

# WORKING WITH POLYMERS

V.Ryan © www.technologystudent.com 2019

This mobile revision pdf is based on detailed work found in the 'EQUIPMENT AND PROCESSES' section. Tap on the green link button below to go to the website.



Tap the blue button to view all work covered by this Revision PDF



V.Ryan © www.technologystudent.com 2019

# WORKING WITH POLYMERS

V.Ryan © www.technologystudent.com 2019

## 1. STOCK FORMS AND SECTIONS

## 2. POLYMERS AND STANDARD FITTINGS / COMPONENTS

## 3. POLYMERS AND WORKSHOP TOOLS AND EQUIPMENT

## 4. FORMING / MOULDING OF PLASTICS

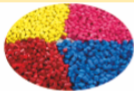
IT IS RECOMMENDED THAT YOU DOWNLOAD THE TWO APPS ON PLASTICS FOUND IN THE MOBILE APP SECTION OF [www.technologystudent.com](http://www.technologystudent.com)

# STOCK FORMS AND SECTIONS

V.Ryan © www.technologystudent.com 2019

**Tap the images** for information / an exercise  
Polymers (plastics) are supplied in a range of forms, sections and shapes.

Companies that intend to process polymers through injection moulding, blow moulding and extrusion, order polymers in the form of granules.



**GRANULES FOR  
INJECTION MOULDING,  
BLOW MOULDING,  
AND EXTRUSION**

Companies shaping polymers through processes such as vacuum forming and compression moulding prefer sheets.



**SHEET FORM.  
VARIETY OF  
SIZES AND  
THICKNESSES**

Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

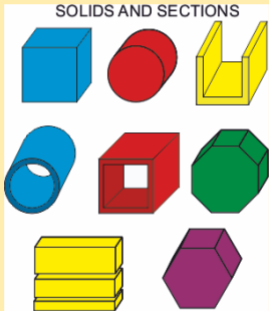


# STOCK FORMS AND SECTIONS

V.Ryan © www.technologystudent.com 2019

Companies often prefer to buy premanufactured solid and hollow sections, as seen below. This depends on the product they are manufacturing

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



# STOCK FORMS AND SECTIONS

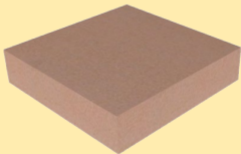
V.Ryan © www.technologystudent.com 2019

## FOAMS

**Styrofoam** is an excellent model making material. It is very light and easy to cut and shape using a hot wire cutter. It can also be shaped with hand tools and files. It can be painted using water based paints (emulsion paints) giving a really good finish.

**Lightweight Polyurethane Model Board** is another popular foam polymer. They are order by length x width x thickness.

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



# STOCK FORMS AND SECTIONS

V.Ryan © www.technologystudent.com 2019

When ordering materials:

Granules are ordered by weight and pigment  
(colour)

Sheets are ordered by length x width x  
thickness (gauge)

Solid Rounds are ordered by diameter x length.

Hollow round sections are ordered by diameter  
x wall thickness x length

Solid square sections are ordered by height x  
width x length

Square sections are ordered by height x width x  
wall thickness

AND SO ON.....

**Tap the link button** for a POSTER on stock  
forms.



Tap the red button to return to the  
Contents page



## POLYMERS AND STANDARD FITTINGS / COMPONENTS

V.Ryan © www.technologystudent.com 2019

Standard fittings and components used with materials such as wood and metal, can generally be used with polymers.

The following slides will take through a range of standard fittings and components

Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

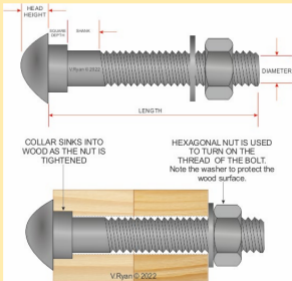


# COACH BOLTS

V.Ryan © www.technologystudent.com 2019

The coach bolt has a square collar under the domed head and this locks into the wood when the nut is tightened. A washer is normally placed before the nut to stop it sinking into the polymer as it is turned.

**Tap the image** for more information



Tap the blue button for the next JOINTS page.



