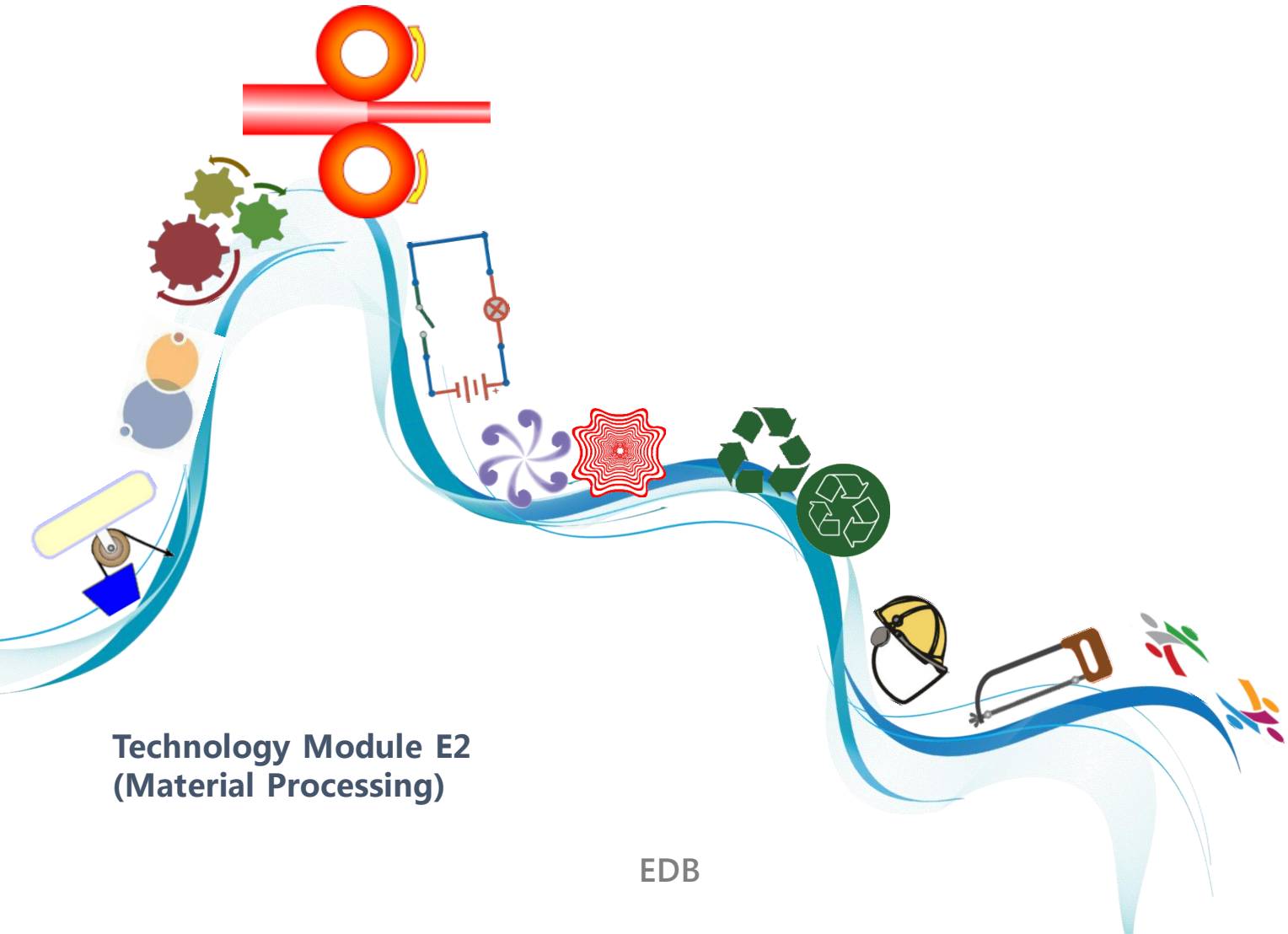
Enriched Technology Education KLA Curriculum

S1 Teaching Material

8

Material Processing



Technology Module E2
(Material Processing)

EDB

Preface

To support the implementation of the Enriched Technology Education Key Learning Area Curriculum (Enriched Curriculum) at junior secondary level, the Technology Education Section of Curriculum Development Institute, Education Bureau, has developed a set of learning and teaching resource materials covering technological subjects learning element modules for teachers' reference and use.

The purpose of providing this set of teaching resource materials is to enable teachers to adopt the related technological subjects learning element modules under the Enriched Curriculum for students to acquire thorough understanding and mastery of the three key aspects in Technology Education Key Learning Area, viz. the technological understanding, technological capability and technological awareness, using a flexible approach with reference to the suggested learning progress.

The content of this learning and teaching resources was compiled with project approach. It gives students a purposeful and meaningful learning context through a series of diversified activities such as design projects, case studies, technological exploration and simulation experiments, and thus arouses their interest in technology and devotion in learning, as well as nurtures their ability in problem-solving, realisation, innovation and spirit of entrepreneurship.

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Relevant Knowledge

Material Processing Technology

Material forming methods can generally be grouped into:

1. Cutting ---- Remove the excess portions of the material;
2. Forming ---- Change the shape of the material; and
3. Jointing ---- Put together different materials.

1. Material cutting

Material cutting is the process of removing the excess portions of it such as cutting to specific dimensions, drilling holes, cutting slots, etc. Material can simply be cut by hand tools; machineries can also be used to enhance the cutting effectiveness.

(a) Hand cutting

Some hand tools for cutting

There are many kinds of hand tools for cutting materials including: hand saw, file, chisel, hand drill and plane, etc. Some handy portable machinery is also frequently used to cut materials quickly such as the portable electric hand drill. Below are the usages and examples of some commonly used hand tools for cutting.

