DESIGNING AND MAKING A 'HI-TECH' PEN

WHAT YOU WILL LEARN

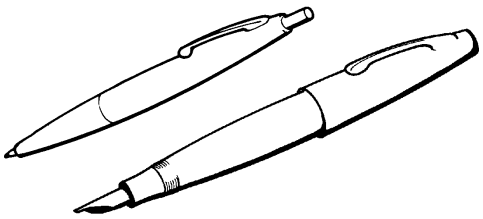
After completing this project, you should understand:

- That *apparently* simple things such as pens require complex manufacturing processes.
- How to measure and cut rod and tubing.
- How to use a lathe for facing off and turning materials.
- How to measure diameters and length accurately.
- The importance of quality control in making several identical things.

After completing this project, you should be able to:

- Work to a design brief and write a specification.
- Recognise design constraints when designing.
- Turn metal and plastics on a lathe with precision.
- Make something that requires the assembly of several parts.

A pen is something we all take for granted. They seem simple enough: they contain ink which flows off a point to make marks on paper. Even simple looking pens are complicated products and it is only recently that so many types have been available Examples include: ball-points, felt-tip, fibre-tip, roller ball pens and so on.



The pen took hundreds of years to evolve into the type we use now.

Egyptians used Calamus reeds as pens because they were hollow and could carry ink.

The need for strength and flexibility at the writing point led to the use of quills. They were used from the 5th century right through to 1850 and, at the peak of their popularity, Britain imported 30,000,000 per year.

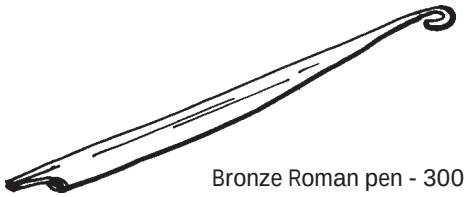
Before the use of quills, the Romans had made tubular bronze pens with a slit in the tip to improve flexibility.

Because quills did not last long in use, people tried to make metal nibs with the same flexibility as quills.

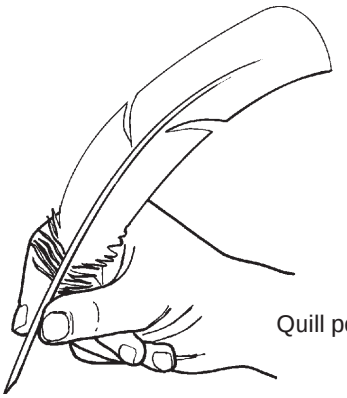
The inks were quite corrosive so early nibs were made of silver.

Improvements in inks made it possible to use steel and the tremendous development of nibs between 1800 and 1830 began. Replacing the quill with steel nibs provided a great business opportunity.

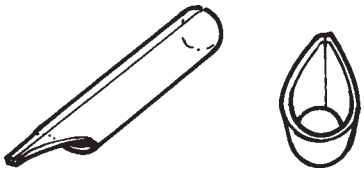
Calamus reed pen - 1300 BC



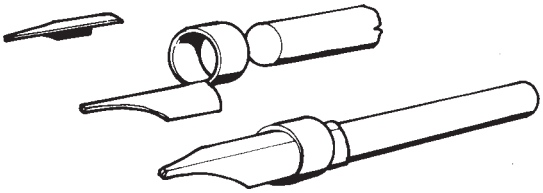
Bronze Roman pen - 300 AD



Quill pens - 500 AD



Tubular silver nib - French - 1656



Steel nib made in two halves - 1800

Soon after the introduction of steel nibs and possibly because of the great interest in their development the first 'fountain' pen appeared in which the pen carried its own ink supply.

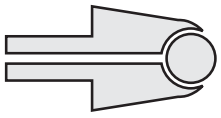
The invention of the rubber ink sac made filling the pen easier. Releasing the sac after squeezing drew ink into the pen as the sac returned to its original shape.

The need to mark on rough surfaces, probably wooden packing cases, led an American to invent the first Ball Point pen. The idea did not succeed because of the lack of a suitable ink.

Biro invented ink suitable for ball points in 1937 and by 1960 the production of throw away ball points by one company had reached 53,000 000 per year. When first introduced in 1945, 10,000 were sold on the first day by one big American store.

