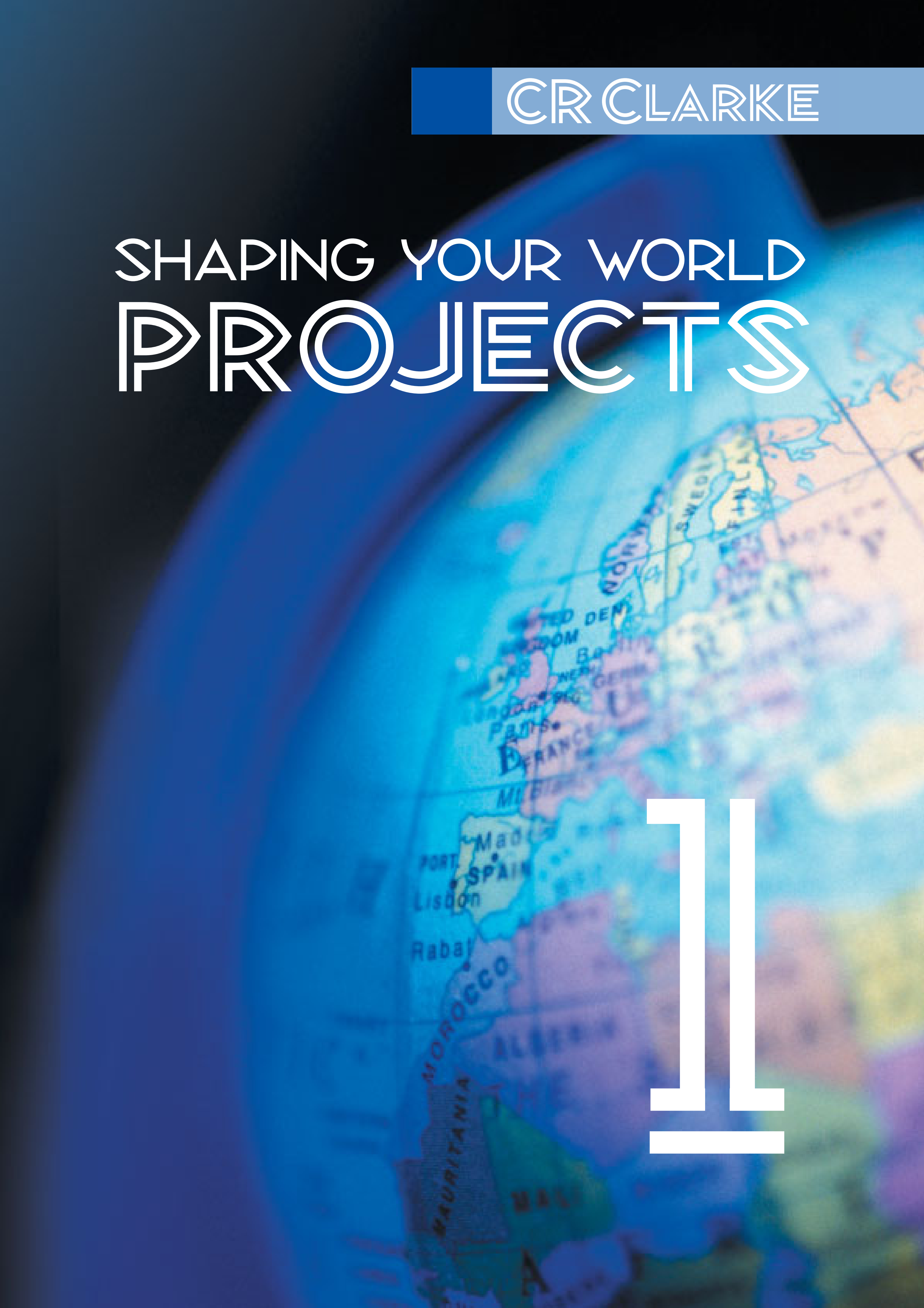
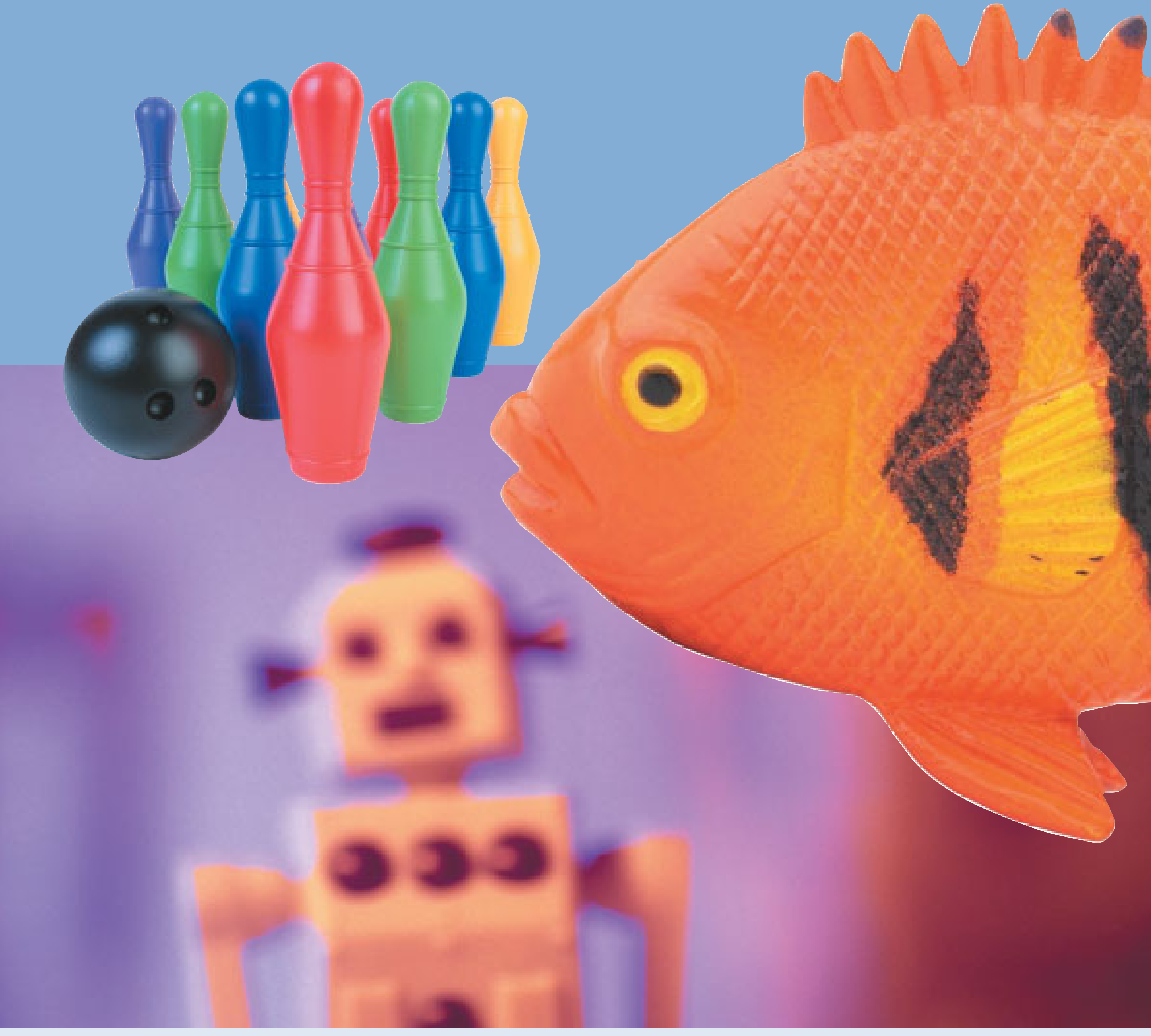
CR CLARKE

SHAPING YOUR WORLD PROJECTS 1



SHAPING YOUR WORLD
PROJECTS



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WELCOME TO PROJECT BOOK 1

THIS IS THE FIRST BOOKLET IN A SERIES THAT AIMS TO GIVE TEACHERS AND STUDENTS SOME IDEAS ON POSSIBLE PROJECTS USING A COMBINATION OF RESISTANT MATERIALS, TECHNIQUES AND PROCESSES.

The ideas included in this edition encompass many well-tried methods, and mix these with some interesting techniques that you may not have experimented with yet.

The Project Books will be given free of charge to education, to assist in the spread of concepts and ideas.

Should you have a project or idea that would be useful for other educational users, please feel free to send us details.

These should include:

- An outline of the Project Brief
- Details of the Design, Construction and Evaluation stages of the Project
- Photos and Drawings as appropriate

All projects should be sent to the address on the rear of this Booklet, or emailed to: info@crclarke.co.uk

We will aim to include all submitted projects in future Project Books, and as an incentive will donate a 50-sheet pack of vacuum forming materials to each school that has a project published. Each entrant will also be acknowledged at the end of their project.

We hope that you find the information and ideas enclosed in our Project Books to be useful, and to assist you in the teaching of Design and Technology. Should you wish to discuss any project or aspect of working with plastics, please do not hesitate to contact us.

CLOCK PROJECT

Target Age Group
Key Stage 3

Skills Learned
CAD, CAM, Design, Marking Out, Cutting, Vacuum Forming, Finishing, and Assembly

Outline of Project
In this project, the students design and make a working clock. The basic structure is pre-prepared to ensure reliable results.

Teacher Preparation
To ensure that this project is completed successfully, the teacher must manufacture the basic vacuum forming mould beforehand. It is recommended that the mould be made from MDF, to the drawing shown in Diagram 1.

