<td>No</td>
<td>Yes</td>
<td>(Plasticized)</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Softens in hot water</td>
<td>No</td>
<td>Yes</td>
<td>No, becomes harder and shrinks</td>
<td>Yes</td>
<td>Yes, if hot enough</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ignites</td>
<td>With difficulty</td>
<td>Easily</td>
<td>With difficulty</td>
<td>Easily</td>
<td>Easily</td>
<td>Easily</td>
<td>Easily</td>
</tr>
<tr>
<td>Flame Colour</td>
<td>Yellowish</td>
<td>Blue with yellow tip</td>
<td>Yellow</td>
<td>Blue with yellow tip</td>
<td>Yellow with blue base</td>
<td>Orange /yellow</td>
<td>Orange /yellow</td>
</tr>
<tr>
<td>Smoke</td>
<td>Little black</td>
<td>Little</td>
<td>White with lots of soot</td>
<td>Little</td>
<td>Little</td>
<td>Black with soot</td>
<td>Black with soot</td>
</tr>
<tr>
<td>Continues to burn</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Smell</td>
<td>Little or none</td>
<td>Like candle wax</td>
<td>Like hydrochloric acid</td>
<td>Like candle wax</td>
<td>Like candle wax but not quite like 2 &amp; 4</td>
<td>Sweet</td>
<td>Sweet</td>
</tr>
</tbody>
</table>

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.
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.

<table>
<thead>
<tr>
<th>Material</th>
<th>Property 1</th>
<th>Property 2</th>
<th>Property 3</th>
<th>Property 4</th>
<th>Property 5</th>
<th>Property 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cup</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ladder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot water bottle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bucket</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>House</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car tyre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspension bridge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toothpaste tube</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamp shade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garden hose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School bag</td>
<td></td>
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</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Property 1</th>
<th>Property 2</th>
<th>Property 3</th>
<th>Property 4</th>
<th>Property 5</th>
<th>Property 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stainless steel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubber</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceramic</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Textile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Code and abbreviation</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = PET</td>
<td>“Polyethylene Terephthalate”</td>
</tr>
<tr>
<td>2 = PE-HD</td>
<td>“High Density Polyethylene”</td>
</tr>
<tr>
<td>3 = PVC</td>
<td>“Polyvinyl Chloride”</td>
</tr>
<tr>
<td>4 = PE-LD</td>
<td>“Low Density Polyethylene”</td>
</tr>
<tr>
<td>5 = PP</td>
<td>“Polypropylene”</td>
</tr>
<tr>
<td>6 = PS</td>
<td>“Polystyrene”</td>
</tr>
</tbody>
</table>

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:                      
DESIGN

Design brief

_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________

Specifications

_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________

Ideas

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


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

__________________________________________________________________________________________________
__________________________________________________________________________________________________
__________________________________________________________________________________________________
__________________________________________________________________________________________________
__________________________________________________________________________________________________
__________________________________________________________________________________________________

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.

<table>
<thead>
<tr>
<th>Name and surname</th>
<th>Mark out of 10</th>
<th>Name and surname</th>
<th>Mark out of 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weaknesses and strengths of your piece of furniture

__________________________________________________________________________________________________
__________________________________________________________________________________________________
__________________________________________________________________________________________________
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__________________________________________________________________________________________________

Changes and improvements you can make to your piece of furniture

__________________________________________________________________________________________________
__________________________________________________________________________________________________
__________________________________________________________________________________________________
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__________________________________________________________________________________________________
__________________________________________________________________________________________________
__________________________________________________________________________________________________
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Level 7 (Mastered excellently)</th>
<th>Level 6 (Meritoriously mastered)</th>
<th>Level 5 (Substantially mastered)</th>
<th>Level 4 (Adequately mastered)</th>
<th>Level 3 (Moderately mastered)</th>
<th>Level 2 (Elementary mastered)</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design Brief (What will be made) (Marks: 5)</td>
<td>Formulation of problem solving is clear and comprehensible.</td>
<td>Formulation of problem solving is reasonably clear</td>
<td>Formulation of problem solving is vague</td>
<td>Formulation of problem solving is incomplete and not relevant</td>
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<tr>
<td>3 Investigation (Case Study)</td>
<td>Various sources were used to obtain relevant information.</td>
<td>Few sources were used to obtain relevant information.</td>
<td>Some of the information obtained is relevant.</td>
<td>Information totally irrelevant.</td>
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<tr>
<td>4 Presentation (Specifications) (Marks: 5)</td>
<td>List of specifications complete and relevant.</td>
<td>Specifications complete</td>
<td>A few specifications were given</td>
<td>Specifications incomplete</td>
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<tr>
<td>6 Planning (Final 3-D drawing and working drawing)</td>
<td>Working drawing and 3-D drawing are neat and is labeled.</td>
<td>Working drawing and 3-D drawing is done and labeled.</td>
<td>Parts of the working drawing and 3-D drawing have been omitted.</td>
<td>Working drawing and 3-D drawing are incomplete.</td>
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<tr>
<td>7 Planning (List of tools and materials) (Flow diagram)</td>
<td>List of tools and materials is detailed Flow diagram is logical and comprehensible.</td>
<td>List of tools and materials is complete Flow diagram is logical and but a bit sketchy.</td>
<td>List of tools and materials is not quite complete Flow diagram is not logical or comprehensible.</td>
<td>List of tools and materials is incomplete Flow diagram is incomprehensible.</td>
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<tr>
<td>8 Product (Marks: 30)</td>
<td>Compiles 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.</td>
<td>Compiles 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.</td>
<td>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.</td>
<td>Compiles with no properties of structures. The properties of plastic which is to the advantage of the project are not implemented or discussed at all.</td>
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