Hand tools for cutting	Usage	Example of tools	Examples of cutting materials
Hammer with metalwork chisel; woodwork chisel	Cutting material with the edges neatly trimmed	Mallet, woodwork chisel, metalwork chisel	Timber, metals
Saw	Separating material into two parts	Woodwork saw, metalwork saw, coping saw, portable jigsaw	Timber, metals, plastics
File	Thin cutting and smoothing of the surface of the material	Flat file, half-round file, square file, round file, triangular file	Timber, metals, plastics
Drill	Drilling holes on the surface of the material	Hand drill, portable electric hand drill	Timber, metals, plastics
Plane	Thick cutting of the surface of the material	Plane, lace planning machine	Timber, soft plastics

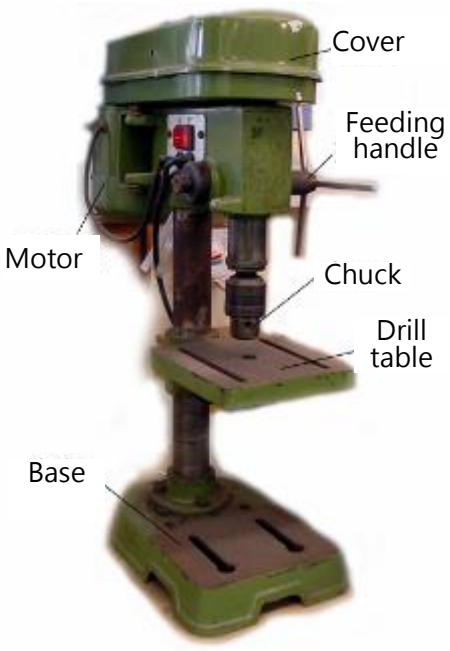
Relevant Knowledge

(b) Machine cutting

Cutting machines can cut materials quickly and efficiently. There are many types of cutting machines including lathe, drilling machine, sawing machine, milling machine, grinding machine, etc., all have their own characteristics.

(i) Drilling machine

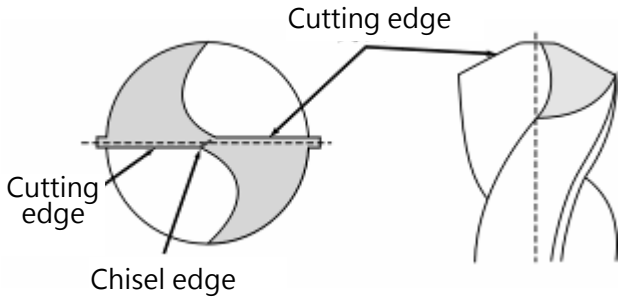
The main function of the drilling machine is to use the drill to drill holes of different diameters on the workpiece; the commonly used ones are bench mounted.



Names of the different parts of a bench type drilling machine

The cutting tool of the drilling machine is the drill bit, which is usually made of high-speed steel and divided into the three parts of head, body and shank. The chisel edge of head cuts and guides the cutting edge into the workpiece, and the cutting edge cuts the workpiece. The flute on the drill body (in helix form) can guide the cutting clips outward; it also allows the cooling fluid to flow into the drill holes.

Drills



Drill head

To ensure safety, the following safety precautions must be observed when using the machine tools:

1. They must be used with the permission and guidance of the teacher.
2. The protective guard must be installed on the machine before use, and users should wear protective goggles.
3. There must be sufficient lighting before starting the drilling machine.
4. While in use, never put your fingers or lean your body close to the rotating or operating parts.
5. To avoid accidental breaking of the cutting tool, we should not press too fast or too hard.
6. Switch off and wait for the machine to stop operation completely before releasing the workpiece or clear the bench top.

Relevant Knowledge

(ii) Metalwork lathe

Lathes can be grouped into the two kinds of woodwork lathe for cutting timber and metalwork lathe for cutting metals. The main function of metalwork lathe is to use the lathe tools for cutting cylindrical metal workpieces.

Finished product cut by the lathe

Metalwork lathe

(iii) Woodwork lathe

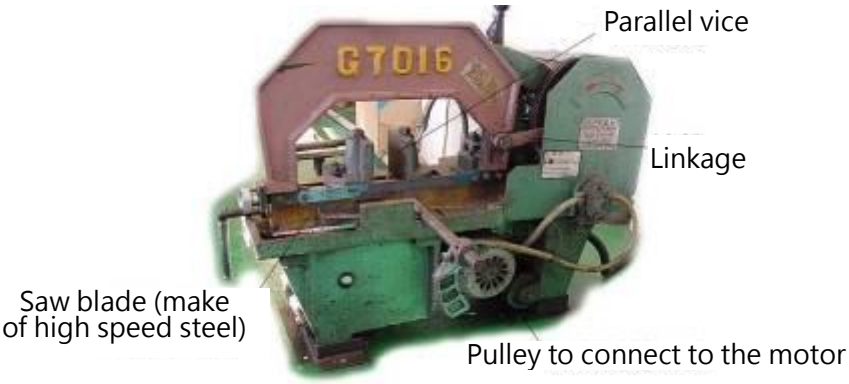
Woodwork lathe is only suitable for turning timber; it can produce lampposts, wooden bowls and wooden plates and others.

(iv) Sawing machine

The main function is to use the saw blade to cut the workpiece, which can be grouped into jigsaw and hacksawing machines.

Name of the sawing machines	Characteristics	Material to cut
Jigsaw	The saw teeth must all point downward, usually used for cutting curves	Thin plywood, plastic sheet, etc.
Hacksawing machine	The saw blade is made of high speed steel and the motor power is larger which can be used to saw workpieces for heavy duty	Metal material such as copper, aluminum and mild steel

(a) Bench type jigsaw



(b) Hacksawing machine

Relevant Knowledge

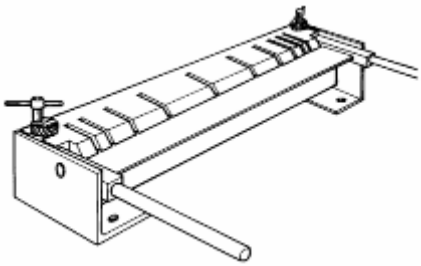
2. Material forming

The process of making material into a suitable shape is known as material forming. There are many methods for material forming including bending, stamping, rolling, moulding, casting and material lamination methods.