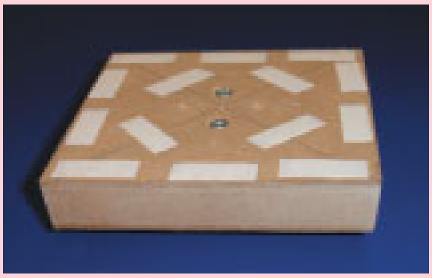
Notes on the production of the vacuum forming mould:

The thickness of the baseboard should be around 8mm. However, there is quite a tolerance on this and materials of 3-10mm can be used successfully.

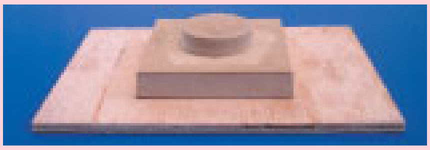
The baseboard in the diagram is suitable for our 1210 Vacuum Forming machine. The baseboard dimensions will need to be amended as required for different makes and models of machine.

The baseboard is drilled with a single, 6mm diameter evacuation hole. The mould itself is mounted on double sided sticky pads. This gap allows air to travel under the mould, giving even evacuation.

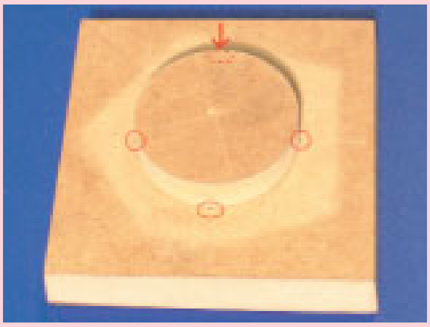
The mould is made in two pieces, which are secured together with two No 8 x 35mm screws.



Two further screws secure the assembled mould to the baseboard.



The 1mm diameter holes allow air to be evacuated from the top face of the completed mould.



Materials to be provided to the Students
1 piece of 18mm MDF, cut to the dimensions in Diagram 2.

1 piece of 1.5mm HIPS (High Impact Polystyrene) per student

1 piece of acrylic 3mm thick, 65mm square.

Clock Movement (we used one from Rapid Electronics, Order Code 85-1410).

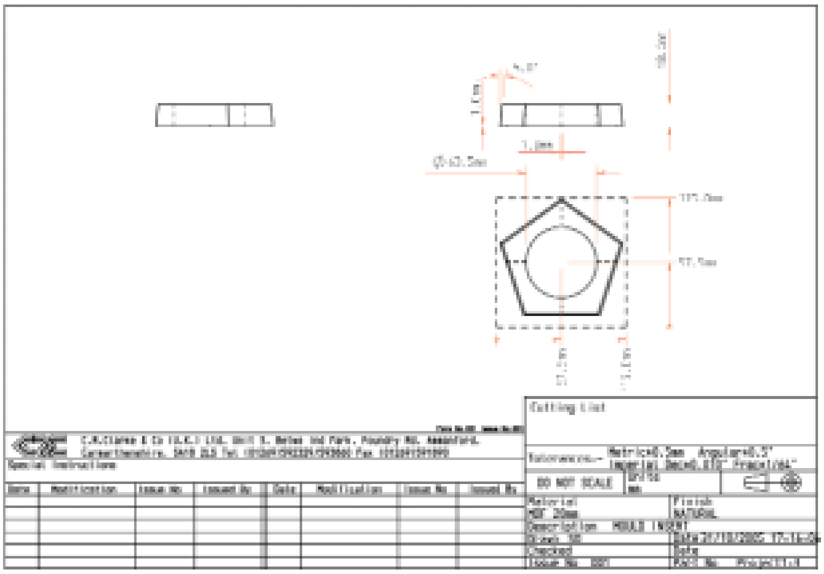
Equipment Requirements
Vacuum Forming Machine

Bandsaw, Router etc.

STEP 1

DESIGN THE SHAPE (CAD)

The students should start with a blank outline of the individual piece of MDF that they have. They can then draw the shape that they require. Once drawn, the shape can be printed out as a template, ready for Step 2.

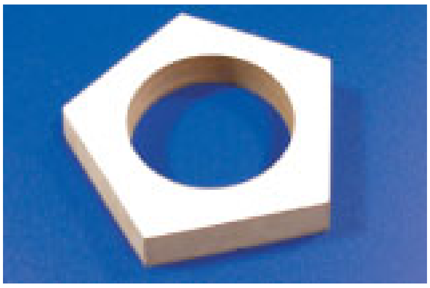


STEP 2

CUT THE MDF BLOCK

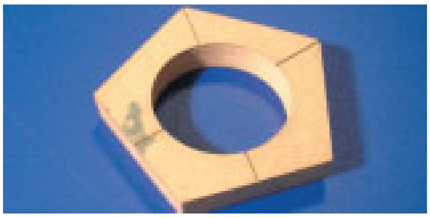
The students should stick the paper to their piece of MDF as a template:

The MDF should then be cut using suitable tools (this will vary from school to school, but could include Hegner saw, bandsaw, CNC router):



Once the shape has been cut, a 5° draft angle should be added to aid release of the moulding:

Two 1mm deep channels should be cut straight across the bottom of the block. This will allow air to travel under the block to the 1mm diameter evacuation holes in the main mould:

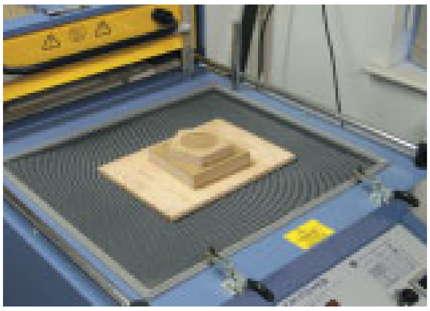


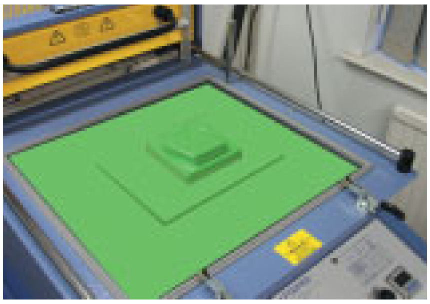
STEP 3

FORM THE CLOCK BASE

Lay the MDF block onto the basic mould shape. There should be no need to secure it for a single forming.

Load into the vacuum forming machine and form as normal.





CLOCK PROJECT

STEP 4

TRIM AND FINISH THE CLOCK BASE

Using a C R Clarke Profile Cutter, or similar tool, trim the base of the forming to leave a smooth edge.

Drill through the centre of the forming (using the detent as a guide) using an 8mm diameter drill.

STEP 5

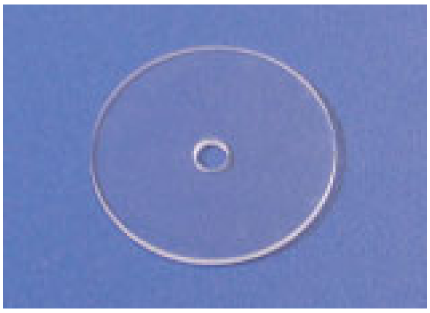
DESIGN THE FASCIA

Make a design 61mm in diameter. This can be a photograph, drawing or other pattern. Print the pattern onto paper and cut into a disc 61mm in diameter. Cut a hole 8mm in diameter in the centre of the disc.

STEP 6

CUT THE ACRYLIC DISC

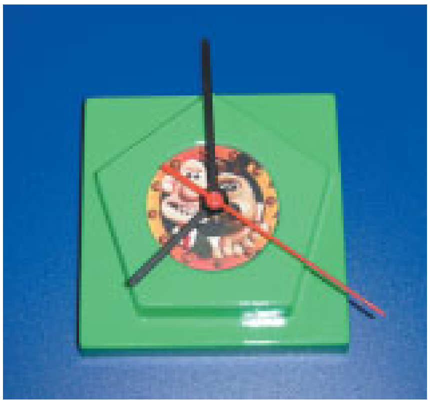
Mark out and cut the acrylic into a 61mm diameter circle. Drill an 8.0mm diameter hole in the centre of the disc. As an alternative, should your workshop be equipped with a laser cutter, this can be used for this operation.



STEP 7

FIT THE MOVEMENT

Fit the movement into the clock base from behind. Place the fascia onto the top face of the Clock Base, followed by the Acrylic Disc. Secure with the washer and nut and fit the clock hands.



With thanks to Mr Barritt at Hawarden High School, Hawarden, Flintshire, for the submission of this project.