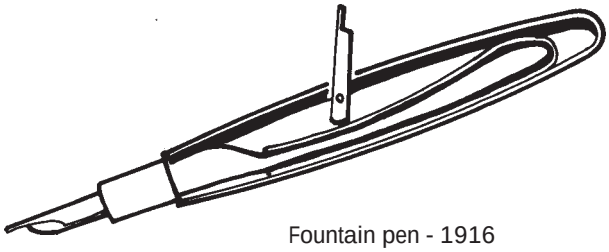
In 1964, the Japanese invented the fibre tipped pen, which had a softer writing point.

Most pens we use now can be called ‘hi-tech’ because they use new materials and it is only possible to make them cheaply in large numbers by using modern manufacturing methods.
Foe example, every ball-point pen re-fill has to be made with greater precision than many of the parts of a space shuttle! This is because the steel ball at the tip has to have enough room to turn in its socket but not allow ink to flood out.

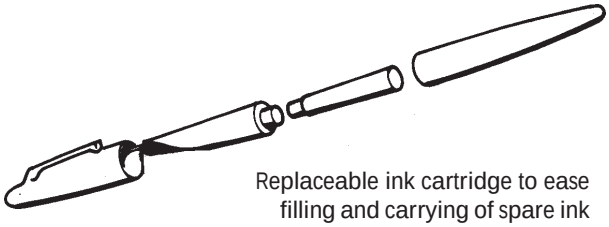


A ball-point pen tip

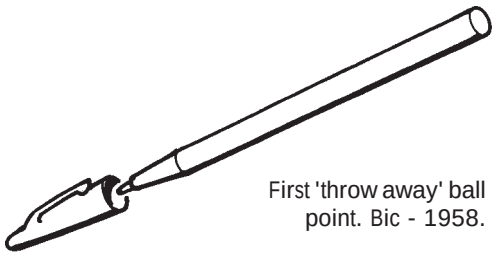
The gap between the ball and socket is hardly wide enough to measure. Although it would be impossible for you to make a ballpoint refill, you can design and make the pen for one to go in with some of the methods that are used to make pens in industry.



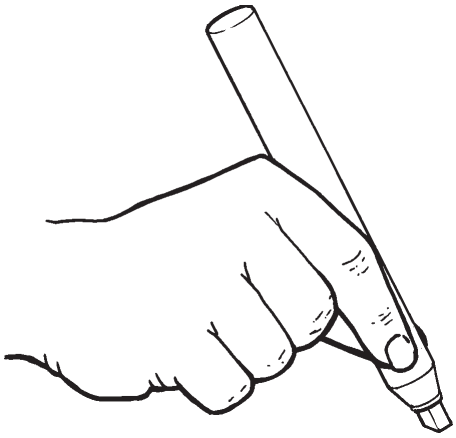
Fountain pen - 1916



Replaceable ink cartridge to ease filling and carrying of spare ink



First 'throw away' ball point. Bic - 1958.



Felt tipped pens

YOUR TASK

◀ DESIGN BRIEF

Design and make a pen that uses a ballpoint refill. The pen is for use by someone who works in an office, and it should be possible to carry it easily in a pocket. As an option, the pen may be sold in a shop 'bubble' packed.

DESCRIBING YOUR TASK

◀ DESIGN SPECIFICATION

First, you need to draw up a *specification* for your pen. A specification is a detailed description of what a product will be like, what it will do, and who will use it.

Here are some questions to help you produce your pen specification:

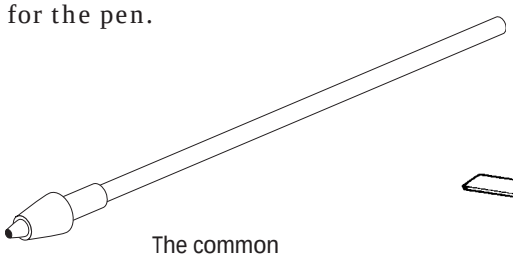
Who will use the pen?
Where will they use it?
How will it normally be held?
(Most ballpoints do not write upside down.)
Will it be stored in a pocket?
Will the ball point need protecting?
What stops ink getting on clothes?
What should the pen cost?