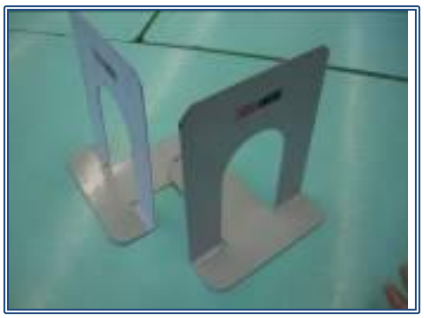
(a) Bending

(i) Metal

Metal sheet can be hammered to a variety of shapes by hand tools and the workpieces can also be bent quickly by mechanical means.



Mini bench type bending machine

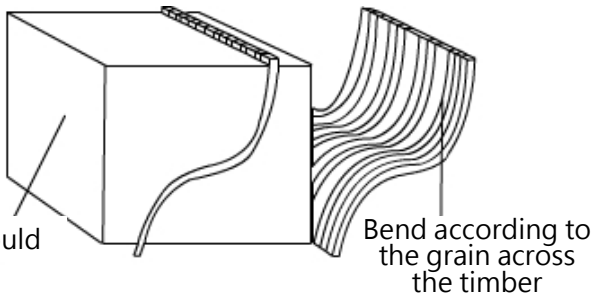


Bookends formed by bending metal sheet

Tube bender

(ii) Timber

Timber can be bent by steam bending or clamping methods. The steam bending method first use steam box to heat and soften the timber, then rapidly place it inside the mould clamping for a long time until the timber comes to a settled shape after drying. The clamping method uses two pieces of positive and negative formers to firmly stick together multilayered timber sheets coated with plastic paddle. After solidification, the multilayered timber sheets will be laminated together and become bent wood panels.



Relevant Knowledge

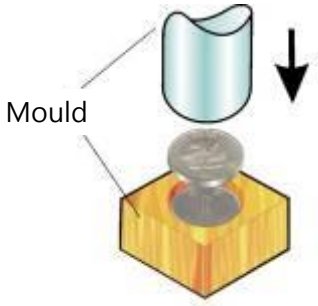
(iii) Plastics

Thermoplastic can make use of the heating method for bending into shapes. For example, acrylics sheet is a commonly used thermoplastic. By using oven or strip heater, the acrylics sheet is heated to about 170℃. When it is softened, the former can be used to bend it into the desired shape.

Name Stand

(b) Stamping

Stamping is to press the metal into the desired shape. Firstly the metallic material is softened by heating, the hydraulic press is then used to vigorously push the punch and press the softened metal into products of different shapes. If the fluted dies sets are mounted on the punch, then patterns can be stamped on the metal surface, for example: stamping the metal disc into coins.

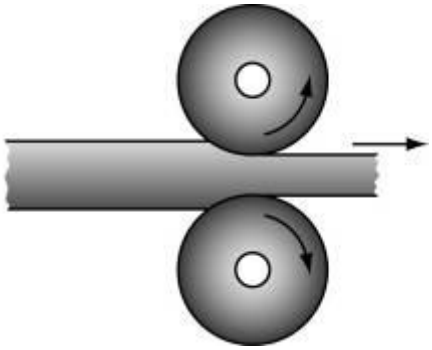


(i) Principle of stamping

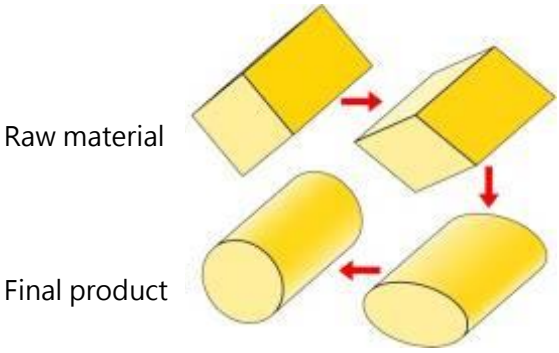
(ii) Coins

(c) Rolling

Rolling uses a set of rollers to reduce the thickness of the metal sheet; it can also be used to change the cross-section of metal rods. Rolling is usually classified into the two categories of cold rolling and hot rolling.

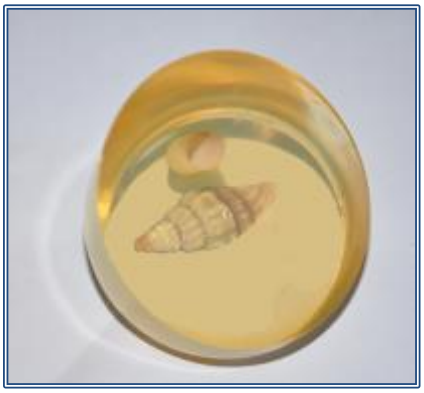


Rolling metal sheet



Rolling metal rod

(d) Moulding



The process of using a mould to change plastic into the desired shape is known as moulding. Moulding methods include moulding, blow moulding, vacuum forming, extrusion blow forming and injection moulding, etc.

(i) Resin Casting

Resin casting is to pour resin (polyester resin) or other thermosetting plastic into the mould. After the resin is hardened it can be released from the mould and becomes finished product of a fixed shape. If trinkets are put into the resin before hardening, they will be sealed inside the plastic.