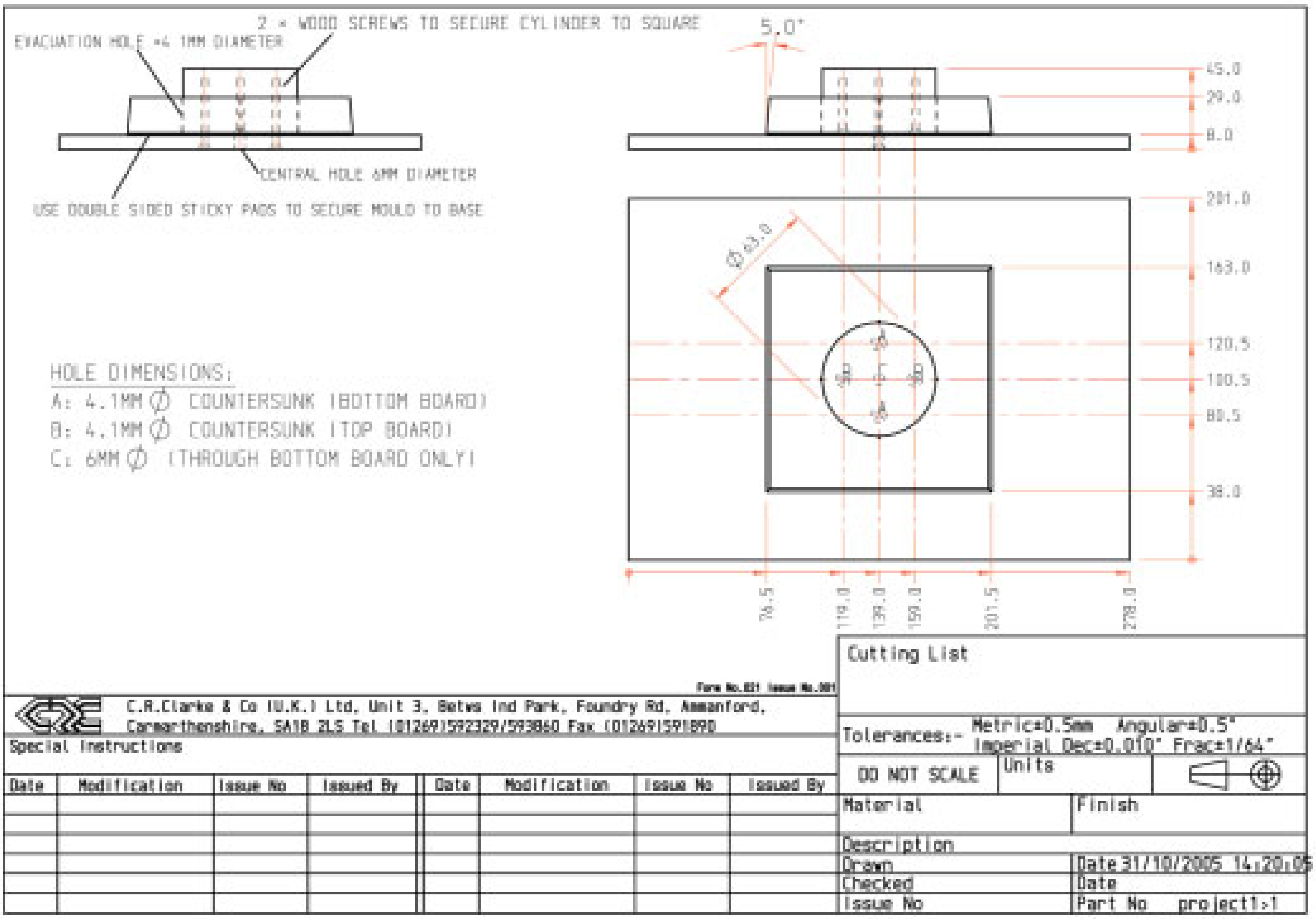

2 × WOOD SCREWS TO SECURE CYLINDER TO SQUARE
EVACUATION HOLE ×4 1MM DIAMETER
CENTRAL HOLE 6MM DIAMETER
USE DOUBLE SIDED STICKY PADS TO SECURE MOULD TO BASE
HOLE DIMENSIONS:
A: 4.1MM Ø COUNTERSUNK (BOTTOM BOARD)
B: 4.1MM Ø COUNTERSUNK (TOP BOARD)
C: 6MM Ø (THROUGH BOTTOM BOARD ONLY)
5.0°
45.0
29.0
8.0
201.0
163.0
120.5
100.5
80.5
38.0
76.5
119.0
139.0
159.0
201.5
278.0
Cutting List
Form No.031 Issue No.001
C.A.Clarke & Co (U.K.) Ltd, Unit 3, Betws Ind Park, Foundry Rd, Ammanford,
Carmarthenshire, SA18 2LS Tel (01269)592329/593860 Fax (01269)591890
Special Instructions
Date
Modification
Issue No
Issued By
Tolerances:- Metric±0.5mm Angular±0.5°
Imperial Dec±0.010" Frac±1/64"
DO NOT SCALE
Units
Material
Finish
Description
Drawn
Date 31/10/2005 14:20:05
Checked
Date
Issue No
Part No project1:1

Diagram 1

CLOCK PROJECT

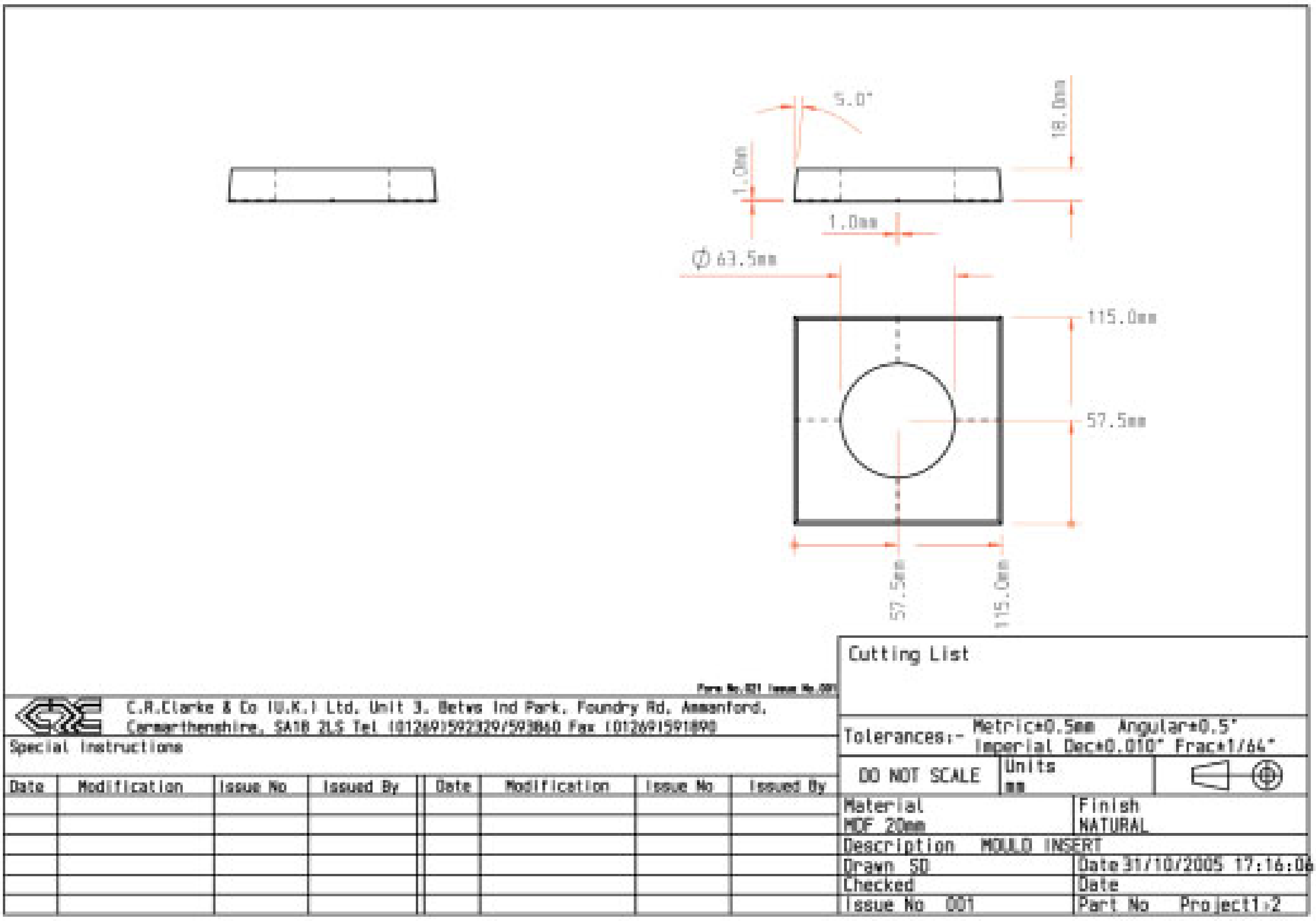


Diagram 2

SPIRO DRAW PROJECT

Target Age Group

Key Stage 4

Skills Learned

CAD, CAM, Design, Laser Cutting, Vacuum Forming, Finishing and Assembly

Outline of Project

In this project, the students design and make a "Spiro Draw" pattern making set. The outer frame of the Spiro Draw has a circular cut-out in its centre. This cut-out is machined with teeth.

A set of wheels is manufactured with varying numbers of matching teeth. (See "Advanced Content for the Brave" for further information on Spirograph geometry)

By adjusting the number of teeth on the gears, and the gears used for each drawing, different patterns can be drawn on a piece of paper.

To complete the project, a vacuum formed tray is manufactured to hold the Spiro Draw set along with pencil, rubber, sharpener etc. An MDF base is manufactured to secure the work to and provide a storage location for A5 paper.

The base is complemented by a line bent clear acrylic cover, giving a complete product.

An MDF base is manufactured to provide both a work surface and a storage location for A5 paper.

Materials to be provided to the Students

1 piece of 3mm MDF, cut to 430mm x 227mm* (Mould mounting board)

7 pieces of 3mm MDF, cut to 310mm x 210mm (Mould Layers)

1 piece of 3mm MDF, cut to 148mm x 210mm (A5 Base plate)

1 piece of HIPS (High Impact Polystyrene) or other suitable material 1.5mm thick, cut to 458mm x 254mm* (Vacuum Forming)

1 piece of acrylic 3mm thick, cut to 320mm x 470mm (Cover)

1 piece of acrylic 3mm thick, cut to 148mm x 148mm (Spiro Draw pieces)

Double Sided Sticky Pads

5 x No 8 x 20mm Woodscrews

* This is based on the C R Clarke 917/725 Vacuum Forming Machine. The dimensions may need to be altered for different makes or models of machine.