MATERIALS AND COMPONENTS PROVIDED

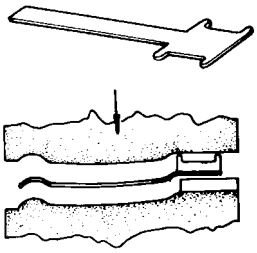
◀ DESIGN CONSTRAINTS

Before you start your design you need to know what materials and other parts are available. You also need to know about the properties of these materials.

First you will need a ball point refill for the pen.

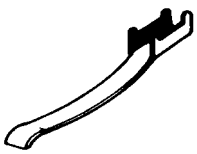


The common 'Bic' type refill

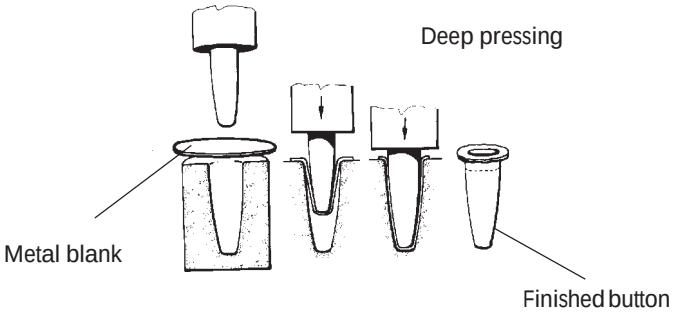


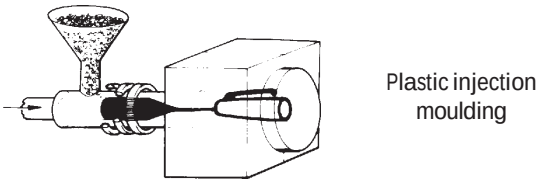
Sheet metal pressing

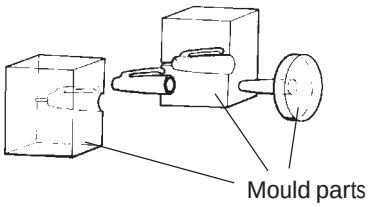
You could use a ready-made pocket-fastening clip. Metal clips are manufactured by pressing sheet metal between two dies.



Other parts of pens such as buttons and caps are often made by the deep pressing of metals or injection moulding. In your project, most of the parts will be made using a lathe.



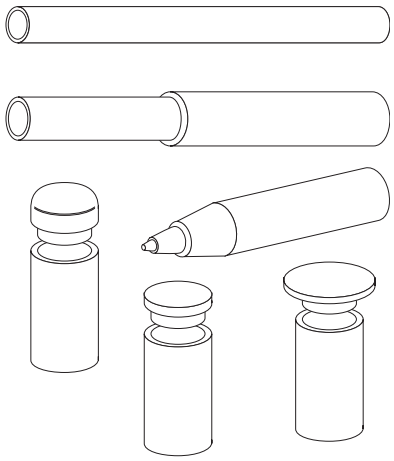




A brightly coloured plastic called *butyrate* is often used for making pens, and it is available in lengths of tubing of different diameters and colours. Suppliers of this material also provide different shaped caps and plugs to fit in the end of tubes.