(ii) Vacuum forming and blow moulding

Vacuum forming uses the atmospheric pressure to press a thermoplastic film into the desired shape. Firstly clamp the film and heat it to softened, and then the mould is elevated towards the film. The vacuum forming machine sucks out the air and the atmospheric pressure will press the film into the shape of the mould, whereas the blow moulding method is to blow in air with increased pressure to force the material against the mould.

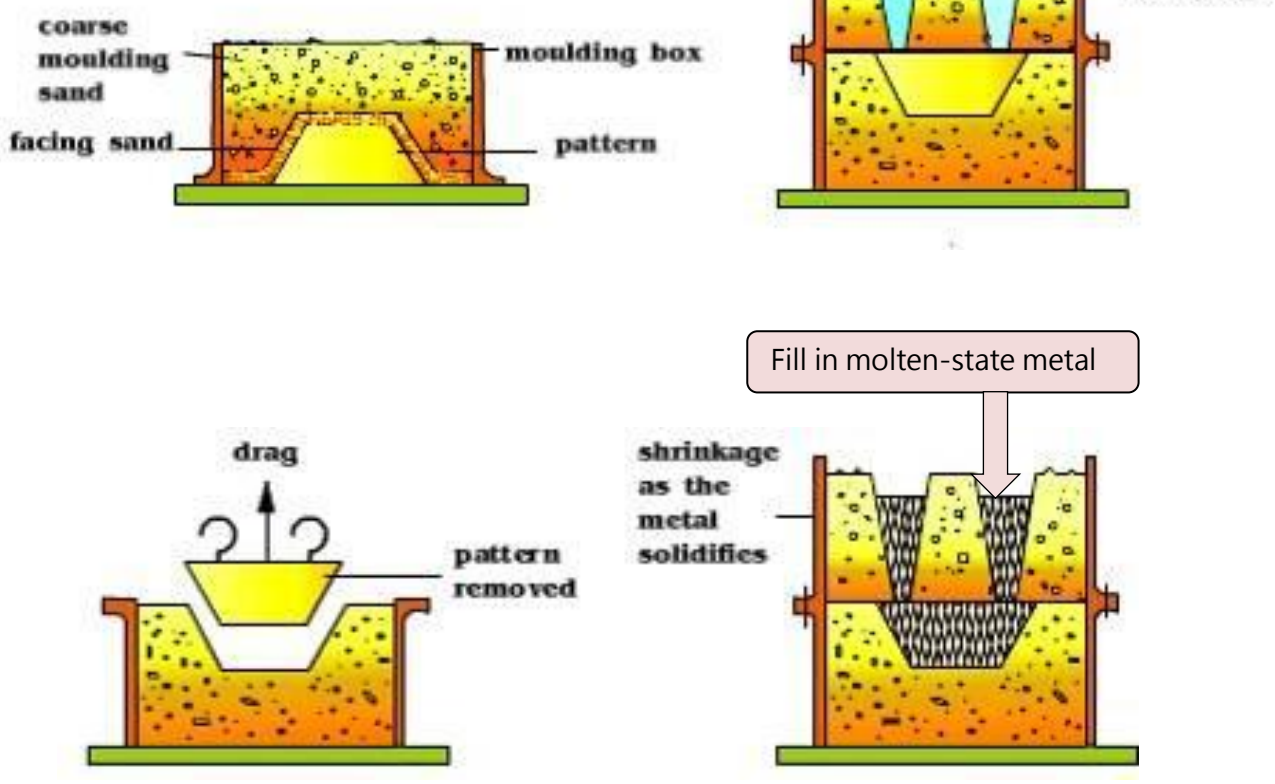
Vacuum former used at schools

A vacuum forming product

(e) Casting

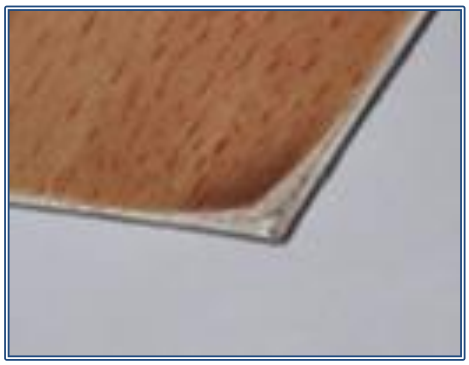
Casting is to fill molten metal into the mould and the finished product can be obtained after solidification. This method can produce metal products of complex shapes such as ship propellers, statues, water pump, etc.

Relevant Knowledge



(f) Laminating

Laminating is to stick together multilayers of thin material with thermosetting plastic such as thin wood veneer, paper, cloth, etc. Firstly the paper or thin cloth is soaked with thermosetting plastics (e.g. resin), then the multi-stage press machine is used to apply pressure and heat, and finally the plastic laminated sheet is formed. For examples, fibre floor tiles, Formica, etc.



5. Glossary of terms

鎚	Hammer	彎曲	Bending
鑿	Chisel	衝壓	Pressing
鋸	Saw	滾壓	Rolling
銼	File	模塑	Moulding
鑽	Drill	真空吸塑	Vacuum forming
鉋	Plane	注塑	Injection moulding
車床	Lathe	鑄造	Casting
		層疊法	Laminating

6. Relevant Information

	Websites	Brief contents
1	http://www.youtube.com/results?search_query=how+it+is+made	Search for how product is formed
2	http://www.kenplas.com/	Plastic products making

Lesson Activities

1. The chairs and desks in the classroom are all made by the processing of a variety of materials.

   (a) Observe them carefully and then record in detail the parts or materials used in each of them (including: screws).

   (b) Analyse and record the making and processing for various parts of the chairs and desks

   (c) During analysis, you may refer to the four main methods for material processing:

   - Material cutting
   - Material forming
   - Material jointing
   - Material surface finishing

   (d) Suggest how to improve the processing so as to improve the quality of the tables and desks.

Extended Activity

Guidelines to case study

1. Objectives

Students get a fundamental understanding of the design process, so as to analyse the design for various parts of the product.