Equipment Requirements

Vacuum Forming Machine

Laser Cutter**

Strip Heaters

** We have used a Laser Cutter throughout this project. Depending upon availability, a Router or Milling machine could be used equally well.

SPIRO DRAW PROJECT

STEP 1
DESIGN THE SPIRO DRAW SHAPES (CAD)

The students should start with a blank outline of the piece of acrylic that they have. Firstly, they should draw a ring gear of a suitable size, which will be cut in the centre of the acrylic. This should start as a circle and then have a number of teeth added.

For initial projects, we recommend using the following tooth details:

No of Teeth = Outside Diameter of Ring Gear in mm

Tooth dimensions as shown in Diagram 1

Note that, when drawing the teeth, the centreline of each tooth must be perpendicular with the outer diameter of the circle. Therefore, the angle a on Diagram 1 will vary depending upon the diameter. Angle a can be calculated as:

(360/No of Teeth) + 60

Four holes 1mm diameter should be added to secure the surround and the insert of the Spiro Draw to the paper being patterned.

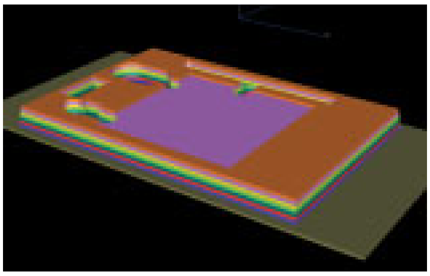
Next, within the ring gear, draw circles and add teeth to make the gears. Again, initially follow the tooth form shown in Diagram 1. Note the relationship between the number of teeth in the ring gear and the number of teeth in each gear. For example, a 50 tooth gear running in a 300 tooth ring gear will produce a six-sided shape (300/50 = 6). Should you choose an odd number of teeth (maybe 300/55), the wheel will run for many revolutions before drawing over the same line. The number can be calculated by working out the Lowest Common Denominator (LCD) of the two numbers, i.e. the LCD of 55 and 300 is 3300. Dividing this number (3300) by the number of teeth in the ring gear (300) gives the number of revolutions that will be completed before the pattern restarts, i.e. in this case 11 revolutions.

Suggestion: engrave your name, school logo or a pattern onto the face of the acrylic. Also engrave the number of teeth onto each gear.

Suggestion: Why limit yourself to round gears? How about elliptical or even polygon gears for an interesting effect?

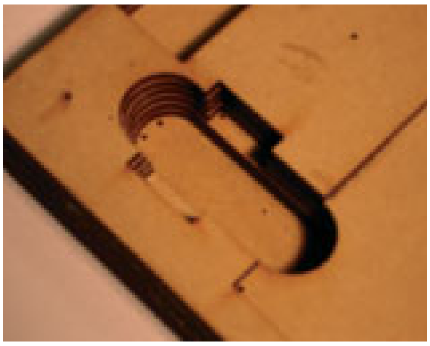
STEP 2
DESIGN THE STORAGE TRAY MOULD (CAD)

The students should start with a blank outline of the seven pieces of MDF that will form a mould for manufacturing the storage tray. Within each layer, the required cut-outs should be drawn for the Spiro Draw set, a pencil, eraser, pencil sharpener and some drawing pins. Diagram 2 gives some outline dimensions for a suitable tray layout.



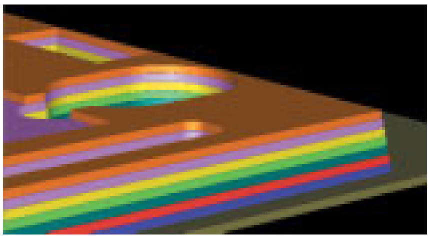
To help align the mould, make five holes in each layer, each a snug fit for a No 8 wood screw (around 4.1mm in diameter). Make the holes in the top layer only 1mm diameter. This will provide a pilot to guide the screw, while not showing on the final forming.

Remember to add ventilation holes of 1mm in diameter at this stage. These should be placed at the last points of evacuation (normally the bases of recesses etc) on the appropriate layers. On any layers below one with evacuation holes, place an aligning hole to allow this air to evacuate. Make these holes around 5mm in diameter to aid airflow and alignment.



When designing the layers ensure that each layer has a difference in size of 0.5mm on each edge (for 3mm MDF), to provide a draft angle to allow the forming to release. Working from the top layer down, any outer edges must increase in size on each layer. Conversely, any apertures must decrease in size.

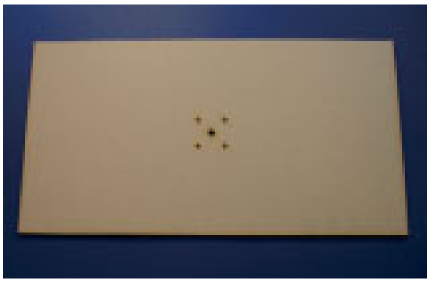
Suggestion: Engrave the number of each layer onto the MDF. This will help with assembly later.



STEP 3

DESIGN THE BASE PLATE OF THE STORAGE TRAY MOULD

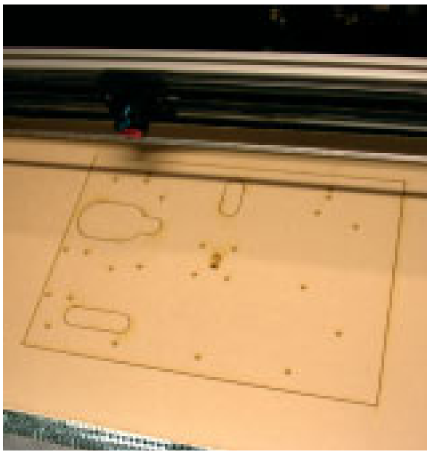
This will simply have a central hole of 6mm diameter to allow air to be evacuated, along with four holes to line up with the screw holes in the other mould layers.



STEP 4

CUT THE STORAGE TRAY (LASER CUTTER, ROUTER)

Load the material into the Laser Cutter. Download the programme. Set the machine at suitable power and speed settings and cut out the components.



STEP 5

CUT THE SPIRO DRAW (LASER CUTTER, ROUTER)

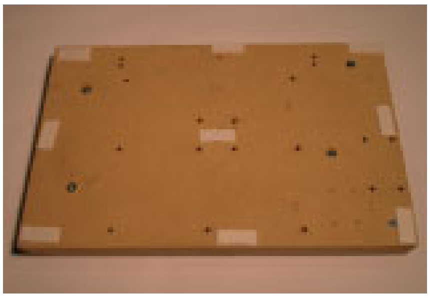
Load the material into the Laser Cutter. Download the programme. Set the machine at suitable power and speed settings and cut out the components.

STEP 6

ASSEMBLE THE MOULD (HAND SKILLS)

Countersink the underside of the securing screw holes. Place each layer in turn over the screws. Add PVA wood glue at any stage where the screws may not be sufficient, for example where there are thin rails of material. Fit the securing screws and tighten.

Place sticky pads onto the underside of the bottom mould layer, and stick to the base plate ensuring that the holes line up. This provides a gap for the air to be evacuated.



Finish any edges with fine glass paper and the mould is ready to use.

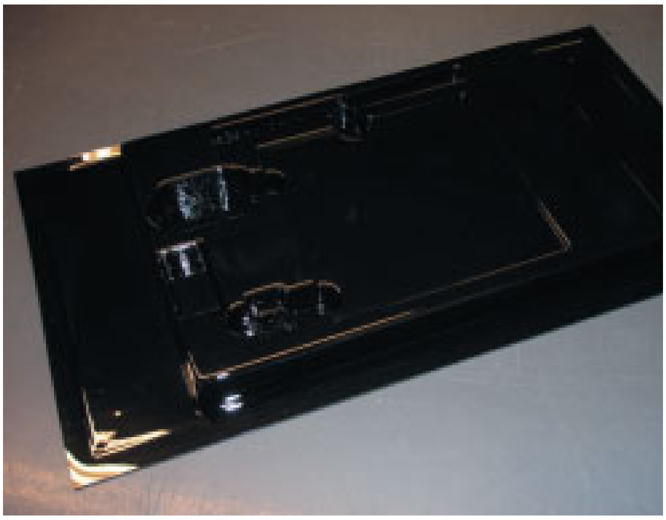
SPIRO DRAW PROJECT

STEP 7

VACUUM FORM THE TRAY (MACHINERY SKILLS)

Load the mould into the vacuum forming machine and form using 1.5mm HIPS.

Suggestion: Flocked or leathergrain material can be used for the tray to give a different feel to the forming.



STEP 8

TRIM THE VACUUM FORMING

Using a C R Clarke Profile Cutter, or similar tool, trim the base of the forming to leave a smooth edge.