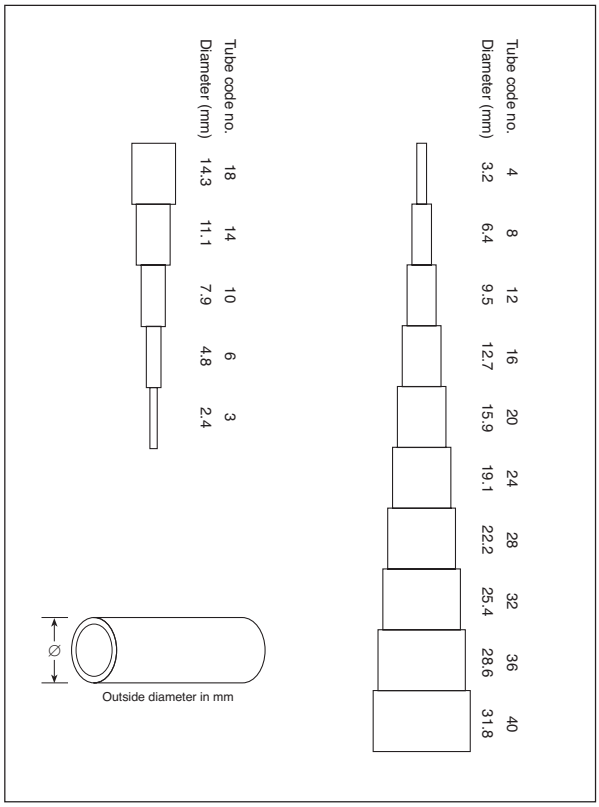
NOTE

A comprehensive pack of pen parts is available from TEP including tubing, refills and metal fittings.



The following is an extract from a supply catalogue. The tables show the diameters of butyrate tubing. The smaller tubes fit inside the larger ones.

MATHS OPPORTUNITY



Which parts can you make?

Which parts do you need to buy in ready made?

To answer these questions you have to ask yourself several others - e.g.,

How do the two options affect the design, cost and speed of making ?
Is buying quicker than making?
How easy would parts be to make?
Is the equipment and material available to make parts?

WORKING OUT YOUR DESIGN

Once you have researched what is available to make the pen, you now need to think about the design.

- *Set your ideas down on paper.*
- *Play around with your ideas.*
- *Check them against your specification.*
- *Decide which is the best design.*
- *Do a detailed drawing of it.*

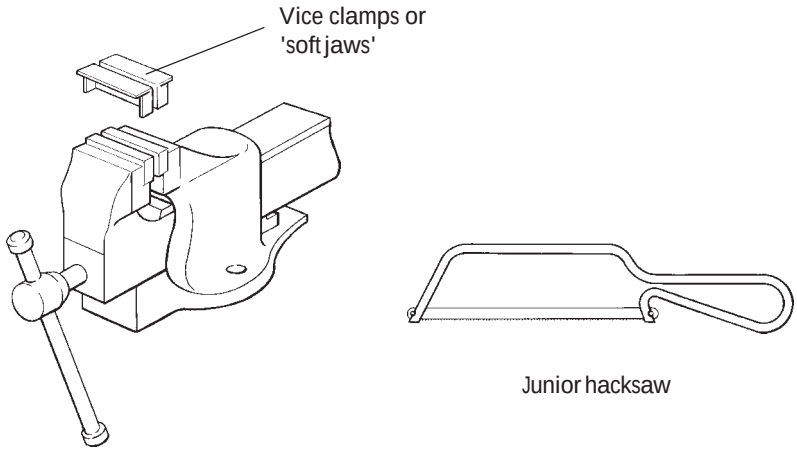
NOTE

See Technology Study Files 3 and 4.

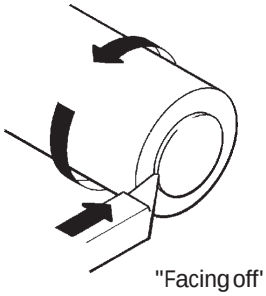
HOW WILL THE PEN BE CONSTRUCTED?