2. On completion of the case study students should be able to master:

1. Conduct focused analysis of the product;
2. Use communication skills to present the results of analysis

3. Situation

Polyethylene terephthalate (abbreviated as PET) is the raw material for the packaging substances of a variety of food and consumer goods, such as the containers for soft drinks, alcoholic beverages, detergents, cosmetics, pharmaceutical products and edible oil. PET is the most popular commercial raw material of plastics closely related to our daily living.

4. Project activity brief

In our daily life no matter at school or home, almost invariably we will make use of PET bottles. In this activity, we focus on investigating the bottle of a bottled drinking water; find out what is special about its materials, design and production methods that make it so successful.

5. Recommended time

3 lessons x 40 minutes (total 120 minutes)

6. Required material

1. Worksheet
2. Students to prepare a bottle of bottled drinking water

7. Contents of activity

1. Material

As the bottle for bottled water, what should be the characteristics of the material used?

i. _____

ii. _____

iii. _____

iv. _____

v. _____

Extended Activity

2. Design

(a) Bottle body

(i) Most of the bottle bodies are round, even square ones have rounded corners, what are the reasons for such design?

_____

_____

(ii) The bottle body has a lot of uneven veins, what are the advantages for such design?

_____

_____

(iii) The mouth of the bottle is smaller than the body, what are the advantages of such design?

_____

_____

(iv) The base of the bottle is sunken inward, what are the advantages of such design?

_____

_____

(b) Bottle cap

(i) What design of the bottle cap can facilitate unscrewing?

(ii) Propose a design to ensure watertight of the bottle when being carried.

Watertight cap design sketch

Extended Activity

3. Manufacturing method

Find out the production method for such bottle and point out the advantages of the method.

Method: _____

Advantages: _____

4. Handling after use

In environmental protection Hong Kong advocates the 4R:

- Reduce (減少使用)
- Reuse (廢物利用)
- Recycle (循環再造)
- Replace (替代使用)

For the design, manufacturing and use of such kind of bottles, state what can be or have been done for these four areas:

a._____

b._____

c. _____

d. _____

e. _____

Reference materials:

Design of the PET bottle

Almost all plastic soda bottles are made of this relatively new plastic referred to as PET. It is a mixture with special nature (copolymer) and its features include:

- Very strong tensile strength, that is the tensile resistance capability
- High impact resistance, that is able to withstand sudden banding
- Impermeable, that is able to prevent pressurised gas to penetrate through the material

Most people get used to the PET bottle and just discard them after use. However, there are many consideration factors behind the scene in the design and making of these economic and safe bottles.

Shape design

Whether the shape of the soda bottle can withstand high pressure is very important. Spherical is an ideal shape to resist pressure, so it is used as the shape of containers for natural or coal gases. However, a bottle designed as a sphere is not very practical as it would take up a lot of space in the packaging boxes or on the shelves. The second choice is a cylindrical shape, but the design has significant stability problem at the base because thin and flat base will expand outward when there is pressure (like a balloon) and overturn the bottle. Therefore, although the bases of some PET bottles are balloon-shaped, there is another plastic ring at the base to enable the bottle to stand firm.

Extended Activity

Base design

Currently most of the PET bottle bases are champagne-like or petal-like. In addition to overcoming the load pressure problem, it also allows the bottle to stand upright. The base is named as champagne-like because it is made similar to the sunken dome shape bottom of champagne bottle.

Champagne base

The petal-like base as named in the following diagram is because it looks like the petals. Such bottle can stand up is in fact because there are multiple balloon-shape bottom gathered at the base. It appears to be very easy in solving the problem to make the bottle stands firm, actually a lot of time has been spent to develop an effective solution.

Petaloid base

Cap design

The screw cap and bottle top are also very special designs. The cap has a built-in seal which gets tighter as it is twisted onto the bottle. Inside the cap, star shaped ribbing helps to keep its top flat under pressure. Without this, the cap tends to balloon out under pressure and cause the seal to break down.

The screw threads on both the bottle top and the screw cap are slotted down their length. This is very important because when you unscrew a bottle top, it is important that any gas pressure build-up is released before the top has been fully unscrewed. Without these slots to release gas, the top could fly off under pressure and cause injury.

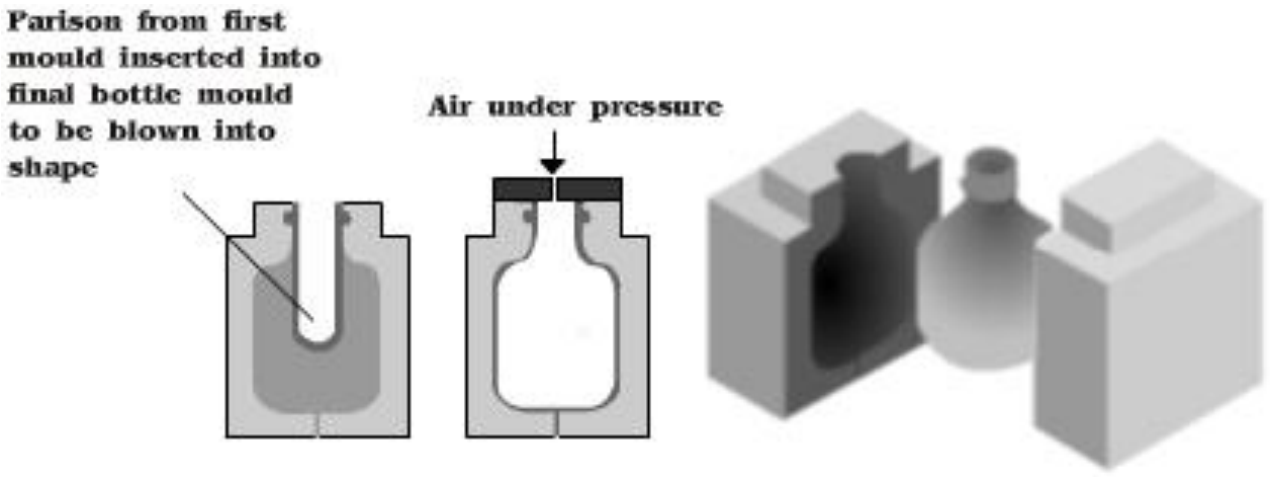
Bottle cap

How they are being made?