STEP 9

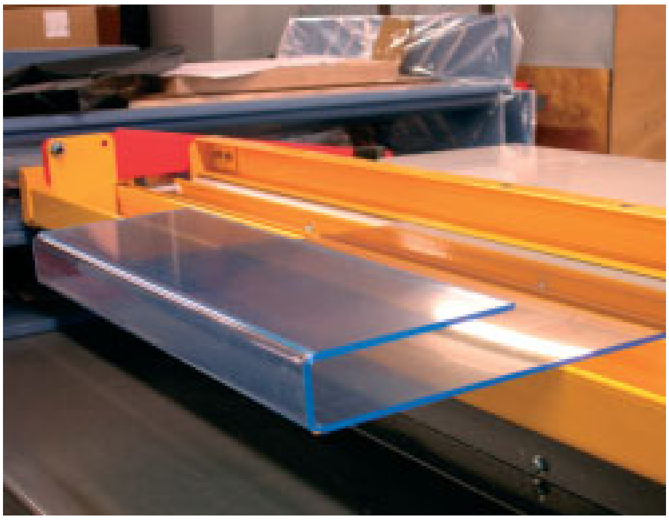
MAKE THE BASEBOARD

This is a pre-cut piece of MDF to suit A5 paper. There is no need to do anything more to this other than sand the edges smooth. However, an engraved pattern can be made on it if desired.

STEP 10

MAKE THE ACRYLIC COVER

Heat and fold the acrylic to the dimensions in Diagram 3. If using a C R Clarke 1000 or 1220 Hot Wire Strip Heater, two folds can be done in each operation. For other machines folds will need to be done singly.



Pack your Spiro Draw into the tray. Fill with A5 paper, place the MDF base under the tray and slide the cover over. Your Spiro Draw set is ready to use!

ADVANCED CONTENT FOR THE BRAVE

If the radius of fixed circle is R, the radius of moving circle is r, and the offset of the pen point in the moving circle is O (Figure 1), then the equation of the resulting curve is defined by:

x = (R+r)*cos(t) - (r+O)*cos(((R+r)/r)*t)

y = (R+r)*sin(t) - (r+O)*sin(((R+r)/r)*t)

Where t = angle (0,1,2,3,4,5,...359,360) etc. These are the parametric equations for the curves. Mathematicians call this path an epicycloid. The rest of the world calls them Spiro Graphs.

For correct meshing of the spirograph it is essential that the size of the teeth on the moving circle are the same as the size of teeth on the fixed circle. One measure of size is the circular pitch, p, the distance between adjacent teeth around the pitch circle thus;

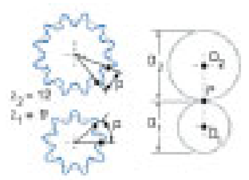
$p = \pi D/z$

where z is the number of teeth on a gear of pitch diameter D.

The SI measure of size is the module;

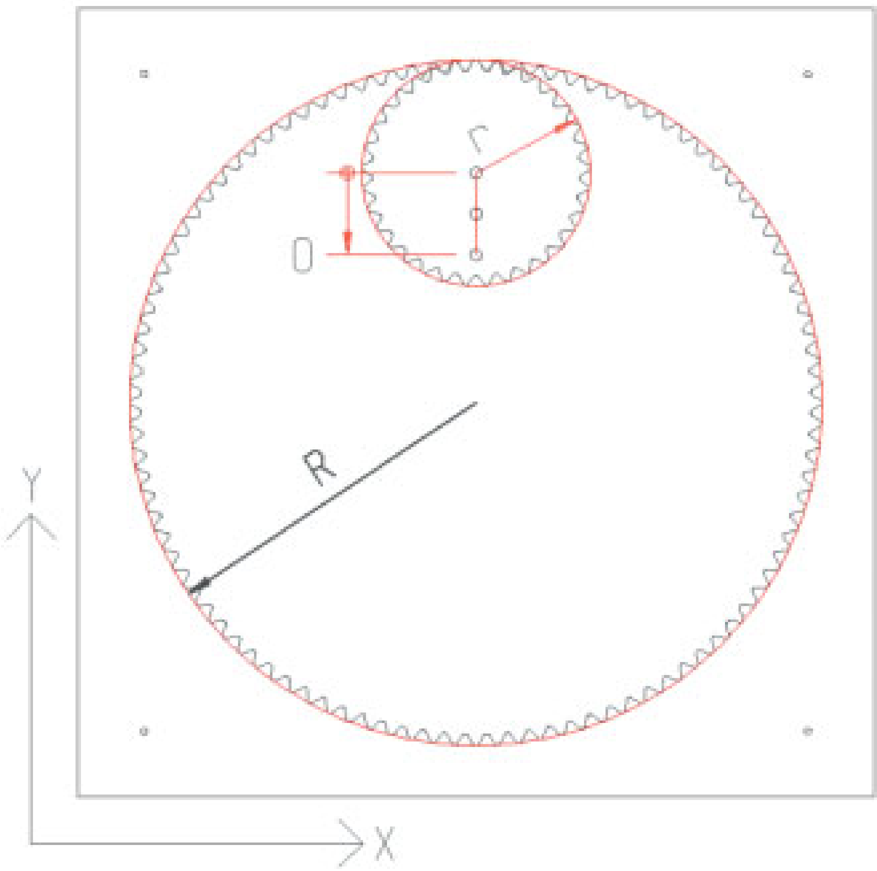
$m = p/\pi$

which should not be confused with the SI abbreviation for metre. So the geometry of the moving circle and the fixed circle must be such that:



$D1 / z1 = D2 / z2 = p / \pi = m$

...that is the module must be common to both gears.