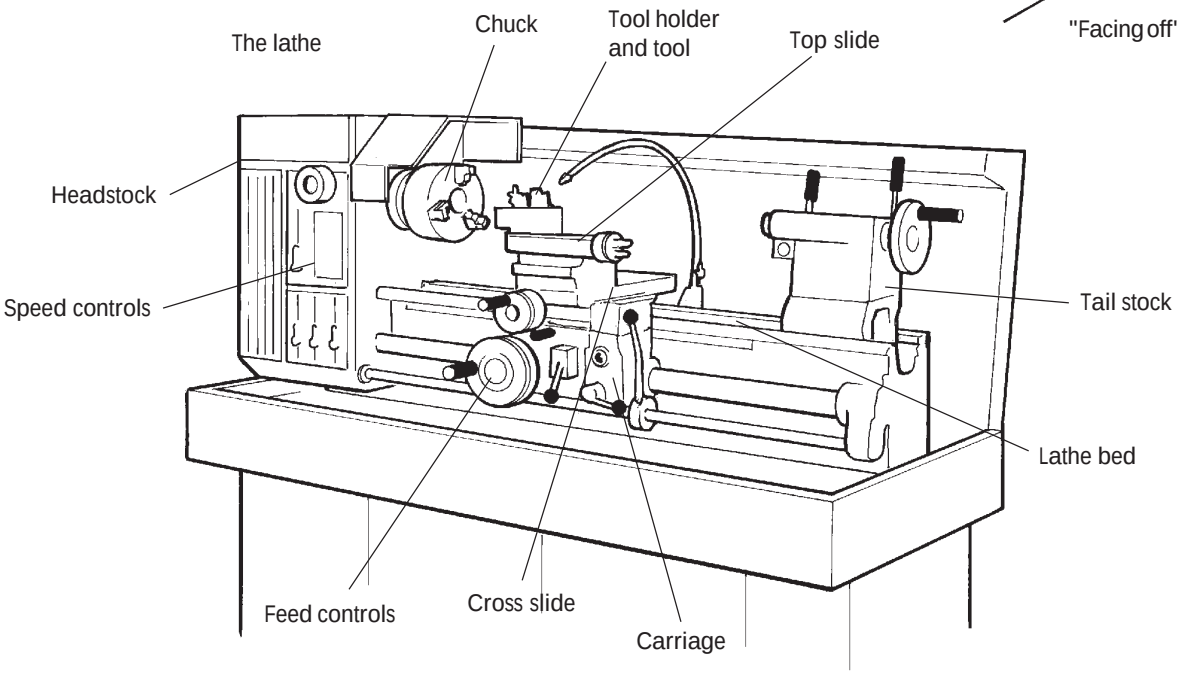
Cutting

Plastic and metal are easily cut using a junior hacksaw. Hold the material in a vice with card or paper between the work and the jaws to prevent scratching. Measure and mark the material to length and cut it off. Make sure you leave an allowance for finishing off the cut ends because these will be rough from the saw cut.

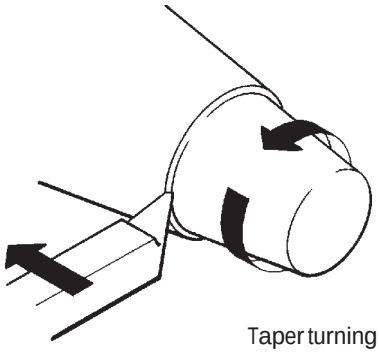


The most accurate way to finish the ends is to use a lathe. This produces a smooth surface and a face at precisely 90° to the *main axis* of the tube (the main axis is an imaginary line running down the middle of the tube).





Use the lathe to turn other pieces to the correct diameter and shape. For example, the refill needs to fit tightly into the end of the pen barrel. You could do this by first turning down a piece of brass to fit the inside diameter of the pen barrel. Then drill a hole in the brass piece for the refill to fit into.



Taper turning

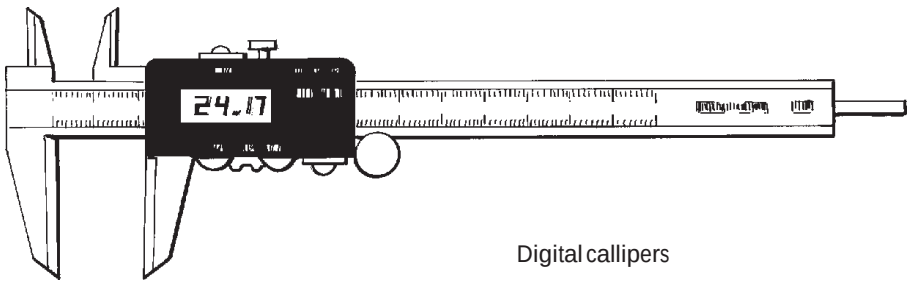
If you make a small part from brass or copper, you can electroplate it to give it a bright silver coloured finish that does not tarnish.

◀ NOTE

See Technology Study File 13.