PET bottles are made by a process called injection blow moulding (see the figure on next page). In the first stage of this process, hot fused PET material is injected into a small mould and blown into shape called parison by the injection of air. This moulding is then transferred to a larger mould and blown into the final shape of the bottle. You can learn more about this manufacturing process in the following website

http://www.kenplas.com/

Extended Activity



Approximately 1.5 million tons of PET are collected each year worldwide. In many countries, including Hong Kong, PET plastics are coded with the number 1 which is found inside the universal recycling symbol, usually located on the base of the container.

Disposed PET is often sorted by different colours: transparent or uncoloured PET, blue and green coloured PET, and the remainder into a mixed colours fraction. This sorted disposed PET waste is crushed and pressed into bales, which are offered for sale to recycling companies. Transparent disposed PET waste attracts higher sales prices compared to the blue and green fractions. The mixed colour fraction is the least valuable.

Recycling companies will further treat the disposed PET by shredding the material into small fragments. These fragments still contain residues of the original content, shredded paper labels and plastic caps. These are removed by different processes, resulting in pure PET fragments, or "PET flakes". PET flakes are used as the raw material for a range of products that would otherwise be made of polyester. Examples include polyester fibres, a base material for the production of clothing, pillows, carpets, etc., polyester sheet, strapping, or back into PET bottles.

In order to ensure a successful recycling process, please always remove the caps of the bottles and rinse them out thoroughly. Attached parts inhibit the re-use ability of these goods. Please remember the following procedures when disposing your PET bottles and plastic bottles for collection:

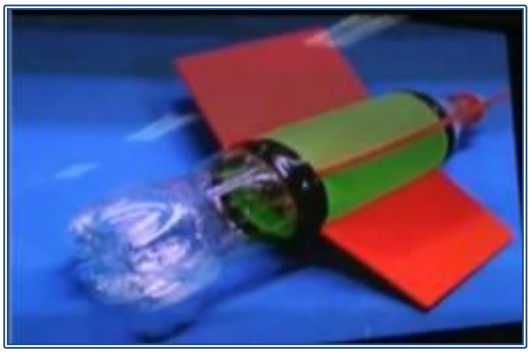
1. Remove the label
2. Remove the cap
3. Rinse the bottle
4. Empty the bottle of water / liquid

Extended Activity

The design and making of water rockets

Form a small group of three to four students and use old water PET bottles to produce several water rockets; then compare which one can fly to the highest and farthest distance. In this activity, you will find how strong PET bottles are. The following websites can help you learn more about the design and production of water rockets:

Aberdeen Technical School / Beichuan Middle School -- Science experiment exchange workshop: Production of water rockets.
http://www.youtube.com/watch?v=CBhvPlsDv40



Water rocket

Moment of launching the water rocket

Supplementary information of PET's material characteristics

Density	1370 kg/m3	Melting point	260°C
Young modulus	2800–3100 Mpa	Thermal conductivity	0.24 W/mK
Tensile strength	55–75 Mpa	Coefficient of linear expansion	7×10–5/K
Elongation	50–150%		

Supplementary information about PET bottles:

- A typical 330ml PET soda drinks bottle weighs only 10 grams.
- The thickness of the wall of a typical 330ml soda drinks bottle is 0.2mm, which consists of 3 separate layers or laminates.
- When a PET bottle is shaken, it must be able to safely withstand a pressure of about 4 bars (twice the pressure of a typical car tyre).
- If you calculate the surface area of a 330ml soda drinks bottle with internal pressure of 4 bars, the total pressure loading of the bottle is approximately 1.5 tons
- After testing, a typical PET bottle can withstand a pressure up to 10 bars.
- As PET bottles are almost unbreakable, accidents are thus reduced.
- It is estimated that more than 1 billion PET bottles are being sold and disposed in Hong Kong every year.

Project Activity - Structure

Expert bridge builder

Guidelines for project activity

1. Objectives

Students get a fundamental understanding about the design procedures and structural analysis, they can use appropriate communication skills to express design ideas and use appropriate hand tools to make the workpiece.

2. On completion of the project activity students should be able to master:

(a) the communication skills to present design ideas;

(b) the fundamental knowledge of structure analysis for the design project;

(c) use of hand tools to make the project.

3. Situation

There are plains and valleys on the earth. Besides using boats, bridges can also be used to cross the rivers. Robust bridges are beneficial not only to the access of residents, but also facilitate logistics and promote economic development.

4. Requirements of project activity

(a) Task brief

(i) Make a frame bridge that can stably span across two bases which are 350mm apart.

(ii) Can stably place a 100mm × 50mm × 8mm timber on the paper bridge.