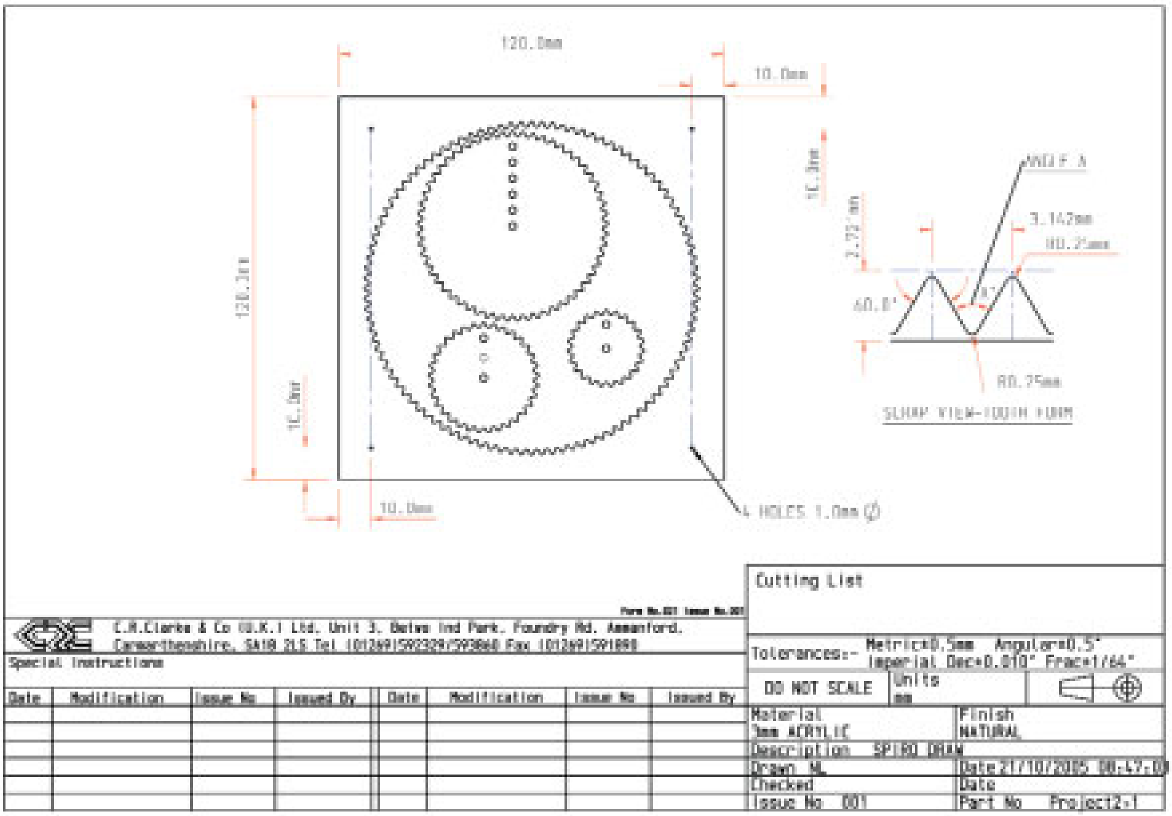


Diagram 1

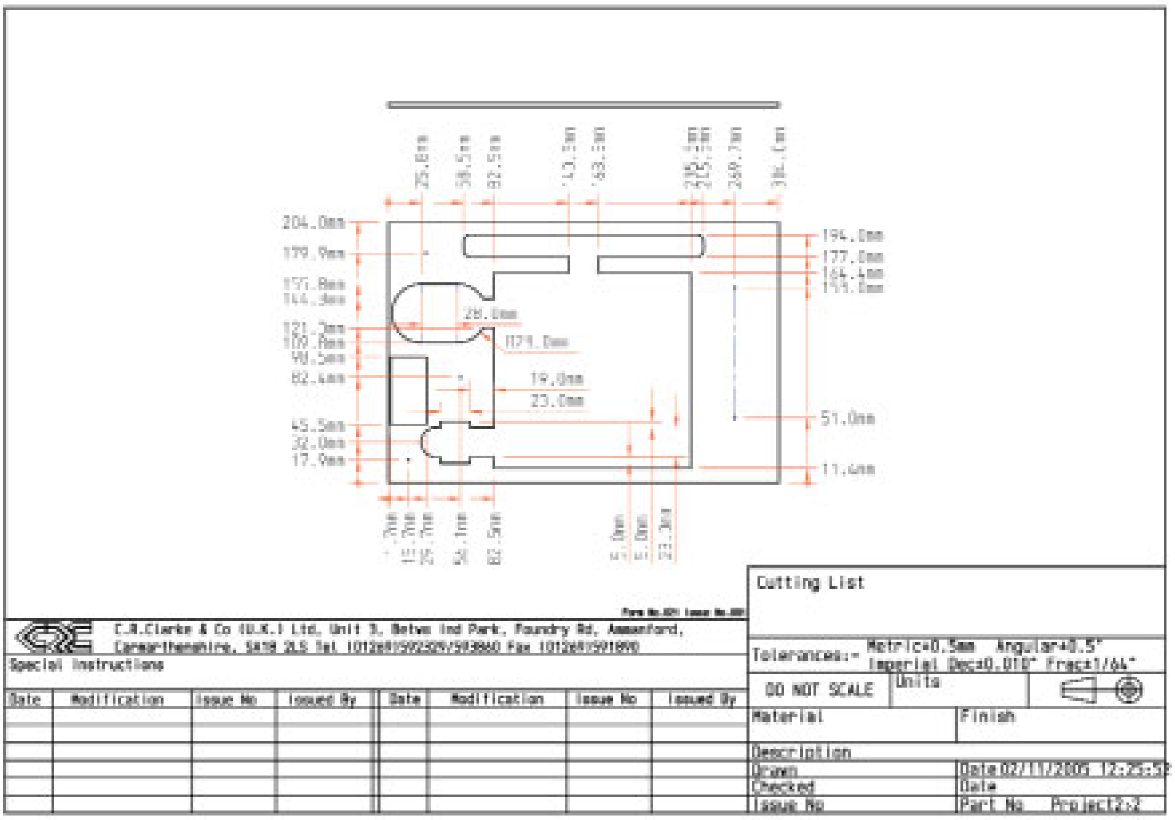


Diagram 2

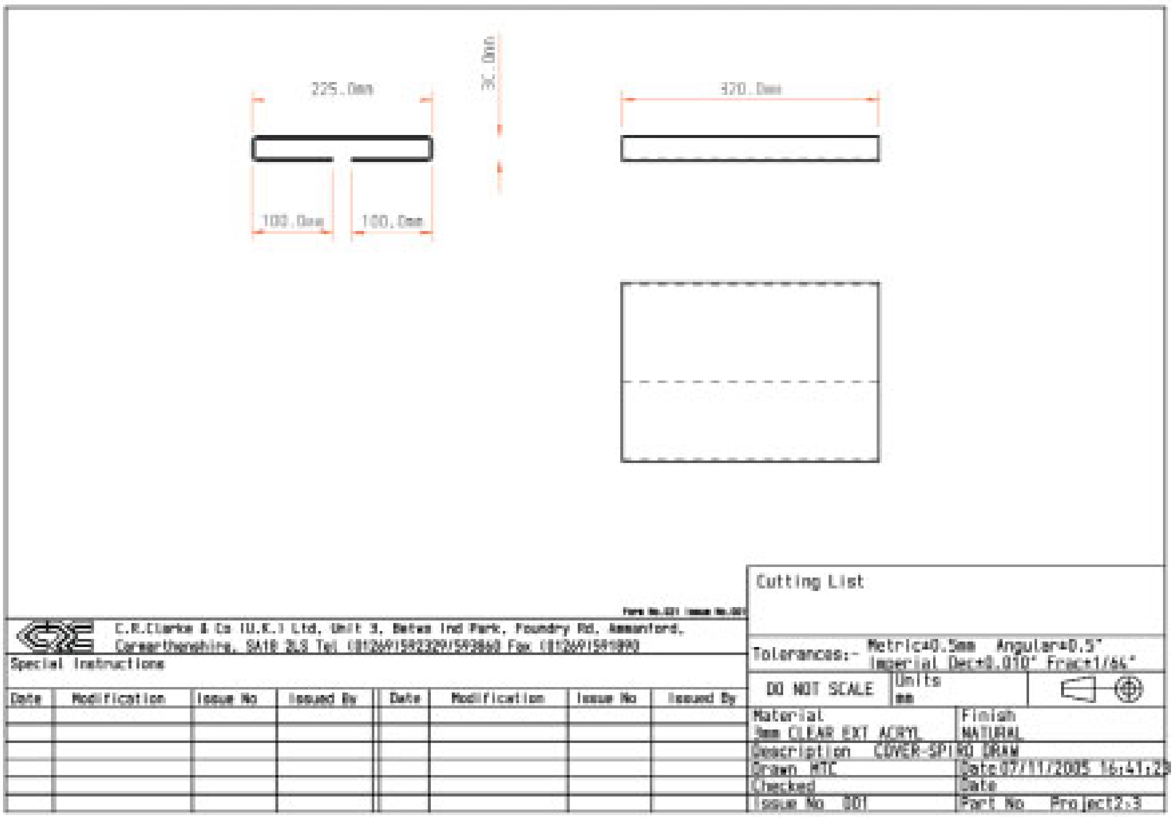
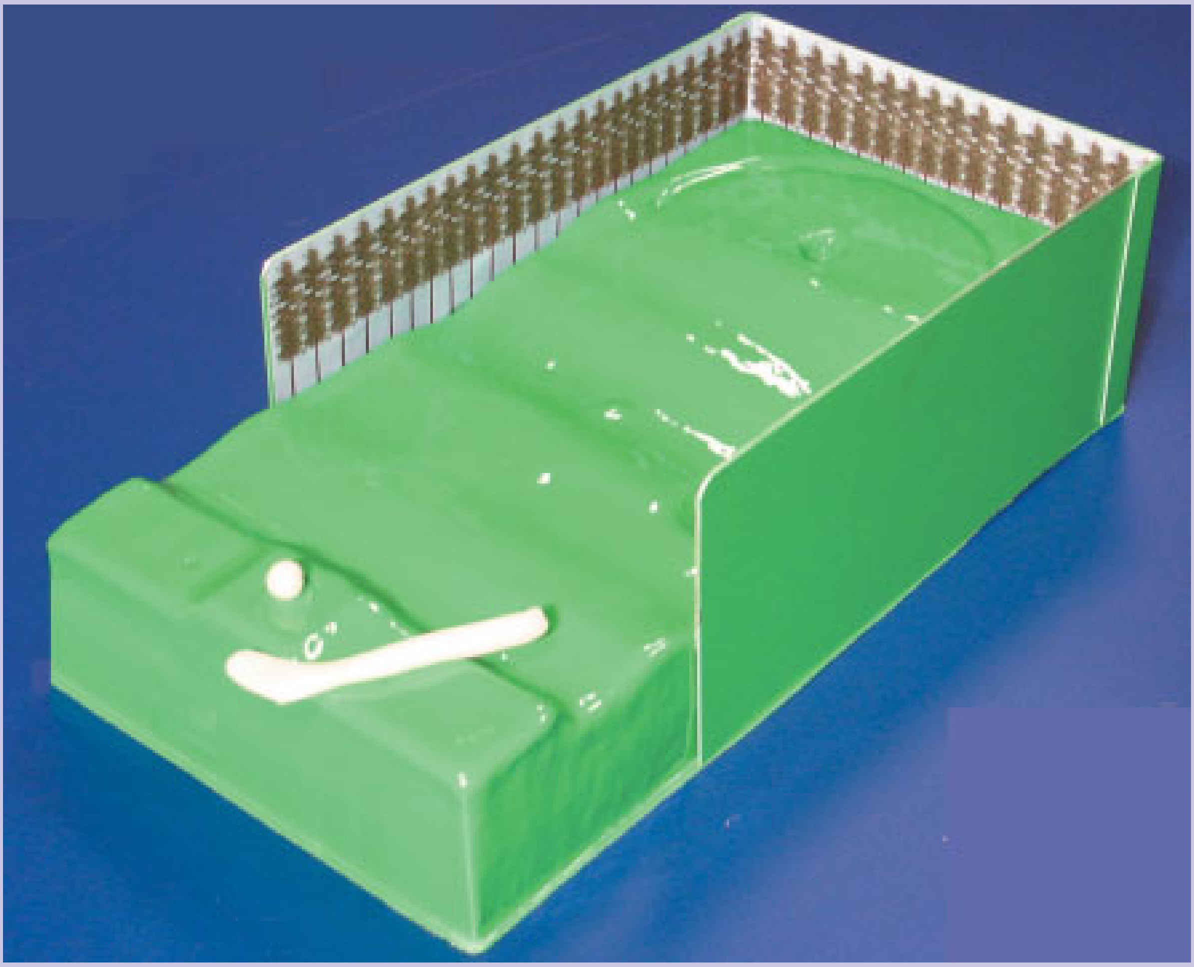

225.0mm
30.0mm
320.0mm
100.0mm
100.0mm
Cutting List
C.R.Clarke & Co (U.K.) Ltd, Unit 3, Betws Ind Park, Foundry Rd, Ammanford,
Special Instructions
Date
Modification
Issue No
Issued By
Date
Modification
Issue No
Issued By
Tolerances:-
Metric±0.5mm Angular±0.5°
Imperial Dec±0.010" Frac±1/64"
DO NOT SCALE
Units
mm
Material
3mm CLEAR EXT ACRYL
Finish
NATURAL
Description COVER-SPIRO DRAW
Drawn MTC
Date 07/11/2005 16:41:23
Checked
Date
Issue No 001
Part No Project2:3
Diagram 3

TABLE GOLF PROJECT



Target Age Group

Key Stage 3/4

Skills Learned

Sculpting, Mould Finishing, Vacuum Forming, Resistant Material properties, Finishing, Assembly and Design

Outline of Project

In this project, students design and make a Table Golf set. This includes a vacuum formed base with Tee, fairway, putting green and hole, along with a golf club and ball.