Tap the red button to return to the Contents page



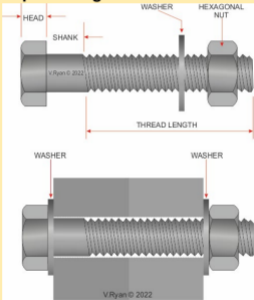


# MACHINE BOLTS

V.Ryan © www.technologystudent.com 2019

Two spanners are needed to tighten this nut and bolt. The first spanner fits round the hexagonal head of the bolt and a second spanner is used to tighten the hexagonal nut.

**Tap the image** for more information



Tap the blue button for the next  
JOINTS page.



Tap the red button to return to the  
Contents page



# EXERCISE

V.Ryan © www.technologystudent.com 2019

**Tap the image** for more information  
and an exercise on coach / machine bolts



Tap the blue button for the next  
JOINTS page.



Tap the red button to return to the  
Contents page

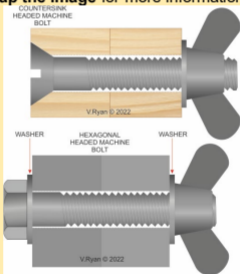


# COUNTERSUNK BOLT AND WING NUT

V.Ryan © www.technologystudent.com 2019

The countersunk machine screw fits level with the surface of the wood/metal/plastic. A screwdriver is used to keep the bolt still whilst the wing nut is tightened by hand. The 'wings' of the wing nut, are designed to be comfortable when tightening the nut and bolt.

**Tap the image** for more information



Tap the blue button for the next JOINTS page.



Tap the red button to return to the Contents page



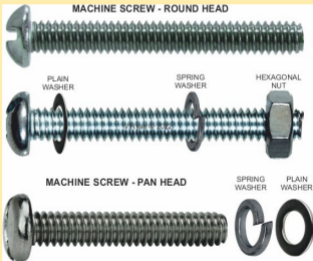
# OTHER COMMON BOLTS

V.Ryan © www.technologystudent.com 2019

**Tap the images** for more information and an exercise

A plain washer prevents the nut sinking into the surface of the wood/plastic/metal

If there is a need to prevent a nut and bolt loosening a spring washer is used.



Tap the blue button for the next JOINTS page.



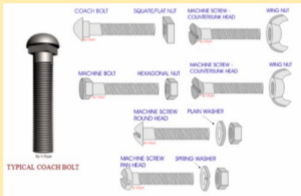
Tap the red button to return to the Contents page



# BOXED LEARNING EXERCISE

V.Ryan © www.technologystudent.com 2019

Tap the image for a revision exercise



Tap the blue button for the next  
JOINTS page.

Tap the red button to return to the  
Contents page

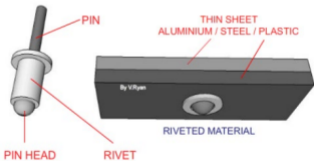


# POP RIVETING

V.Ryan © www.technologystudent.com 2019

Pop riveting is a technique that is used to join thin pieces of metal and it can also be used to join plastic sheet. The rivet has two parts; the pin and the rivet. The pop rivet pliers are used to pull the pin through the rivet and as this happens the rivet is deformed slightly so that it joins the metal or plastic pieces. This technique is used where the metal or plastic is thin and where the joint does not have to be very strong.

**Tap the image** for more information



Tap the blue button for the next  
JOINTS page.



Tap the red button to return to the  
Contents page

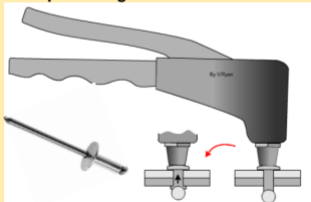


# POP RIVETING

V.Ryan © www.technologystudent.com 2019

The two pieces of plastic or aluminium are drilled slightly larger than the rivet. The pop rivet is passed through both holes in the sheet plastic / aluminium. Rivet pliers are pushed on to the pin of the rivet and the handles are pulled together. The pin head is pulled into the rivet and the end of the rivet expands. Eventually the pin breaks off, leaving the rivet permanently fixed in position, holding the two pieces of plastic / aluminium together.

**Tap the image** for more information



Tap the blue button for the next  
JOINTS page.



Tap the red button to return to the  
Contents page



# POP RIVETING - EXERCISES

V.Ryan © www.technologystudent.com 2019

**Tap the link buttons** for exercises



Tap the blue button for the next page.