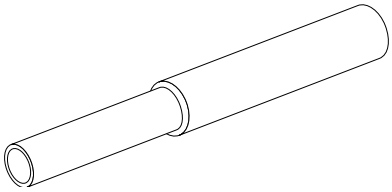
Before you can drill a hole in the brass piece for the ballpoint refill, you need to measure the refills diameter accurately. This can be done with a micrometer, or vernier or digital callipers. Electronic versions of these instruments provide a clear digital read-out. Always select a drill which is slightly undersize because the drilled hole will tend to be slightly larger in diameter than the stated size of the drill.

◀ MATHS OPPORTUNITY

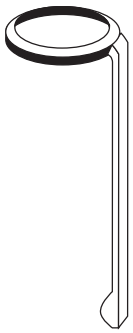


Digital callipers

If your design includes a removable cap to protect the ball point, it is a good idea to select two diameters of tubing that fit one within the other. If this is not possible, select a close match and drill one out using the lathe. (Warning: plastics get hot when they are being drilled. Make sure you feed the drill in and out slowly to get rid of swarf and if possible use a lubricant.)



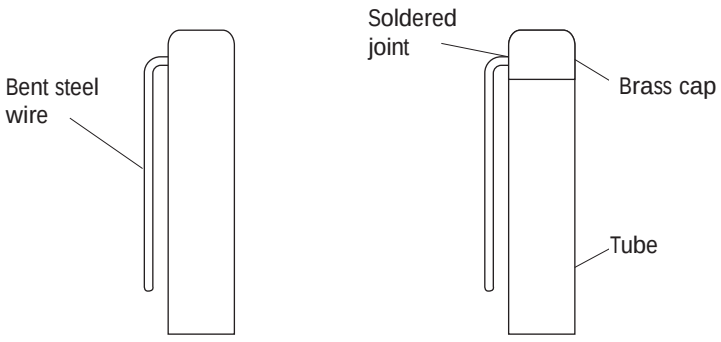
If you use a ready-made pocket clip, the pen barrel may have to be turned down or shaped for the clip to fix on. In many pens, the clip is pressed metal and has a small ring which clips tightly around the pen. If you use this sort, you may need to turn down your pen barrel at the end so the clip fits over tightly.



Ready made clip

Measure the inside diameter of your clip and turn down the barrel until it is slightly more than the inside diameter of the clip - e.g., 0.1mm oversize. This will give a good *interference fit*. (An interference fit is where two or more parts are 'wedged' together. It is often used in manufactured products because it is a cheap and strong way of making joints.)

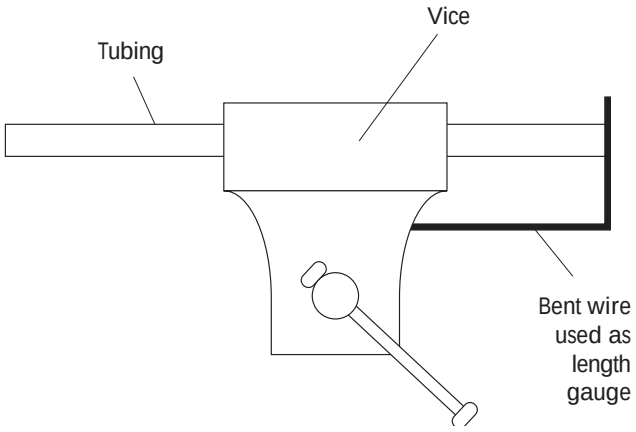
Metal clips can be made using thick wire such as welding rod. This can be bent at 90°, for example, and passed through a drilled hole in the pen barrel. A more secure way of fitting is to solder the clip into a turned metal end cap.



MANUFACTURING IN QUANTITY

If you wish to make more than one pen - e.g., as part of a mini-enterprise project - you need to think about the *production process*. If it takes you 2 hours to make one pen, it should be possible to make 10 identical ones in far less than 20 hours. This is because, the parts can be made quickly in batches or groups. For example, if the lathe is set up with the correct tool for facing off tubes, these can be machined one after the other very quickly.

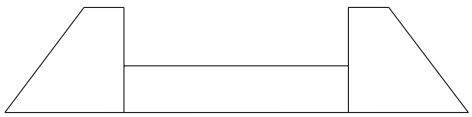
When *production lines* are set up for manufacturing, *jigs and fixtures* are used to speed up operations such as cutting and forming. (Jigs and fixtures are things that assist making.) You could use a very simple jig to speed up the operation of sawing tubes to length. A piece of thick wire bent at 90° and held with Plasticine on the fixed jaw of the vice would act as a length gauge and avoid the need for marking out each length.