Materials to be provided to the Students

1 piece of High Density Expanded Polystyrene 75mm thick, cut to 380mm x 203mm

1 piece of 6mm MDF, cut to 430mm x 226mm*

C R Clarke Foamould coating Resin

1 piece of HIPS 1.5mm thick, cut to 458mm x 254mm* (Vacuum Forming).

3 pieces of HIPS 1.5mm thick, cut to 300mm x 150mm (Backdrop).

10 grammes of Polymorph

Double Sided Sticky Pads

4 x No 8 x 50mm Woodscrews

1 x M6 Plain Washer

* This is based on the C R Clarke 917/725 Vacuum Forming Machine. The dimensions may need to be altered for different makes or models of machine.

Equipment Requirements

Expanded Polystyrene Sculptor

Vacuum Forming Machine

Injection Moulding Machine (if needed for Golf Club)

STEP 1

MAKE THE GOLF CLUB

We have provided an initial shape and size for a suitable golf club in Diagram 1 (see page 16). These dimensions can obviously be tailored to your needs if required, There are several ways of making the golf club, and it may be worth going through these with the students to point out the strong and weak points of each method. A few suggestions are as follows:

Method	Strong Points	Weak Points
Draw a suitable shape using a CAD system. Print your design and stick it to a piece of 5mm MDF. Cut the MDF using a Hegner saw or similar. Finish with fine glass paper.	Easy to achieve in the workshop. Sanding will produce a round handle Quick to produce a single product No tooling	It would be laborious to produce a number of clubs The quality of the finish of each club depends on the skill of the student Limited to 2 dimensional contouring
Heat 10 grammes of Polymorph in hot water. Once the Polymorph has softened, remove from the water and form by hand into the shape of a Golf Club.	Can produce a sculpted shape with 3 dimensional contouring Very quick to produce No tooling	Relies completely on the ability of student to quickly mould the heated material. No consistency if a number of clubs were produced.
Design your golf club using a CAD system. Download the file and cut the club from acrylic using a laser cutter. This technique would also allow for an engraved pattern on the club.	Easy to achieve in the workshop. Quick to produce a single product. A production run of consistent clubs can be made. No tooling	The handle has sharp edges, making it more difficult to use. Limited to 2 dimensional contouring.
Design and make an injection mould for the golf club.	Once the mould is complete, it can quickly produce many identical golf clubs. The mould will be durable, enabling many hundreds of clubs to be produced. Can produce a sculpted shape with 3 dimensional contouring. It would be possible to include the ball in the mould, to reduce manufacturing time.	Precision mould manufacture is required. Very limited possibilities for varying the design of each club.

STEP 2

MAKE THE GOLF BALL

The golf ball should be a sphere of approximately 12mm diameter. This can be purchased (for example a marble), made in the workshop (for example in Polymorph), or included in an injection moulding tool (see above).

STEP 3

SCULPT THE GOLF COURSE

Start by cutting a 5° draft angle on the four edges of the expanded polystyrene. This will enable the forming to be released easily after vacuum forming.

Next, sculpt the shape that you require. In the sample project, we initially used the wire bow to profile the block, giving a higher Tee area, a contoured fairway, and then a flat putting green.

Once the basic contour has been completed, it can be detailed using the hand sculptor tool. In the sample, we added a bunker to one side of the fairway and a gulley around the edge of the putting green. Also, a hole is sunk into the putting green, of a size suitable for the ball made in Step 2.

The mould can be tested at this stage, to ensure that it provides the right level of challenge to the user.

TABLE GOLF PROJECT

STEP 4

COAT THE MOULD

This project demonstrates the ability of expanded foam to be used as a viable mould making material. However, this can only be achieved by coating the mould to ensure release of the finished vacuum forming. The mould should be mounted onto four pins (long nails are very good for this), so that the coating can be applied right down to the bottom of the side faces. Place the mould onto a protective surface (e.g. newspaper, polythene etc). Mix the resin as detailed in the instructions and apply a single coat over all of the surfaces that will contact the plastic.

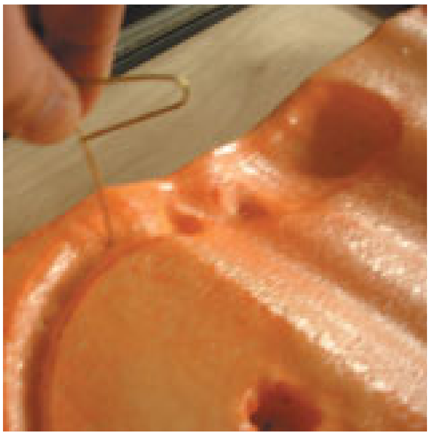
While the coating is still wet, place the M6 washer on the Tee off position.

Allow the coating to cure as detailed in the instructions (normally overnight).

STEP 5

PIERCE THE EVACUATION HOLES

High density foam is closed cell, and as such is not porous to air. Therefore, the mould must be pierced at the lowest point of any evacuation cavity, in the same way as a wooden mould. However, the foam can be simply pierced by pushing a piece of 1mm diameter brazing rod into it. Ensure that each hole goes right through the foam.



STEP 6

MOUNT THE MOULD ONTO THE BASEBOARD

Drill four 4.5mm diameter holes in the baseboard and countersink them from the underside. Drill a central 6.0mm diameter hole to allow the air to evacuate. Apply six or eight sticky pads to the underside of the expanded foam mould to provide an air path underneath it. Stick the mould to the baseboard. Turn the complete mould upside down and fit four No 8 x 50mm screws into the foam.
The screws will have sufficient grip in the foam to hold the mould securely to the baseboard.

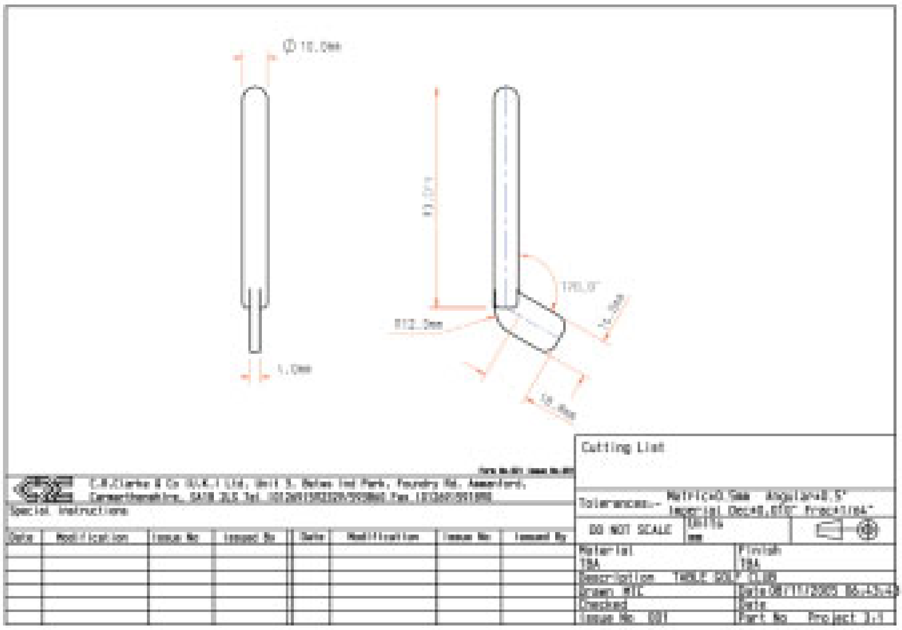


Diagram 1

STEP 7

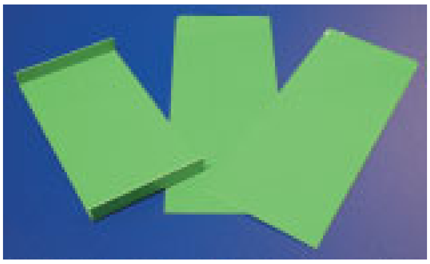
FORM & TRIM THE MOULD

Load the completed mould into the vacuum forming machine and form as normal. Note that the plastic behaves very differently over the foam mould. Most moulds (e.g. MDF, resin) are quite thermally conductive, and chill the formed material quite quickly. By contrast, the foam is an excellent insulator and therefore holds the heat in the plastic being formed. For this reason, the vacuum cycle will be much longer when using the foam mould. The completed forming can be trimmed using a C R Clarke Profile Router or similar. It is beneficial to leave a small flange at the bottom of the forming to add some strength to it.

STEP 8

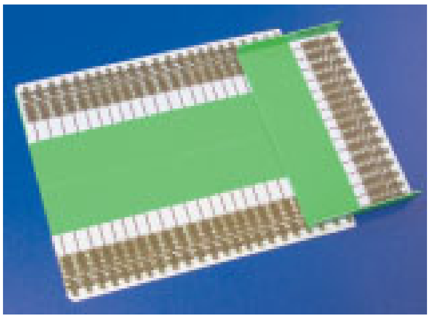
CUT THE BACKDROP PIECES

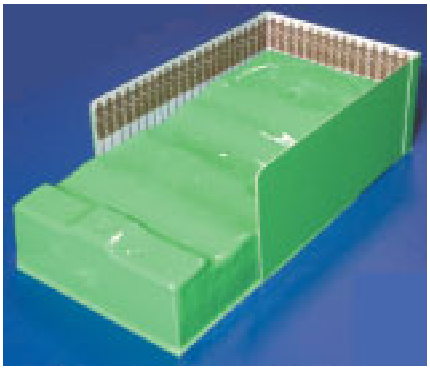
Cut the three pieces of HIPS into suitable shapes to stop the ball falling off the table when the game is being played. The corners at the Tee end should be rounded to prevent injury to the player. At the green end, the corners can either be butted together or heat folded and overlapped.