Tap the red button to return to the  
Contents page





# SELF-TAPPING SCREWS

V.Ryan © www.technologystudent.com 2019

These are normally used to cut a thread in metal. A hole is drilled in the metal, a fraction smaller than the width of the screw. The self-tapping screw is then turned into the hole cutting a thread. This type of screw works well with plastics.

**Tap the images** for more information and an exercise



Tap the blue button for the next page.



Tap the red button to return to the Contents page



# TENSOL CEMENT

V.Ryan © www.technologystudent.com 2019

Tensol cement is a type of glue called 'dichlormethane methyl methacrylate' and produces a chemical weld between two surfaces. The glue is applied to the surfaces to be glued and they are pressed together. They should be clamped for 24 hours and this gives a permanent joint.

**Tap the images** for more information and an exercise



Tap the blue button for the next page.



Tap the red button to return to the Contents page



# CONTACT / IMPACT ADHESIVE

V.Ryan © www.technologystudent.com 2019

Contact adhesive can be used to join plastics. The adhesive is applied to both surfaces and when the surfaces appear to be dry they are pushed together. If the two pieces of material are left for a number of hours, they are virtually impossible to take apart.

**Tap the images** for more information and an exercise



Tap the blue button for the next page.



Tap the red button to return to the Contents page



# EPOXY RESIN

V.Ryan © www.technologystudent.com 2019

Epoxy Resin is a two part adhesive. One tube is the glue and the other is the hardener / catalyst. The catalyst speeds up the hardening / drying process. When the two 'glues' are mixed together the solution hardens very quickly. This is a permanent glue although it can be quite 'messy' to use. It can be used to join almost any material.

**Tap the images** for more information and an exercise



Tap the blue button for the next page.



Tap the red button to return to the Contents page



# CYANOACRYLATE (SUPER GLUE)

V.Ryan © www.technologystudent.com 2019

Cyanoacrylate is an extremely popular glue and is found in almost every household. Some super glues are liquid which is helpful when there is a need to allow the glue to flow along a joint line.

Other super glues are in a gel form, which means more precise application can be made.

**Tap the images** for more information and an exercise



Tap the blue button for the next page.

Tap the red button to return to the Contents page



# CYANOACRYLATE (SUPER GLUE)

V.Ryan © www.technologystudent.com 2019

A hot glue gun is a very useful tool for joining modelling materials and even more substantial materials can be fixed together with it. 'Sticks' of solid glue are pushed into the back of the gun, the trigger is pressed pushing the glue stick forward and molten glue comes out of the nozzle. The glue is manufactured from thermoplastics.

**Tap the images** for more information and an exercise



Tap the blue button for the next page.



Tap the red button to return to the Contents page



# CYANOACRYLATE (SUPER GLUE)

V.Ryan © www.technologystudent.com 2019

Liquid solvent is applied using a brush or a syringe (often supplied with the glue). As it is a liquid, it is drawn along joints and surfaces through a process called capillary action. Care must be taken, as the glue damages exposed surfaces (as it melts the surfaces of the materials forming a 'weld joint').

**Tap the images** for more information and an exercise



Tap the blue button for the next page.



Tap the red button to return to the Contents page



# HINGES

V.Ryan © www.technologystudent.com 2019

Hinges can be regarded as a standard fitting. They are used on wood, metal and plastics. They are fitted to plastics with screws, glues and even welded through a heat treatment process. Some common standard hinges are shown below

**Tap the image** for information / an exercise

**BUTT  
HINGE**



**BUTTERFLY  
HINGE**



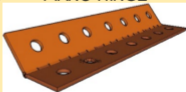
**FLUSH  
HINGE**



**BARREL HINGE**



**PIANO HINGE**



Tap the red button to return to the Contents page



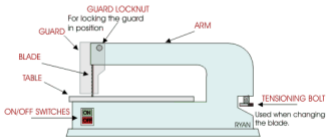


# THE FRETSAW

V.Ryan © www.technologystudent.com 2019

The fretsaw is a general workshop machine. It is used to cut and shape light materials such as perspex, MDF and plywood. These can be used to cut very detailed shapes and they are supplied with different types of blade according to the material that is to be cut. Plastics such as acrylic, should have a layer of masking tape on the surface, before cutting, just in case the material shatters.