A CNC (computer numerically controlled) lathe can be programmed to make a number of identical parts. Such machines are used throughout industry.

QUALITY CHECKING

Checking for quality is very important when products are manufactured in quantity because a manufacturing fault could be repeated many times. When making several pens, for example, you would need to ensure that length of barrels was consistent. A simple length gauge can be made for this purpose.

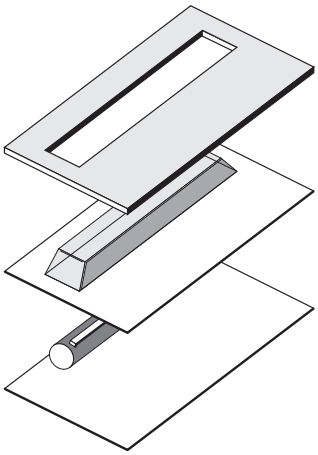


Length gauge using aluminium joined with double sided tape

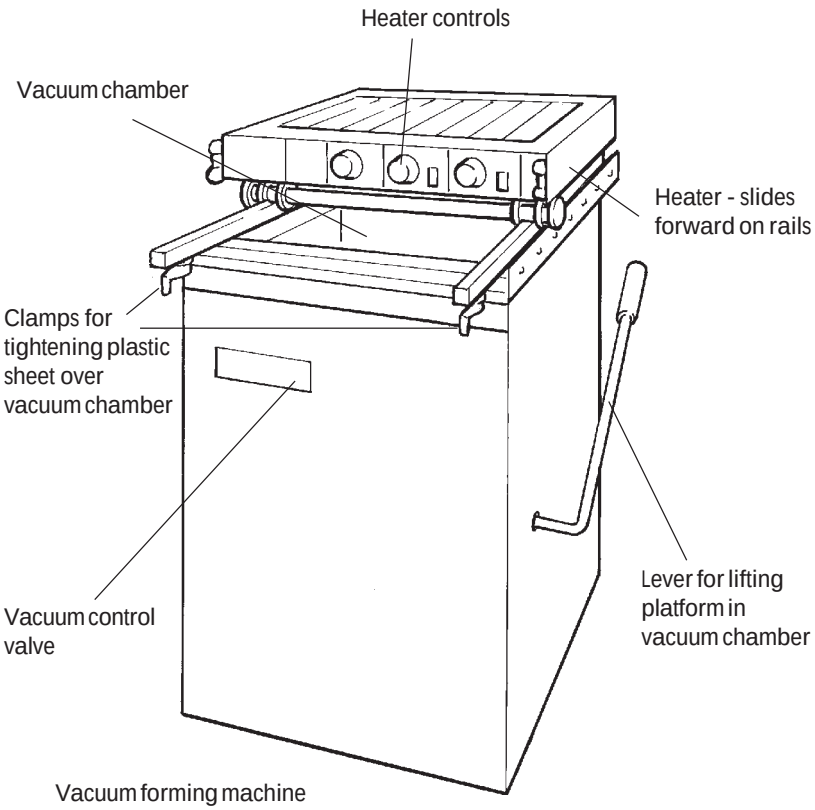
MATHS OPPORTUNITY

PACKAGING THE PEN

When the pen is finished it may need to be packaged so that it can be displayed at the point of sale. This is easily achieved by making a wooden mould over which clear plastic is vacuum formed. In vacuum forming, a plastic sheet is clamped over a vacuum chamber and heated. When air is drawn out of the chamber, the plastic is forced down by atmospheric pressure and will take the shape of a mould placed beneath it.



The final point-of-sales package can be assembled by glueing thin card either side of the plastic moulding as shown. Any graphics can be applied to the card before assembly.



EVALUATING THE PRODUCT

There are a number of things to consider when evaluating the success of your pen (or pens).

1. Does the pen meet your specification? Consider all the points you originally listed.
2. Costs. What did the pen cost to make? How much could you sell it for?
3. Checking against the competition. Compare: quality, unique features, possible selling price.

NOTE

See Technology Study File 12.