The inside faces of the backdrop can be decorated with paint or images stuck onto it, to represent a realistic background.

Glue the backdrop pieces into place around the base using a polystyrene solvent cement.



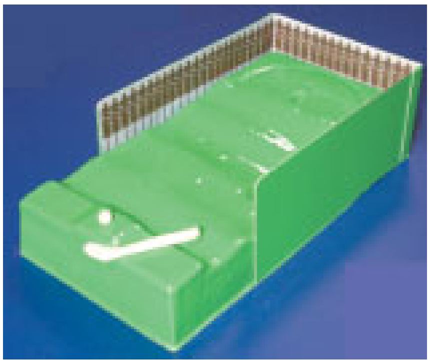


STEP 9

COMPLETION

Any details can be painted onto the face of the completed game, for example a sandy colour to represent a bunker.

Your Table Golf game is now ready to play.



MOBILE PHONE HOLDER PROJECT

Target Age Group

Key Stage 3

Skills Learned

CAD, CAM, Design, Laser Cutting and Line Bending

Outline of Project

In this project, the students design and manufacture a functional mobile phone holder. Each student has the freedom to design a completely unique holder of their own design using CAD technology.

The design is then laser cut and folded into the desired shape for the completed phone holder.

Materials to be provided to the Students

1 piece of 3mm acrylic (large enough for the template of the phone holder.)*

Equipment Requirements

Laser Cutter **

Hot Wire Strip Heaters***

* We recommend a thickness of 3mm acrylic because this provides enough rigidity for the holder but still allows the acrylic to be folded on a single wire

** We have used a Laser Cutter throughout this project. Depending upon availability, a Router or Milling machine could be used equally well

*** Any hot wire line bender will be suitable for this project

STEP 1

DESIGN THE PHONE HOLDER SHAPE (CAD)

The students have the opportunity to design from scratch a personalised mobile phone holder. They should first decide if the phone holder is to be used for a particular phone or a general design for many different types of phones and hence design it appropriately. The design process can be carried out in either 2D or 3D CAD software.

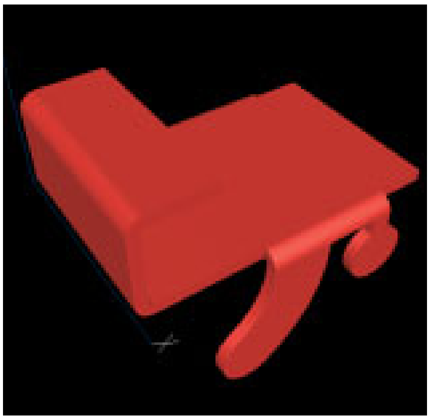


Figure 1: 3D CAD Design

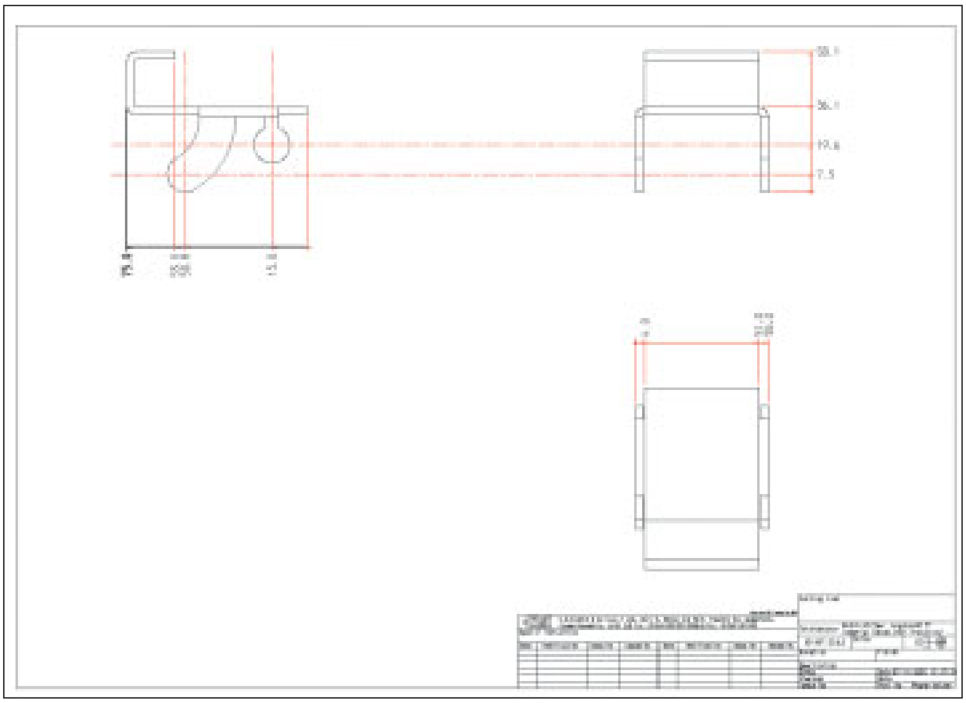


Figure 2: 2D CAD Design

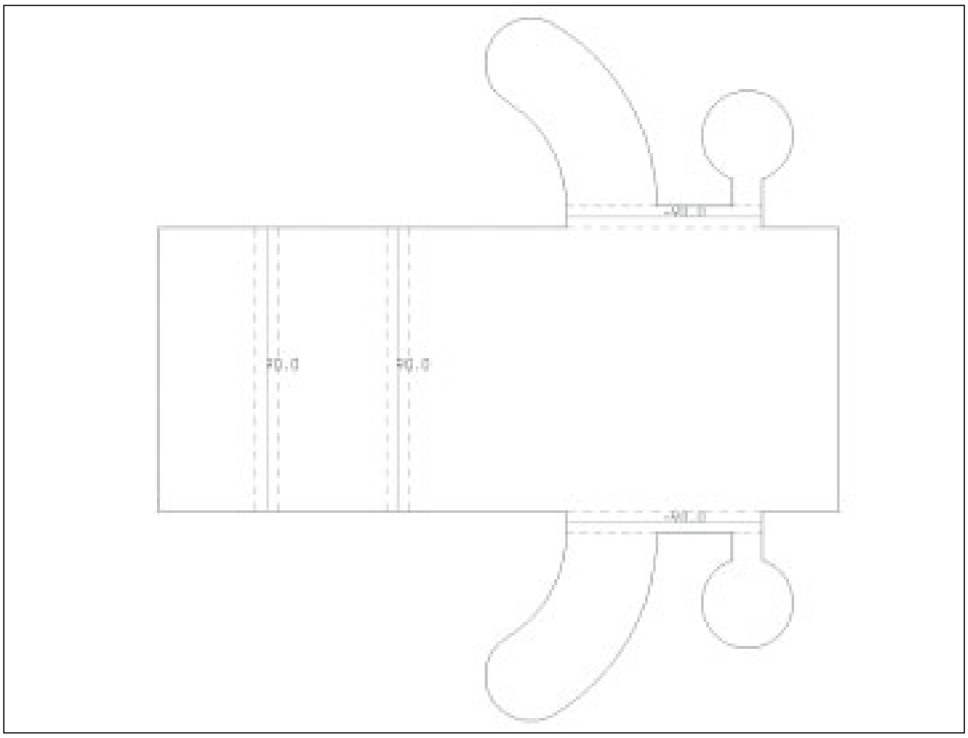


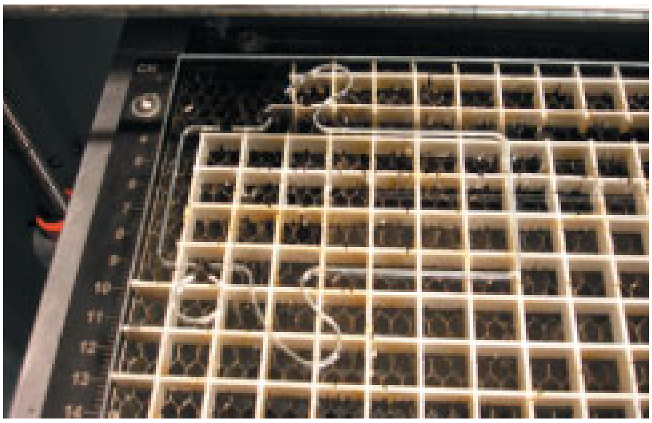
Figure 3: Template Layout

MOBILE PHONE HOLDER PROJECT

STEP 2

LASER CUTTING

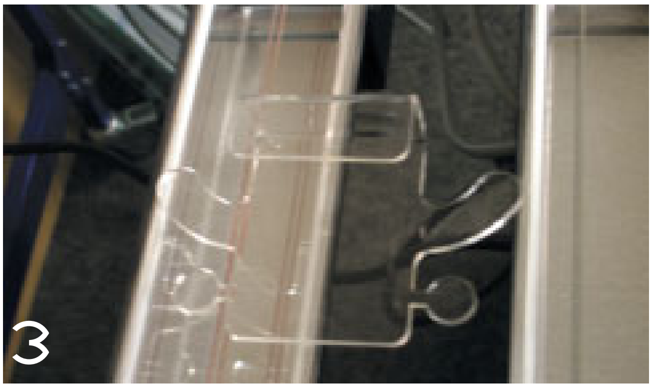
Place the material in the laser and cut out the template at the required speed and power.



STEP 3

LINE BENDING

Fold the phone holder in the required locations and in the correct order



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