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



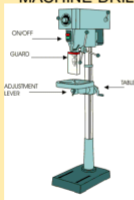
# THE DRILLING MACHINE

V.Ryan © www.technologystudent.com 2019

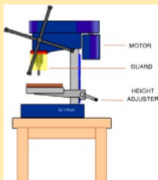
There are two types of machine drill, the bench drill and the pillar drill. Both are used for drilling holes through materials including a range of woods, plastics and metals. The material should be clamped, placed in a machine vice or bolted down, for safety. Plastics such as acrylic, should have a layer of masking tape on the surface, before drilling, just in case the material shatters.

**Tap the images** for information / an exercise

MACHINE DRILL



BENCH DRILL



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



# SUITABLE DRILL BITS

V.Ryan © www.technologystudent.com 2019

Tap the images for information / an exercise

## Twist Drill

Used for drilling holes.

A normal drill set will include sizes from 1mm to 14mm.



## Hole Saw

For large diameters a 'hole saw' can be used.

Interchangeable sizes



## Countersunk Bit

Creates a hole that allows countersunk screws to be level with the surface



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

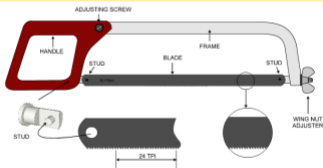


# SAWS SUITABLE FOR PLASTICS

V.Ryan © www.technologystudent.com 2019

The **hacksaw** is used to cut steel and other metals. It can also be used to **cut plastics**, although it is not normally used to cut woods. It is sometimes called an adjustable hacksaw because the length of the frame can be altered to hold blades of different sizes. Blades are supplied in two lengths, 250mm and 300mm. If the adjusting screw is unscrewed, the frame can be pushed into the handle so that the smaller blades fit the hacksaw.

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



# SAWS SUITABLE FOR PLASTICS

V.Ryan © www.technologystudent.com 2019

The Junior Hacksaw. This is a small version of the full sized hacksaw. It has a smaller blade which has 'fine' teeth, making it a little easier to use when cutting plastics. Other smaller saws suitable for plastic include the 'abrafile', ideal for cutting in any direction and the piercing saw for very fine and accurate work.

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

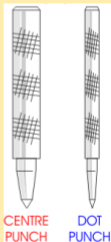


# PUNCHES

V.Ryan © www.technologystudent.com 2019

Both the centre and dot punches are used in the same way. A ball pein hammer is used to tap the head of the punch and this delivers enough force to the point of the punch to put a small indentation into the surface of the material. This is important when drilling plastic accurately and safely.

**Tap the image**  
for information /  
an exercise



Tap the blue button for the next  
slide / page.



Tap the red button to return to the  
Contents page

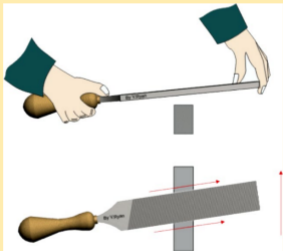


# HAND FILES

V.Ryan © www.technologystudent.com 2019

Hand files are used in the workshop to smooth rough edges. They can be used to smooth a range of materials including metals such as brass and steel to plastic based materials. They are made from high carbon steel and they are heat treated so that they are tough and durable.

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

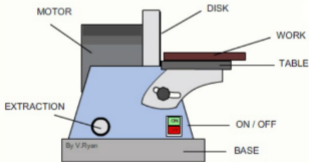


# THE DISK SANDER

V.Ryan © www.technologystudent.com 2019

The Disk Sander is used to smooth materials such as woods and **plastics**. It is also used to remove small amounts of waste material. It is a dangerous machine if safety is ignored. Goggles must be worn at all times. Hands and fingers must be kept as far away from the rotating disk as possible. A guard, making it impossible to use the wrong portion of the rotating disk must be in permanent position.

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



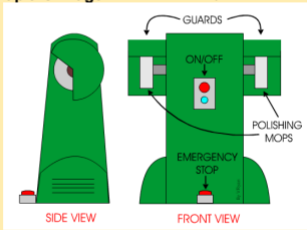


# THE POLISHING MACHINE

V.Ryan © www.technologystudent.com 2019

The edge of a piece of plastic is smoothed using hand files, sanding disks, wet and dry paper and finally the **buffing / polishing machine**. It is used to polish the plastic 'edge'. The two 'mops' spin at high speed when the 'on' switch is pressed. If the material is carefully pressed against the mop and moved backwards and forwards it will be polished.