(b) Grouping

Two persons per group Group name:_____

Names of group members:

(1) : _____ ( ) (2) : _____ ( )

5. Recommended time

(4 lessons + 1 lesson for competition) x 40 minutes (total 200 minutes)

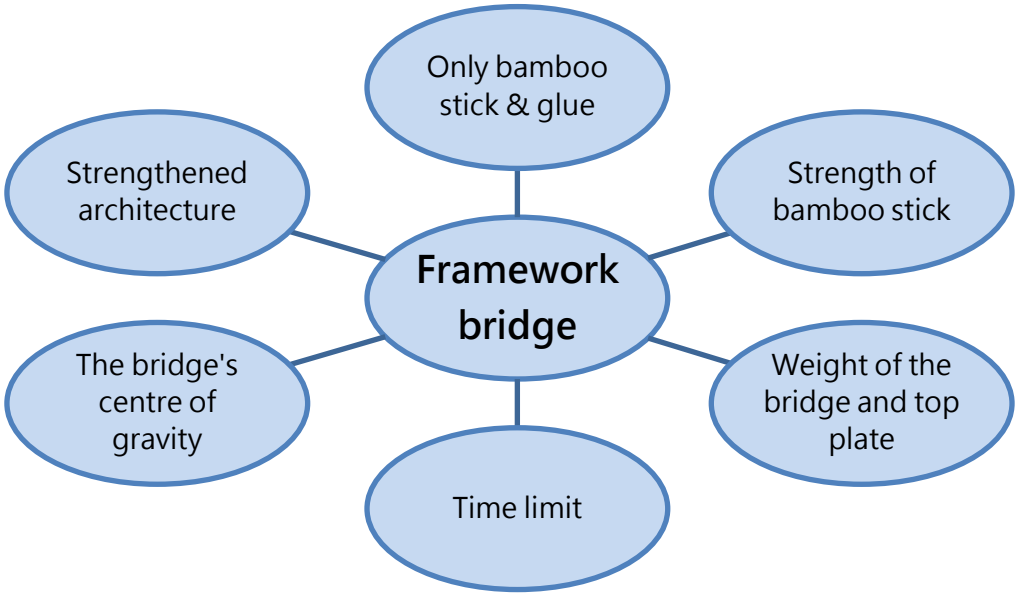
6. Required materials

(a) Bamboo stick (240mm long x 40 sticks)

(b) Glue / white glue / hot melt glue

7. Activity contents

(a) Consideration factors



In designing and making the frame bridge, the following issues should be considered:

(i) Only limited amount of bamboo sticks and glue can be used

(ii) How to increase the strength of the framework

(iii) How to make good use of the glue

(iv) The weight of the bridge and top plate

(v) Effects of extra weights on the centre of gravity

(vi) Time is limited

(b) Members discuss, test and modify:

(i) Various methods to increase the strength of the framework

(ii) Which parts of the bridge need stronger materials

(iii) Methods to carry a greater weight with less materials

8. Making the bridge:

(a) Sketch the bridge design on an A3 paper with full-scale (full scale drawing of the side view of the bridge).

(b) According to the design drawing and the length of the rods, cut the bamboo sticks to appropriate length and join one side of it with the glue (should pay attention to safety when using glue gun and avoid being burned).

(c) Use the same method to join the other side of the bridge.

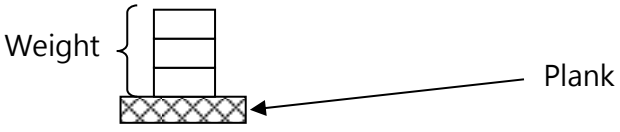
(d) When both sides of the bridge have been shaped, clamp them vertically and separate them in parallel with appropriate distance apart.

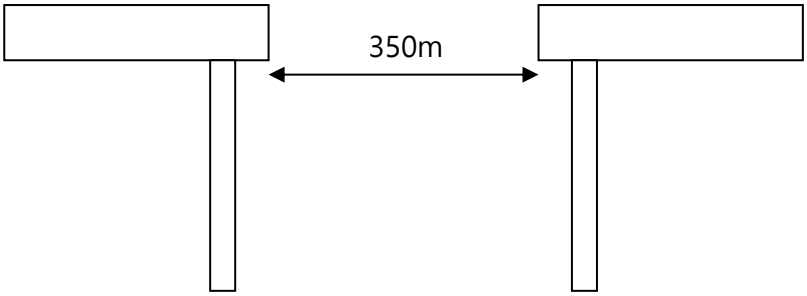
(e) Finally, use the remaining connection rods to glue together the left and right sides of the framework to complete the entire bridge.

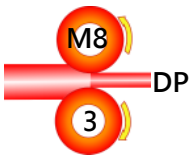
9. Competition:

Add weights to the plank on the bridge framework until the bridge is broken or deformed and the plank or weights fall down. Maximum loading of the bridge will be divided by the weight of the bridge itself before falling down of the plank or weights - the one with the highest loading ratio will win.

$$\text{Loading ratio} = \frac{\text{Maximum loading for the bridge}}{\text{Weight of the bridge itself}}$$







Our design:

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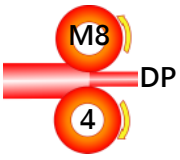
Print this page with A3 paper, or replace with the p 4x

Full scale diagram of the side view of the bridge



Our bridge:

Sketch or affix photos

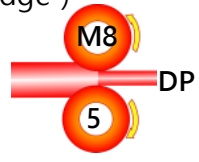
Our results:

The total weight of our bridge is:_____ grams

The best result in the class is:_____ grams / grams

The loading that can be carried by our bridge is:_____ grams

The loading ratio of our bridge:_____ grams / grams (loading ÷ weight of bridge)



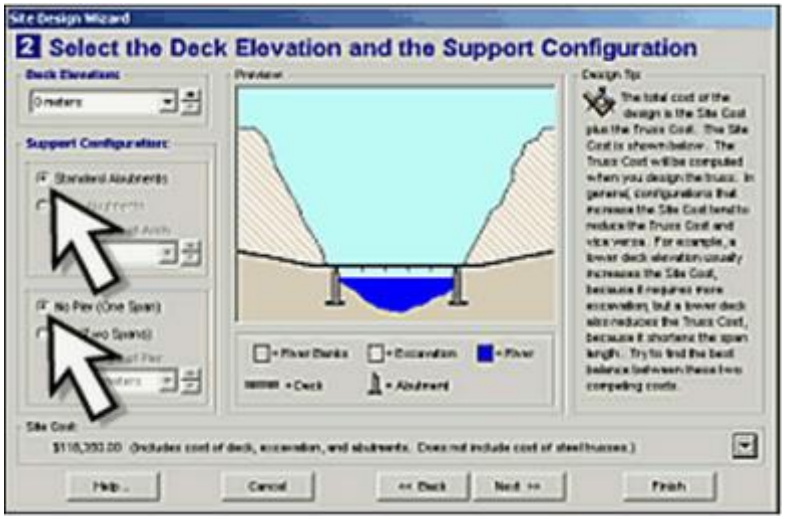
References

Bridge designer (Computer Program)