**Tap the image** for information / an exercise



Tap the red button to return to the Contents page

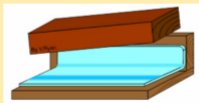
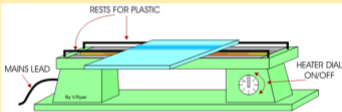


# THE STRIP HEATER (LINE BENDER)

V.Ryan © www.technologystudent.com 2019

One of the most popular methods of shaping plastic materials like acrylic, is to fold (bend) it on a 'strip heater'. A heating element extends along the length of the strip heater. The plastic is warmed on the 'heater', it becomes pliable and is placed in a mould, bending / holding it to the required shape. When it cools, it can be removed, set to the angle

**Tap the image** for detailed information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

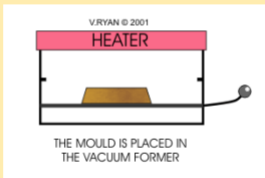


# VACUUM FORMING

V.Ryan © www.technologystudent.com 2019

Vacuum forming is used when an unusual shape like a 'dish' or a box-like shape is needed. Many everyday items have been vacuum formed in this way. The process starts with making a former, over which, the plastic will be 'formed'.

**Tap the images** for detailed information / an exercise



Tap the blue button for the next slide / page.



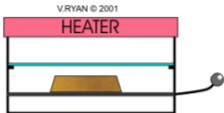
Tap the red button to return to the Contents page



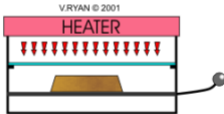
# VACUUM FORMING

V.Ryan © www.technologystudent.com 2019

**Tap the images** for detailed information / an exercise



PLASTIC SHEET IS PLACED ABOVE  
THE MOULD AND CLAMPED  
SECURELY.



THE ELECTRIC HEATER IS TURNED ON  
TO WARM THE PLASTIC SHEET.

Tap the blue button for the next  
slide / page.



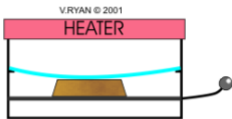
Tap the red button to return to the  
Contents page



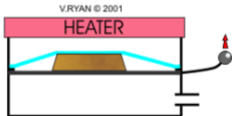
# VACUUM FORMING

V.Ryan © www.technologystudent.com 2019

Tap the image for detailed information / an exercise



THE PLASTIC BECOMES FLEXIBLE  
WHEN HEATED



MOULD MOVED UPWARDS

Tap the blue button for the next  
slide / page.



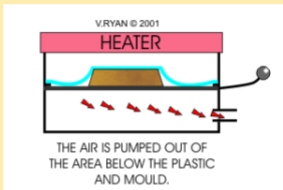
Tap the red button to return to the  
Contents page



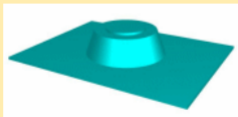
# VACUUM FORMING

V.Ryan © www.technologystudent.com 2019

**Tap the images** for detailed information /  
an exercise



The plastic sheet is removed from  
the vacuum former.



Tap the blue button for the next  
slide / page.



Tap the red button to return to the  
Contents page

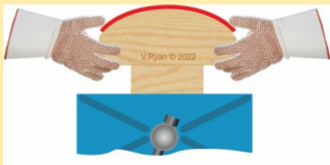


# DRAPING / DRAPE FORMING OF PLASTICS

V.Ryan © www.technologystudent.com 2022

Draping is ideal when shaping / forming plastics, as it is a relatively cheap and simple process. It involves heating a thermoplastic (e.g. acrylic) in an oven and then pressing it against a single mould (sometimes called a mandrel or former). When the plastic has cooled, it remains in the shape / form of the mould.

**Tap the images** for detailed information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

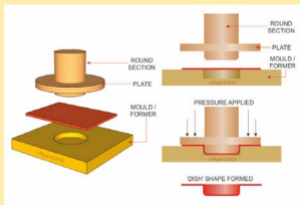


# PRESS MOULDING

V.Ryan © www.technologystudent.com 2022

Press moulding - 'pressing' a mould into a sheet of heated and pliable acrylic, so that it takes on the form of the mould. Below, a small strip of heated acrylic is placed on top of a piece of pine, directly over a 'blind' hole (the former / mould ). A piece of round section of wood is pressed into the acrylic, forcing a portion of the acrylic into the blind hole, forming a 'dish' shape.

**Tap the images** for detailed information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page





# DOMING PLASTICS

V.Ryan © www.technologystudent.com 2022

A thermoplastic sheet, such as acrylic, is heated in an oven and formed into a dome, using pressurised air. Domes are very strong structures and are ideal for light covers and fitments, security camera covers, underwater devices including large scale submerged viewing areas and hygiene / display covers for food.

**Tap the images** for detailed information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

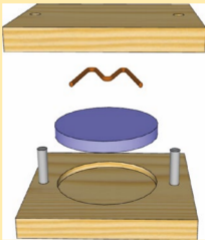


# PLASTIC MEMORY

V.Ryan © www.technologystudent.com 2022

When a thermoplastic is heated until it becomes pliable / flexible, it can be moulded into another shape. When the same thermoplastic is heated again, it will return to its original shape / form. This is called 'plastic memory'. This is a very useful physical property.

**Tap the images** for detailed information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

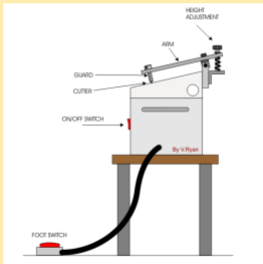


# THE PROFILE CUTTER

V.Ryan © www.technologystudent.com 2019

The profile cutter is used for trimming vacuum formed 'plastic'. It produces a smooth, professional finish to the edge .

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

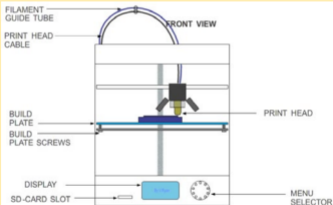


# FILAMENT SPOOL 3D PRINTERS

V.Ryan © www.technologystudent.com 2019

3D printers construct a 'model' by building up layer upon layer of PLA, Nylon or ABS, fed from spool, usually at the back of the printer. Each layer is a fraction of a millimetre and building even a small model can take sometime. Filaments tend to be 2.85mm diameter (known as 3mm filament), rolled on to a spool. The spool fits on a roller, normally on the back of the 3D printer

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

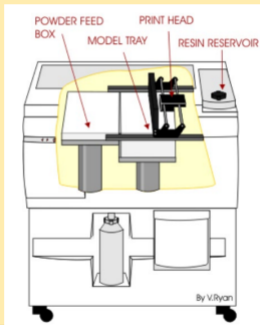


# STEREOLITHOGRAPHY

V.Ryan © www.technologystudent.com 2019

Layers are built up one at a time. A laser 'solidifies' a layer of polymer powder, layer after layer, until the product is complete.

**Tap the image** for detailed information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



# PRACTICAL APPLICATION OF 3D PRINTING

V.Ryan © www.technologystudent.com 2019

3D printing is a process, whereby a 3D CAD design is manufactured on a machine capable of producing a solid form / model.

3D printing is already important as an industrial process, in the production of some tools, textiles, toys, jewellery and a range of components. The technology also has been used in the medical world, in the manufacture of custom made prosthetic limbs and hearing aids. It even has a practical application in the world of dentistry. Research has been taking place for several years on 'bioprinters'. These are complex 3D printers, capable of printing bio-structures, used in surgery.

Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



# 3D PRINTING – LINKS TO INFORMATION AND EXERCISES

**Tap the link buttons** for detailed information / an exercises on 3D Printing

V.Ryan © www.technologystudent.com 2019



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

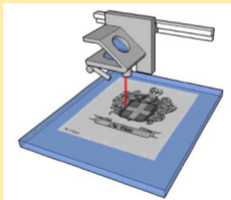


# LASER CUTTING MACHINES

V.Ryan © www.technologystudent.com 2019

Laser cutting / etching machines are quite simple in the way they work. The lens system that controls the position of the laser, is itself moved by a motorised slide control system. This allows movement in any direction. The control system moves according to the CAD design. An industrial laser cuts or etches the surface of plastics such as acrylic. NOT ALL PLASTICS CAN BE LASER CUT / ETCHED.