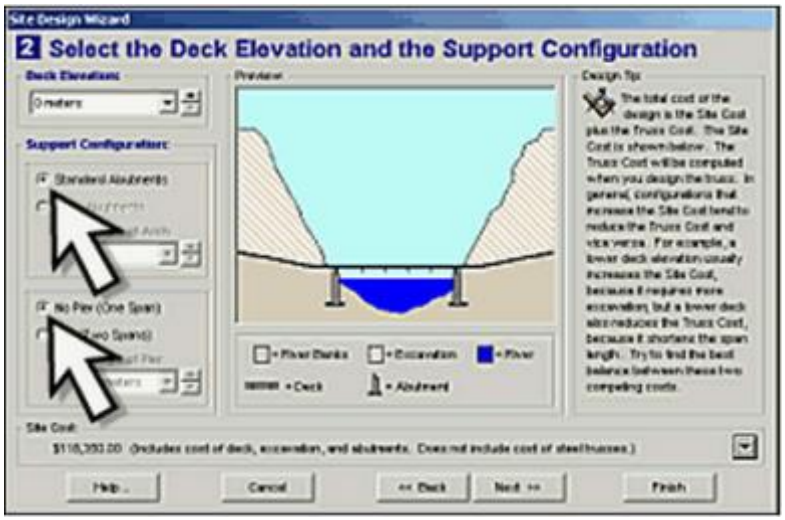
1. Download the latest version of West Point Bridge Designer from the Internet - Freeware
2. Install on the computer and open it
3. Design and test the bridge

(i) Design a new bridge

(ii) Select a lower position

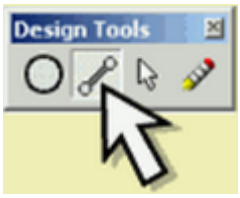


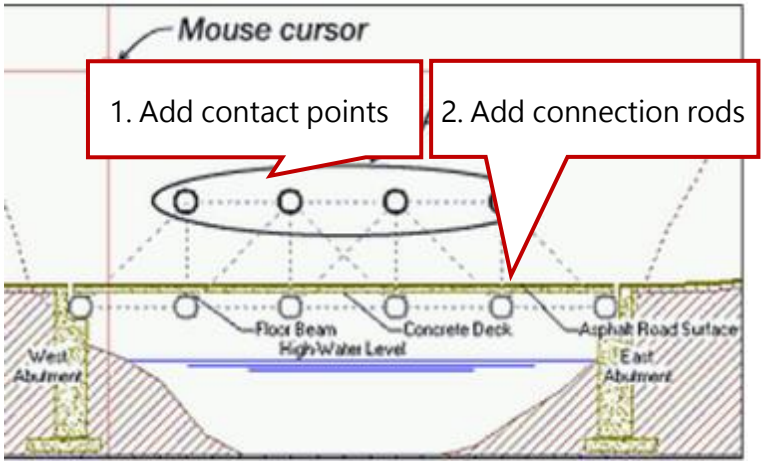
(iii) Let the computer provide a simple design for you



References

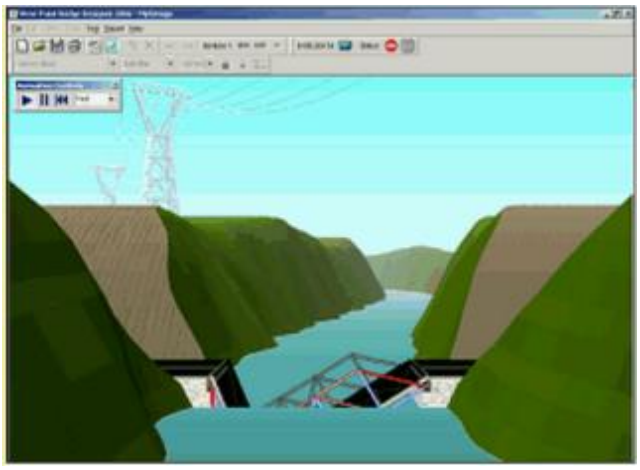
(iv) Design your own later on





(v) Conduct testing after completion of the design, the redder in colour of the connection rod indicates the higher pressure it experiencing whereas the bluer indicates larger tensile force.

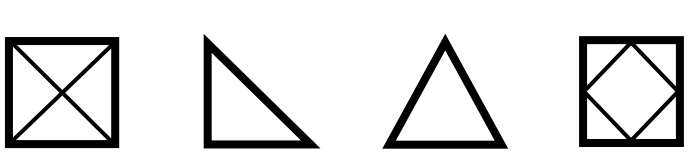
(vi) If the bridge collapses, it would mean poor design or there is something wrong with the material.



(vii) In this case you need to change the material or the size of the connection rods.

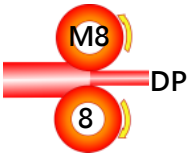
References

4. In order to enhance the strength of the entire bridge, which structural unit should we use?



☐ ☐ ☐ ☐ ☐ Other shapes

5. Our initial design after adopting the above structural unit:



Our design

References

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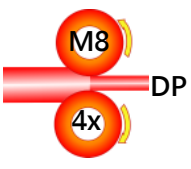
Full-scale drawing of the side view of the bridge



Our design

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