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page



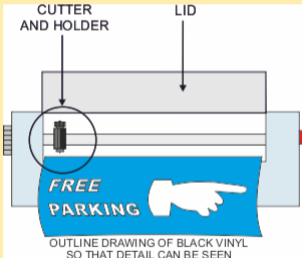


# VINYL CUTTERS

V.Ryan © www.technologystudent.com 2019

Vinyl cutters are used to cut shapes from sticky back plastic. They are ideal for making road signs, shop signs. The design is first drawn CAD software and exported to the cutter

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

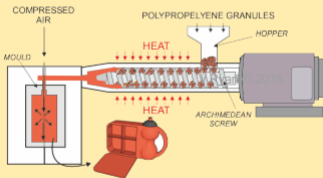


# INJECTION MOULDING

V.Ryan © www.technologystudent.com 2019

Materials such as polystyrene, nylon, polypropylene and polythene can be used in a process called injection moulding. These are thermoplastics - this means when they are heated and then pressured in a mould they can be formed into different shapes.

**Tap the image** for detailed information / an exercise on Injection Moulding



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

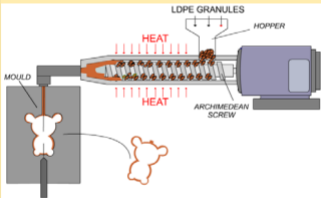


# BLOW MOULDING

V.Ryan © www.technologystudent.com 2019

HDPE (high density polyethylene) is ideal for this type of manufacturing technology. The HDPE granules / powder is placed into the hopper. It drops down on to a rotating thread and travels along its distance, being heated and becomes fluid. When it reaches the mould, **compressed air** is also blown into the mould. This pushes the HDPE around the edges of the mould, forming a hollow shape.

**Tap the image** for detailed information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

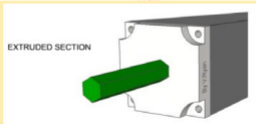
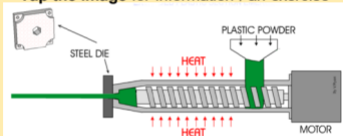


# EXTRUSION OF PLASTICS

V.Ryan © www.technologystudent.com 2019

A machine used to extrude materials is very similar to the injection moulding machine. A motor turns a thread which feeds granules of plastic through a heater. The granules melt into a liquid which is forced through a die, forming a long 'tube like' shape. The extrusion is then cooled and forms a solid shape. The shape of the die determines the shape of the tube.

**Tap the image** for information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

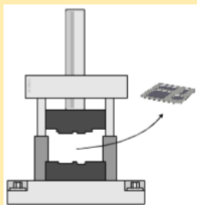
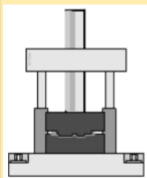


# MOULDING THROUGH COMPRESSION

V.Ryan © www.technologystudent.com 2019

Moulding through the force of compression is another very common industrial process. The materials used are melamine formaldehyde, phenol and urea. These materials can be formed into different shapes through applying both heat and pressure, other plastics do not have these properties.

**Tap the images** for detailed information / an exercise



Tap the blue button for the next slide / page.



Tap the red button to return to the Contents page

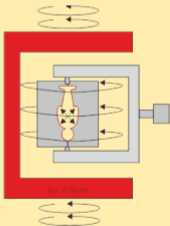


# ROTATIONAL MOULDING

V.Ryan © www.technologystudent.com 2019

Ideal for the moulding of hollow products, including tanks holding liquids, flower pots, rainwater tanks, footballs, road cones, fenders, luggage trays. Polyethylene and Polypropylene are ideal polymers for this moulding process. It is particularly suitable for the manufacture of batches from 100 to 5000 units. The mould is heated to 300 degrees centigrade and rotated, forcing the polymer powder against the sides of the mould

**Tap the image**  
for information  
/ an exercise



Tap the blue button for the next  
slide / page.



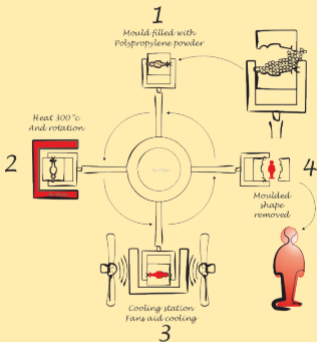
Tap the red button to return to the  
Contents page



# ROTATIONAL MOULDING

V.Ryan © www.technologystudent.com 2019

Tap the image for information / an exercise



Tap the red button to return to the Contents page

